

НАУКОВО-МЕТОДИЧНИЙ ЖУРНАЛ



ТЕОРІЯ ТА МЕТОДИКА ФІЗИЧНОГО ВИХОВАННЯ

[Physical Education Theory and Methodology]

[Teorià ta Metodika Fìzičnogo Vihovannâ]



№ 4 · Том 23 · серпень 2023

Адреса журналу в Інтернет:

<https://tmfv.com.ua>

<https://doi.org/10.17309/tmfv.2023.4>



/ ОВС ТОВ
Харків
Україна



Теорія та методика фізичного виховання
Physical Education Theory and Methodology
Teoriâ ta Metodika Fizičnogo Vihovannâ
Abbreviated key-title: Teor. metod. fiz. vihov.

Науково-методичний журнал
Scientific-methodological journal

Шість випусків на рік. Заснований у 2000 році
Six issues per year. Established in 2000

<https://www.tmfv.com.ua>. E-mail: tmfv@tmfv.com.ua

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Теорія та методика фізичного виховання

Науково-методичний журнал

Серпень 2023. Том 23, № 4

<https://doi.org/10.17309/tmfv.2023.4>

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Physical Education Theory and Methodology

Scientific-methodological journal

August 2023. Vol. 23, Num. 4

<https://doi.org/10.17309/tmfv.2023.4>

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ORIGINAL SCIENTIFIC ARTICLE

EXPLORING THE EFFECTIVENESS OF A BATTERY OF PHYSICAL FITNESS TESTS VIA VIRTUAL LEARNING ENVIRONMENT

Joseph Lobo^{1ABCE}, Francisco Gabriel Prevandos^{2ACD}, Clarenz Bautista^{2ADE},
Don Al De Dios^{2ADE}, Genesis Dimalanta^{3ADE} and Novri Gazali^{4ADE}

¹Independent Researcher, Angeles City

²Pampanga State Agricultural University

³Mabalacat City College

⁴Universitas Islam Riau

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Joseph Lobo, E-mail: jtdlobo@gmail.com

Accepted for Publication: June 18, 2023

Published: August 30, 2023

DOI: 10.17309/tmfv.2023.4.01

Abstract

Background. Online PFTs can assess students' physical fitness, according to several studies. However, few papers examined this issue in the setting of a Philippine higher education institution.

Study purpose. This experimental research examined how a subset of Physical Fitness Tests (PFTs) affects BMI improvement.

Materials and methods. After five weeks of fitness tests, this study used an experimental design to compare pre- and post-test scores while controlling for gender, age, and BMI. A two-part survey questionnaire collected the participants' data. First, gender, age, and pre-test BMI were provided. The Physical Activity Readiness Questionnaire was the second part (PAR-Q). Analysis of the 5-week experiment data used IBM SPSS version 27. Descriptive statistical approaches displayed the participants' demographics and fitness testing results (frequency, percentage, mean, and standard deviation). Before and after the selected PFTs, the students' performance was examined using the one-way ANOVA and the independent samples t-test to determine if factors like gender, age, and body mass index affected performance. After the fitness tests, the paired samples t-test was used to see if the pre- and post-test scores were statistically different.

Results. Performance before and after the selected PFTs was not statistically different between age groups. Except for the vertical jump test, gender groups did not differ significantly. Males outperformed females. Finally, after five weeks of performing the recommended PFTs, post-test scores were statistically significantly higher than pre-test levels.

Conclusions. The selected PFTs were useful in online learning, especially in a Philippine local institution. This study supports the idea that college physical education instructors can regularly test their students' fitness levels using the above assessments.

Keywords: distance learning, effectiveness, local college, physical education, physical fitness tests.

Introduction

Apathy toward physical activity has been considered a global pandemic in recent years (Tanucan et al., 2022). College students, especially, are becoming less active (Chaput et al., 2020; Katzmarzyk et al., 2018). The COVID-19 pandemic also has a major influence on individuals worldwide (Haleem et al., 2020; Prevandos & Martin, 2022). Many educational

institutions, especially higher education institutions, have had to close their campuses and offer courses online (Aristovnik et al., 2020). College students' physical health suffered from this fast academic environment adjustment (Ding et al., 2021; Nguyen et al., 2021). Physical education teachers urge pupils to have a healthy lifestyle outside of class. Several academic studies have shown that reducing physical activity can lower an individual's fitness level, resulting in decreased muscular strength, agility, and flexibility, cardiorespiratory endurance, and body composition (Armstrong et al., 2011; Bermejo-Cantarero et al., 2017; Pinho et al., 2020). Higher education institutions continue to face several challenges. It has been

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Dimalanta, G., & Gazali, N., 2023.



emphasized that online PE classes may not provide educational benefits to students because both the teacher and student are physically and spatially separated (Yu & Jee, 2020). In this regard, despite technological developments, virtual physical education cannot adequately mimic social and experiential components (Moustakas & Robrade, 2022). Due to repetition of courses in limited environments and poor learning tools, physical education has disastrous outcomes when its genuine objective and value are not successfully communicated (Jeong & So, 2020). Virtual physical education courses do not affect students' motor skills or tendency to participate in physically demanding activities (Chan et al., 2021). These factors may reduce students' motivation, interest, and peer interactions. Even after the pandemic, higher education institutions worldwide struggle to supply online courses. Online physical education lessons may not seem suitable (Konukman et al., 2022; Selvaraj et al., 2021).

On a more positive note, internet-based instruction will undoubtedly continue to play an essential part in a variety of higher education institutions. In particular, with regard to those educational institutions of higher learning that are still operating under this system of operation. Attending Physical Education lessons in an online environment, like the one studied by Idris et al. (2021), leads to increased levels of self-sufficiency and the ability to adjust to changes in the status quo, as the authors of the study discovered. Additionally, due to the rapid feedbacks and responsiveness of the teachers, the students in the health and physical education classes have a pleasant experience, and they were able to learn the subject more, as well as experience health gain (D'Agostino et al., 2021; Webster et al., 2021). To put it succinctly, resolving the difficulties encountered by students is of the utmost importance in order to give students with meaningful learning experiences, most notably in Physical Education classes, and this is true even in the context of an online learning environment.

Administration of Physical Fitness Test in an online environment

Online physical fitness testing has been studied extensively, where students will perform these tests in the comfort of their homes. It has been known that allowing students to administer these tests on their own provides critical understanding of their own goals, ideas, values, and emotions (Yan & Brown, 2017) in relation to their own health. Most importantly, it can be an alternative form of assessment that emphasizes a learner-centered approach (Keating et al., 2020). Instead of relying solely to the instructors, this student-centered approach aids students in engaging in a critical thinking process about the quality of their own learning. Furthermore, integrating technology in these kinds of tests has been seen to be popular among students and seen as a highly effective strategy in improving testing results. Keating et al. (2020) highlight the potential for student-provided video-clips to aid in fitness self-testing by demonstrating the proper form for exercises like the sit-and-reach test, sit-ups, and push-ups. The idea of sharing fitness testing results with school officials, teachers, and parents, as well as doing away with uncomfortable testing environments, is another exciting feature that is highly applicable to the present generation of students.

Furthermore, there have been various conducted concerning the administration of physical fitness testing in an online setting. The newly published study of J. Sun et al. (2023) which focused on the impact of physical education class, specifically physical fitness testing, to college students during the onslaught of COVID-19 from 2019-2021. Based on the findings of J. Sun et. al., it was found that the replacement of in-person physical education with its online counterpart in 2020 had negative effects on pull-ups and 800-/1000-metre runs but had significantly positive effects on other items [50-m run, sit-ups, standing long jump, pull-ups (males), and sit-and-reach (females)]; these findings are consistent with the study of Xia et al. (2021). Additionally, the experimental study of Xu et al. (2022) found that integrating an IoT smart sensor into a system for managing college students' physical fitness test results improves process efficiency by 60%, allowing the system to more quickly respond to diverse clientele. Likewise, the findings on the study of Ashley and Kawabata (2021), fitness test results from Singaporean students were mainly positive. The study found that students' happiness with fitness testing was strongly connected with their views about it. However, only the following research described above examined the efficacy of measuring physical fitness online and using various technologies. To assess if online fitness testing is highly effective, a rigorous investigation is needed. Researchers in this study assessed participants' pre- and post-exercise scores on a battery of PFTs to determine whether or not the workouts improved their fitness levels. This experimental study's results can lend credence to the idea that PFTs can be successfully administered via distance education.

Materials and methods

Study participants

The participants were selected via Judgmental Sampling Technique, which is a non-probability sampling technique in which the study's participants are exclusively selected due to their characteristics that are highly suitable for the study (Thomas, 2022). This study is an extension of another study which was already performed in a local college in Angeles City, Pampanga. In this particular study, undergraduate students taking the degree of Bachelor of Physical Education at a prominent college in Mabalacat, Pampanga, Region III, in the Philippines, enrolled in the Physical Education 1 course are the participants for the study. In connection to this, the researchers formulated a selection criterion in order to obtain the most reliable data possible: (1) must be at least 19 years old; (2) can be either male or female; (3) no history of any medical illness;

The demographic characteristics of the participants are typified in Table 1 according to age, gender, and pre-test BMI scores. Among the 50 participants, majority of them are females compared to their counterpart [(Nfemale = 33(66.00%), Nmale = 17(34.00%)]. Additionally, most of the participants fall under 21 years old, followed by those who are 19 and 20, respectively [(N21yo = 20(40.00%), N19yo = 15(30.00%), N20yo = 15(30.00%)]. According to participants' pre-test BMI, most of them are normal, followed by those who are underweight and overweight [(Nnormal = 30(60.00%), Nunderweight = 12(24.00%), Noverweight = 8(16.00%)].

Table 1. Demographic characteristics

Variable	Item	N(%)
Gender	Male	17(34.0%)
	Female	33(66.0%)
Age	19 years old	15(30.0%)
	20 years old	15(30.0%)
	21 years old	20(40.0%)
Body Mass Index (pre-test)	Underweight (UW)	12(24.0%)
	Normal	30(60.0%)
	Overweight	8(16.0%)

Study organization

By using an experimental design, this study compared the participants' body mass index (BMI) before and after they participated in the selected PFTs in an online learning environment over the course of five (5) consecutive weeks. An additional analysis (pre- and post-test) will compare students' overall performance on the basis of their gender, age, and body mass index (BMI). A well-designed experiment will yield the most precise results available, allowing researchers to draw the most definitive conclusions feasible about a hypothesis (Miller et al., 2020) appropriate use, and sustainability of effective clinical practices in real world clinical settings. Many implementation science questions can be feasibly answered by fully experimental designs, typically in the form of randomized controlled trials (RCTs). This research attempted to find out if these PFTs are necessary for keeping students' BMIs in a healthy range, even if the tests were done in the comfort of their own homes.

A two-part survey questionnaire was used to elicit responses from the test subjects. The first section consists of demographic information about the participant, such as their gender, age, and pre-test Body Mass Index. In the second section, participants were asked to complete the Physical Activity Readiness Questionnaire (PAR-Q). Participants who have had medical conditions in the past are disqualified from taking part in the study.

A battery of PFTs, including the hexagonal test, Plank test, Hand-wall test, Stork-balance test, and Vertical jump, were given to the participants. Before students administer the following tests, the teacher (researcher) will go over the

Table 2. Physical Fitness Test design for five (5) weeks

Week	Selected physical fitness test (PFT)
Week 1	Hexagonal Test (s)
Week 2	Plank Test (s)
Week 3	Hand-wall Test (catches/30s)
Week 4	Stork-balance test (s)
Week 5	Vertical jump (cm)

procedures and materials they will need with them during a designated week. Due to the nature of the online course delivery, students were additionally provided with a video and a module detailing the specifics of how to succeed on the subsequent assessments. Table 2 details the weekly schedule and specific evaluations that participants must complete during the investigation.

Monitoring procedures for physical fitness test program adherence. Participants were required to submit both (1) an index card in the standard format required by the educational institution outlining the tests they took and (2) an unaltered and unprocessed video recording of themselves completing the tests. Participants uploaded both essential monitoring tools to Google Drive. Each week, students must demonstrate that they are actively participating in the assessment by submitting the following. Surprisingly, every participant met the requirements and submitted their work on schedule.

Statistical analysis

Data was handled with IBM SPSS 27 (IBM Statistical Package for the Social Sciences). The demographic profile and selected assessments of fitness were analyzed using descriptive statistics including frequency (f), percentage (%), mean (M), and standard deviation (SD). Each fitness test's tabular description is shown in Table 3. In addition, Independent Samples T-Test and One-way ANOVA were used to determine if gender, age, and BMI affect participants' pre- and post-test performance on various physical fitness tests (PFTs). Parametric tests like the Independent Samples T-Test and One-Way Analysis of Variance (ANOVA) evaluate the means of two or more groups to discover if there is a statistically significant difference (Ahmed & Hamarai, 2022;

Table 3. Descriptive Interpretation per test

Hexagonal (s)		Plank test (s)		Hand-wall (catches/30s)		Stork-balance (s)		Vertical-jump (cm)			
								Male		Female	
s	Rate	s	Rate	Catches	Rate	s	Rate	cm	Rate	cm	Rate
<12	E	>60	E	>35	E	>50	E	>70	E	> 60	E
13-17	G	40-50	VG	30-35	G	40-50	G	61-70	VG	51-60	VG
18-22	F	30-39	G	20-29	A	25-39	A	51-60	AA	41-50	AA
>22	P	20-29	A	15-19	F	10-24	F	41-50	A	31-40	A
		10-19	P	<15	P	<10	P	31-40	BA	21-30	BA
		1-9	VP					21-30	P	11-20	P
								<21	VP	< 11	VP

Hexagonal: E – Excellent, G – Good, F – Fair, P – Poor; Plank Test: E – Excellent, VG – Very Good, G – Good, A – Average, P – Poor, VP – Very Poor; Hand-Wall: E – Excellent, G – Good, A – Average, F – Fair, P – Poor; Stork-Balance: E – Excellent, G – Good, A – Average, F – Fair, P – Poor; Vertical-Jump: E – Excellent, VG – Very Good, AA – Above Average, A – Average, BA – Below Average, P – Poor, VP – Very Poor.

Gerald, 2018). After the physical fitness tests, the Paired samples t-test was performed to see if the participants' IBM scores changed significantly (Ross & Willson, 2017).

Ethical considerations

All participants were briefed on the experiment's goals, as well as any instruments or tests that would be used to evaluate their progress and output. The study's positive effects for higher education institutions and the scientific community at general have also been outlined.

Results

Table 4 displays participants' pre-test Body Mass Index (BMI) by gender and age. Age-wise, most male participants are normal, followed by overweight and underweight [(Nmale(normal) = 10(58.82%), Nmale(overweight) = 5(29.41%), Nmale(underweight) = 2(11.77%)], while most female participants are normal, followed by overweight and underweight [(Nfemale(normal) = 20(60.60%), Nmale(underweight) = 10(30.30%), Nmale(overweight) = 3(9.1%)]. Concerning age, most 19-year-olds are normal, followed by those who are underweight and overweight [(N19yo(normal) = 7(46.67%), N19yo(underweight) = 5(33.33%), N19yo(overweight) = 3(20.0%)]; most 20-year-olds are normal, followed by those who are overweight and underweight [(N20yo(normal) = 10(66.67%), N20yo(underweight) = 4(26.66%), N20yo(overweight) = 1(6.67%)]; and finally, most 21 years old fall under the normal classification, followed by those who are overweight and underweight [(N21yo(normal) = 13(65.0%), N21yo(underweight) = 4(20.0%), N19yo(overweight) = 3(15.0%)]. Based on the table, most participants across genders and ages are normal.

The outcomes of the participants' fitness assessments are displayed in Table 5. More than half (52.0%) of the sample scored an "excellent" (<12s) on the hexagonal test. The majority of participants scored "excellent" (>60s) on the plank test, accounting for 44.00% of the total population. Based on their performance on the hand-wall test, nearly half of the participants (48.00%) were classified as "average" (catches/30s). About three-quarters (72.00%) of the sample population scored "excellent" (>50s) on the stork balance test. Finally, 38.00% of the overall sample group scored within the "average" range (41-50cm-male/31-40cm-female) on the vertical-jump test.

Table 6 displays the average mean score on the performance of the participants after performing all the selected physical fitness tests with respect to gender, age, and body mass index (pre-test). Based on the findings, most of the female participants (17.47 ± 15.16) performed higher in the hexagonal test compared to males (13.32 ± 7.91), but both yielded a "good" rating (13-17s); male participants (53.31 ± 14.15) performed better in the plank test compared to females (46.54 ± 14.74), but both yielded a "very good rating" (40-50s); female participants (24.01 ± 7.76) performed better in the hand-wall test compared to males (22.52 ± 8.44), but both yielded an "average" rating (20-29 catches/30s); female participants (54.35 ± 17.50) performed better in the stork-balance test compare to males (52.35 ± 33.45), but both yielded a "good" rating (40-50s); lastly, male partici-

Table 4. Contingency Table on gender, age, and Body Mass Index (BMI)

	Body Mass Index Classification		
	Underweight/UW (%)	Normal/N (%)	Overweight/OW (%)
Gender			
Male	2(11.77%)	10(58.82%)	5(29.41%)
Female	10(30.30%)	20(60.60%)	3(9.1%)
Age			
19 years old	5(33.33%)	7(46.67%)	3(20.0%)
20 years old	4(26.66%)	10(66.67%)	1(6.67%)
21 years old	3(15.0%)	13(65.0%)	4(20.0%)

pants performed better in the vertical-jump test compared to females, which yielded a "very good" (61-70cm) and "average" (31-40cm) rating, respectively. Additionally, 20-years old participants performed better in the hexagonal tests (17.06 ± 19.15), followed by those who are 19- (16.61 ± 9.63) and 21-years old (14.89 ± 10.43) respectively, but yielded a "good" rating across age groups (13-17s); 19-years old participants performed better in the plank test (14.89 ± 10.43), followed by those 21- (49.30 ± 15.75) and 20-years old (46.77 ± 14.27), but yielded a "very good" rating across age groups (40-50s); 20-years old participants performed better in the hand-wall test (24.58 ± 7.15), followed by those 21- (24.28 ± 9.57) and 19-years old (21.42 ± 6.19), but yielded an "average" rating across age groups (20-29 catches/30s); lastly, 21-years old participants performed better in the stork-balance test (57.26 ± 32.99), followed by those 20- (56.82 ± 10.02) and 19-years old (45.73 ± 17.52), and yielded an "excellent" (>50/s) and "good" (40-50/s) ratings respectively. Finally, participants who are underweight performed better in the hexagonal test (14.08 ± 8.62), followed by those who are normal (15.61 ± 14.60) and overweight (20.69 ± 13.71), and yielded a "good" (13-17/s) and "fair" (18-22/s) rating respectively; overweight participants performed better in the plank test (51.41 ± 10.17), followed by those who are normal (48.70 ± 15.41) and underweight (47.48 ± 16.45), but all yielded a "very good" rating (40-50/s); normal participants performed better in the hand-wall test (24.81 ± 6.31), followed by those who are overweight (24.75 ± 12.62) and underweight (19.44 ± 7.11), and yielded an "average" (20-29 catches/30s) and "fair" (15-19 catches/30s) rating respectively; lastly, overweight participants performed better in the stork-balance test (60.37 ± 47.40), followed by those who are underweight (57.75 ± 10.48) and normal (50.24 ± 18.46), and yielded an "excellent" (>50/s) rating across groups.

Table 7 lists gender-specific physical fitness test results. The Independent Samples T-test showed that both genders performed similarly on the hexagonal [$t(47.966) = -1.274$, $p = 0.209$], plank [$t(33.636) = 1.581$, $p = 0.123$], hand-wall [$t(30.094) = -0.607$, $p = 0.548$], and stork-balance [$t(20.622) = -0.230$, $p = 0.820$]. Males performed better in the vertical jump test (69.99 ± 27.50 vs. 38.21 ± 17.78) [$t(48) = 4.946$, $p < 0.05$].

The results of a one-way ANOVA comparing the participants' ages to their scores on a variety of fitness tests are shown in Table 8. Based on the findings, no significant difference was observed in between groups after performing hexagonal ($F(46.761, 8498.678) = 0.129$, $p = 0.879$),

Table 5. Results of selected physical fitness tests

Participant	Selected Physical Fitness Test (PFT)									
	Hexagonal (s)		Plank test (s)		Hand-wall (catches/30s)		Stork-balance (s)		Vertical-jump (cm)	
	s	Rate	s	Rate	Catches	Rate	s	Rate	cm	Rate
F	7.80	E	22.00	A	16	F	50.00	E	40.64	AA
F	8.55	E	30.42	G	28	A	64.00	E	30.00	BA
F	26.00	P	60.00	E	21	A	55.00	E	30.48	BA
F	7.00	E	42.00	VG	27	A	32.00	A	45.72	AA
F	32.00	P	65.00	E	12	P	50.00	E	81.00	E
F	8.90	E	40.00	VG	20	A	20.00	F	24.00	BA
M	10.00	E	60.00	E	20	A	20.00	F	120.00	E
M	5.18	E	60.00	E	20	A	55.00	E	50.00	A
M	12.00	E	60.00	E	32	G	60.00	E	85.00	E
F	36.00	P	60.00	E	30	G	10.00	P	24.25	BA
F	7.30	E	34.00	G	28	A	50.00	E	40.64	A
F	20.00	F	60.00	E	30	G	50.00	E	45.72	AA
F	12.40	G	30.00	G	20	A	40.00	G	31.00	A
F	7.19	E	21.57	A	30	G	50.98	E	34.00	A
F	6.68	E	65.00	E	21	A	71.00	E	27.00	BA
F	7.00	E	60.00	E	20	A	50.00	E	27.00	BA
F	6.69	E	60.00	E	7	P	60.00	E	26.70	BA
F	65.00	P	49.98	VG	23	A	65.00	E	32.00	A
F	12.40	G	35.36	G	21	A	75.00	E	115.40	E
F	61.20	P	50.58	VG	22	A	70.30	E	32.00	A
F	11.00	E	60.00	E	35	E	60.00	E	31.75	A
M	4.64	E	45.00	VG	35	E	50.00	E	50.00	A
F	7.52	E	27.00	A	31	G	50.00	E	36.00	A
F	16.50	G	43.00	VG	24	A	50.00	E	43.18	AA
F	10.50	G	60.00	E	22	A	60.00	E	28.00	BA
F	21.00	F	30.00	G	13	P	60.00	E	33.02	A
F	11.70	E	60.00	E	21	A	60.00	E	29.00	BA
F	22.00	F	70.00	E	15	F	64.00	E	42.00	AA
F	19.00	F	52.00	VG	19	F	45.00	G	36.00	A
M	22.00	F	43.00	VG	27	A	41.00	G	43.18	A
F	11.00	E	51.88	VG	33	G	67.20	E	32.00	A
F	11.72	E	42.00	VG	30	G	54.00	G	43.18	AA
F	6.68	E	22.00	A	23	A	26.00	A	30.00	BA
F	45.00	P	40.00	VG	47	E	90.00	E	32.00	A
F	5.65	E	60.00	E	20	A	96.00	E	24.00	BA
F	5.00	E	60.00	E	30	G	50.00	E	58.42	VG
F	26.00	P	27.00	A	33	G	38.00	A	43.00	AA
M	15.00	G	52.00	VG	27	A	17.00	F	50.80	A
F	14.29	G	45.00	VG	21	A	60.00	E	32.00	A
M	20.00	F	39.00	G	20	A	39.00	A	58.42	AA
M	5.77	E	33.00	G	21	A	60.00	E	55.88	AA
M	7.00	E	60.00	E	30	G	2.00	P	71.12	E
M	7.00	E	60.00	E	10	P	60.00	E	71.12	E
M	32.00	P	55.00	VG	18	F	60.00	E	55.88	AA
M	22.00	F	60.00	E	18	F	60.00	E	101.60	E
M	21.90	F	60.00	E	12	P	60.00	E	129.54	E
M	15.40	G	36.31	G	7	P	160.00	E	44.00	A
M	12.75	G	90.00	E	32	G	26.00	A	50.80	A
M	8.00	E	60.00	E	20	A	60.00	E	50.80	A
M	5.80	E	33.00	G	34	G	60.00	E	101.60	E

Hexagonal: E – Excellent, G – Good, F – Fair, P – Poor; Plank Test: E – Excellent, VG – Very Good, G – Good, A – Average, P – Poor, VP – Very Poor; Hand-Wall: E – Excellent, G – Good, A – Average, F – Fair, P – Poor; Stork-Balance: E – Excellent, G – Good, A – Average, F – Fair, P – Poor; Vertical-Jump: E – Excellent, VG – Very Good, AA – Above Average, A – Average, BA – Below Average, P – Poor, VP – Very Poor.

Table 6. Contingency Table for gender, age and Body Mass Index (BMI) on selected physical fitness tests

Variables	HT (s)		PT (s)		HWT (s)		SBT (s)		VJT (cm)	
	M ± SD	R	M ± SD	R	M ± SD	R	M ± SD	R	M ± SD	R
Gender										
Male	13.32 ± 7.91	G	53.31 ± 14.15	VG	22.52 ± 8.44	A	52.35 ± 33.45	G	69.99 ± 27.50	VG
Female	17.47 ± 15.16	G	46.54 ± 14.74	VG	24.01 ± 7.76	A	54.35 ± 17.50	G	38.21 ± 17.78	A
Age										
19 years old	16.61 ± 9.63	G	50.29 ± 14.66	VG	21.42 ± 6.19	A	45.73 ± 17.52	G	-	-
20 years old	17.06 ± 19.15	G	46.77 ± 14.27	VG	24.58 ± 7.15	A	56.82 ± 10.02	E	-	-
21 years old	14.89 ± 10.43	G	49.30 ± 15.75	VG	24.28 ± 9.57	A	57.26 ± 32.99	E	-	-
Body Mass Index (Pre-test)										
Underweight	14.08 ± 8.62	G	47.48 ± 16.45	VG	19.44 ± 7.11	F	57.75 ± 10.48	E	-	-
Normal	15.61 ± 14.60	G	48.70 ± 15.41	VG	24.81 ± 6.31	A	50.24 ± 18.46	E	-	-
Overweight	20.69 ± 13.71	F	51.41 ± 10.17	VG	24.75 ± 12.62	A	60.37 ± 47.40	E	-	-

Table 7. Independent Samples T-test measuring the difference in performance of various physical fitness test with respect to gender

Variables	N	M ± SD	SE	df	t-test	Sig.	Decision
Hexagonal (s)							
Male	17	13.32 ± 7.91	1.91	47.966	-1.274	0.209	Not significant
Female	33	14.47 ± 15.15	2.63				
Plank (s)							
Male	17	53.31 ± 14.15	3.43	33.636	1.581	0.123	Not significant
Female	33	46.54 ± 14.74	2.57				
Hand-wall (catches/30s)							
Male	17	22.53 ± 8.44	2.05	30.094	-0.607	0.548	Not significant
Female	33	24.01 ± 7.76	1.35				
Stork-balance (s)							
Male	17	52.35 ± 33.45	8.11	20.622	-0.230	0.820	Not significant
Female	33	54.34 ± 17.49	3.05				
Vertical jump (cm)							
Male	17	69.99 ± 27.50	6.67	48	4.946	0.000	Significant
Female	33	38.21 ± 17.78	3.10				

Table 8. One-way ANOVA test measuring the difference in performance of various physical fitness test with respect to age

Variable	Sum of Squares	df	Mean Square	F	Sig.
Hexagonal (s)	Between Groups	46.761	2	23.381	0.129
	Within Groups	8498.678	47	180.823	
	Total	8545.439	49		0.879
Plank test (s)	Between Groups	100.671	2	50.336	0.224
	Within Groups	10569.539	47	224.884	
	Total	10670.210	49		0.800
Hand-wall (catches/30s)	Between Groups	94.554	2	47.277	0.742
	Within Groups	2995.360	47	63.731	
	Total	3089.914	49		0.482
Stork-balance (s)	Between Groups	1351.334	2	675.667	1.203
	Within Groups	26389.259	47	561.474	
	Total	27740.592	49		0.309
Vertical-jump (cm)	Between Groups	2455.867	2	1227.933	1.856
	Within Groups	31088.420	47	661.456	
	Total	33544.287	49		0.168

Table 9. One-way ANOVA test measuring the difference in performance of various physical fitness test with respect to Body Mass Index (pre-test)

	Variable	Sum of Squares	df	Mean Square	F	Sig.
Hexagonal (s)	Between Groups	224.838	2	112.419	0.635	0.534
	Within Groups	8320.601	47	177.034		
	Total	8545.439	49			
Plank test (s)	Between Groups	75.719	2	37.860	0.168	0.846
	Within Groups	10594.491	47	225.415		
	Total	10670.210	49			
Hand-wall (catches/30s)	Between Groups	261.669	2	130.834	2.174	0.125
	Within Groups	2828.245	47	60.175		
	Total	3089.914	49			
Stork-balance (s)	Between Groups	910.442	2	455.221	0.797	0.456
	Within Groups	26830.150	47	570.854		
	Total	27740.592	49			
Vertical (cm)	Between Groups	380.722	2	190.361	0.270	0.765
	Within Groups	33163.565	47	705.608		
	Total	33544.287	49			

Table 10. One-way ANOVA test measuring the difference in performance of various physical fitness test with respect to Body Mass Index (post-test)

	Variable	Sum of Squares	df	Mean Square	F	Sig.
Hexagonal (s)	Between Groups	6727.395	41	164.083	0.722	0.768
	Within Groups	1818.044	8	227.256		
	Total	8545.439	49			
Plank test (s)	Between Groups	8579.136	41	209.247	0.801	0.704
	Within Groups	2091.074	8	261.384		
	Total	10670.210	49			
Hand-wall (catches/30s)	Between Groups	2887.580	41	70.429	2.785	0.064
	Within Groups	202.333	8	25.292		
	Total	3089.914	49			
Stork-balance (s)	Between Groups	25685.439	41	626.474	2.439	0.092
	Within Groups	2055.153	8	256.894		
	Total	27740.592	49			
Vertical (cm)	Between Groups	31112.432	41	758.840	2.496	0.086
	Within Groups	2431.855	8	303.982		
	Total	33544.287	49			

plank ($F(100.671, 10569.539) = 0.224, p = 0.800$), hand-wall ($F(94.554, 2995.360) = 0.742, p = 0.482$), stork-balance ($F(1351.334, 26389.259) = 1.203, p = 0.309$), and vertical-jump ($F(2455.867, 31088.420) = 1.856, p = 0.168$) tests.

The results of a one-way ANOVA comparing the participants' Body Max Index (pre-test) to their scores on a variety of fitness tests are shown in Table 9. Based on the findings, no significant difference was observed in between groups after performing hexagonal ($F(224.838, 8320.601) = 0.635, p = 0.534$), plank ($F(75.719, 10594.491) = 0.168, p = 0.846$), hand-wall ($F(261.669, 2828.245) = 2.174, p = 0.125$), stork-balance ($F(910.442, 26830.150) = 0.797, p = 0.456$), and vertical-jump ($F(380.722, 33163.565) = 0.270, p = 0.765$) tests.

The results of a one-way ANOVA comparing the participants' Body Max Index (post-test) to their scores on a variety of fitness tests are shown in Table 10. Based on the findings,

no significant difference was observed in between groups after performing hexagonal ($F(6727.395, 1818.044) = 0.722, p = 0.768$), plank ($F(8579.136, 2091.074) = 0.801, p = 0.704$), hand-wall ($F(2887.580, 202.333) = 2.785, p = 0.064$), stork-balance ($F(25685.439, 2055.153) = 2.439, p = 0.092$), and vertical-jump ($F(31112.432, 2431.855) = 2.496, p = 0.086$) tests.

The comparison of the participants' post-test scores to their pre-test scores is presented in Table 11. It is possible to deduce, on the basis of the findings, why there was a shift in the pre-test scores of the participants after they had been putting themselves through the selected physical fitness tests for a period of five (5) weeks.

As can be shown in Table 11, there was a statistically significant difference between the scores obtained on the pre-test (20.85 ± 3.77) and the scores obtained on the post-test (20.45 ± 3.53); $t(49) = 4.233, p < 0.05$. In light of the findings,

Table 11. Body Mass Index (BMI)-based pre- and post-test scores of participants after completing a series of physical fitness tests

Post-test						Pre-test					
Participants	BMI	Class	Participants	BMI	Class	Participants	BMI	Class	Participants	BMI	Class
1	17.52	UW	26	16.99	UW	1	18.02	UW	26	17.02	UW
2	18.35	UW	27	18.90	N	2	18.37	UW	27	18.50	N
3	22.92	N	28	17.24	UW	3	23.05	N	28	18.01	UW
4	18.65	N	29	18.59	N	4	19.05	N	29	18.00	N
5	17.76	UW	30	15.17	UW	5	18.02	UW	30	16.22	UW
6	20.50	N	31	28.01	O	6	21.20	N	31	27.59	O
7	23.15	N	32	20.20	N	7	23.45	N	32	19.50	N
8	26.44	O	33	18.15	N	8	25.02	O	33	18.30	N
9	23.79	N	34	20.80	N	9	22.25	N	34	19.50	N
10	29.03	O	35	29.10	O	10	28.06	O	35	28.35	O
11	19.23	N	36	18.75	N	11	18.06	N	36	18.00	N
12	29.45	O	37	21.62	N	12	29.25	O	37	21.33	N
13	19.20	N	38	17.36	UW	13	18.50	N	38	17.30	UW
14	18.75	N	39	26.96	O	14	18.25	N	39	26.00	O
15	17.24	UW	40	24.80	N	15	16.45	UW	40	23.25	N
16	22.00	N	41	23.41	N	16	21.75	N	41	23.30	N
17	17.92	UW	42	14.76	UW	17	17.05	UW	42	15.15	UW
18	19.80	N	43	22.08	N	18	19.00	N	43	21.20	N
19	17.33	UW	44	25.36	O	19	16.55	UW	44	25.20	O
20	19.50	N	45	18.52	N	20	18.50	N	45	18.60	N
21	21.19	N	46	24.80	N	21	20.20	N	46	23.50	N
22	20.90	N	47	16.14	UW	22	19.50	N	47	16.85	UW
23	18.50	N	48	26.80	O	23	17.25	UW	48	25.58	O
24	18.59	N	49	20.80	N	24	18.01	UW	49	21.25	N
25	17.52	UW	50	18.50	N	25	18.02	UW	50	18.70	N

Class: UW-Underweight, N-Normal, O-Obese

Table 12. Pre-test versus post-test scores after performing the selected physical fitness tests

		Paired Differences				t	df	Sig.
		M ± SD	SE	95% Confidence Interval of the Difference				
				Lower	Upper			
1	Pre-test - post-test	0.41 ± 0.68	0.09642	0.21443	0.60197	4.233	49	0.000

one reasonable conclusion that can be drawn is that participation in the various physical fitness tests that were chosen may have contributed to an improvement or reduction in the Body Mass Index of the students.

Discussion

Except for the vertical jump, the results of the PFTs indicated no significant variations by gender, age, or body mass index (both before and after the test). Previous research publications have identified disparities in students' physical fitness assessments based on their gender, age, and body mass index (Busing & West, 2016; Devries & Jakobi, 2021). However, there was no significant difference

in PFT performance between both genders or between the participants of different ages or body compositions. There was a statistically significant change between the participants' pre- and post-test scores on the specified physical fitness tests after they had taken the tests weekly for five (5) weeks. Students' body mass indexes likely improved because of the PFTs they were required to do, even though the course was delivered entirely online. These results corroborated those of previous studies that had shown that online fitness assessments were effective (Apriyanto & Adi, 2021; Xu et al., 2022) XI and XII sample using total sampling. There are 346 respondes. The data collection instrument used online learning questionnaire used google form. Data analysis used descriptive statistics. The study showed that, students

assessed physical education learning with online learning is very effective (8.3%). However, no previously published papers were found to have been conducted in conjunction with this current inquiry that prompted the selected PFTs in a technologically driven environment. In light of this issue, it is recommended that another research investigation with similar goals be conducted to determine whether or not the findings of this study can be accepted or repudiated.

PFT performance can also be impacted by a number of other factors, all of which must be taken into account. Studies have found that the eating habits of an individual are significantly linked to their BMI, which in turn may affect their performance (Grace et al., 2021; Gutiérrez-Pliego et al., 2016; M. Sun et al., 2020; Xie et al., 2020). The inverse is also true; a higher score of harmful patterns correlates with a higher BMI. There was also a strong connection between BMI and factors associated to individuals' dietary and physical activity habits. Numerous studies have linked a person's BMI to their personal habits including not getting enough exercise, smoking, and drinking too much (Günalan, 2020; Hossein Abbasi & Aghaamiri, 2020; Nejadsadeghi et al., 2018; Štefan et al., 2017). To determine whether or not there is a significant difference in the findings of the participants when taking into account such variables, an experimental study may be conducted with the inclusion of other aspects specified previously.

Conclusions

This analysis was conducted to evaluate the usefulness of the enumerated physical fitness tests in the context of a virtual environment. Participants were selected from a pool of undergraduates majoring in physical education at an esteemed college in Mabalacat City, Pampanga, Region III, Philippines. After five weeks of testing, results showed that the examined physical fitness assessments are useful for students of both genders between the ages of 19 and 21, regardless of body mass index. This study provides support for the idea that college physical education teachers might routinely employ the aforementioned assessments to determine their students' fitness levels. Using a pre- and post-test technique, we can determine which students are at risk and work with them to make positive changes that will have a positive impact on their health and well-being. It's possible that this method will only work if teachers implement a rigorous and meticulous monitoring plan. The compliance of students with the exams they are required to take should be the primary emphasis of this monitoring.

Limitations are incredibly important factors to keep in mind during the process, and the investigators of this experimental study hope to place special attention on these. At the outset, only those who are majoring in physical education at the Bachelor's level will be allowed to take part. This limits the generalizability of the study's results to other degrees or other forms of teacher education at the same institution. The results of this study strongly suggest that a comparable study be conducted with the involvement of students from other academic disciplines. It's also possible that other educational institutions all across the world may conduct the same tests to verify or disprove the initial findings. Finally, this study did not account for the participants' eating habits, lifestyle choices, or other

measures of physical fitness. Consequently, it is strongly advised that similar tests be conducted while considering the aforementioned other variables. In conclusion, this study adds new information to the current body of knowledge about the effectiveness of the identified physical fitness tests in reducing and improving participants' Body Mass Index (BMI) within an online setting.

Acknowledgment

All of the students who volunteered their time and energy to this study are deeply appreciated by the researchers.

Conflict of interest

The authors have no competing interests to disclose.

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ВИВЧЕННЯ ЕФЕКТИВНОСТІ КОМПЛЕКСУ ТЕСТІВ ФІЗИЧНОЇ ПІДГОТОВЛЕНOSTІ ЗА ДОПОМОГОЮ ВІРТУАЛЬНОГО НАВЧАЛЬНОГО СЕРЕДОВИЩА

Джозеф Лобо^{1ABCE}, Франциско Габріель Превандос^{2ACD},
Кларенс Баутіста^{2ADE}, Дон Аль Де Діос^{2ADE}, Генезіс Дімаланта^{3ADE},
Новрі Газалі^{4ADE}

¹Незалежний дослідник

²Пампангський державний сільськогосподарський університет

³Мабалакатський міський коледж

⁴Ісламський університет в Ріау

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 12 с., 12 табл., 42 джерел.

Історія питання. Згідно з результатами кількох досліджень, рівень фізичної підготовленості студентів можна оцінювати за допомогою онлайн-тестів фізичної підготовленості. Проте вивченню цього питання в умовах філіппінського закладу вищої освіти присвячено небагато статей.

Мета дослідження. У цьому експериментальному дослідженні вивчали вплив підгрупи тестів фізичної підготовленості (ТФП) на покращення ІМТ.

Матеріали та методи. Після п'яти тижнів виконання тестів фізичної підготовленості в цьому дослідженні використовували експериментальний план для порівняння результатів попереднього й підсумкового тестування з контролем статі, віку та ІМТ. Дані учасників збирали за допомогою опитувальника з двох частин. У першій частині учасники надавали дані про стать, вік та показник ІМТ до початку тестування. Другою частиною була анкета готовності до фізичної активності (PAR-Q). Для аналізу даних 5-тижневого експерименту використовували програмне забезпечення IBM SPSS версії 27. Описові статистичні підходи відображали демографічні показники та результати тестування фізичної підготовленості учасників (частота, відсоток, середнє значення та стандартне відхилення). До та після проведення відібраних ТФП, щоб визначити, чи впливають на результативність такі фактори, як стать, вік та індекс маси тіла, результативність студентів

досліджували з використанням однофакторного дисперсійного аналізу та t-критерію Стюдента для незалежних вибірок. Після проведення тестів фізичної підготовленості, щоб побачити, чи відрізняються статистично значущі результати попереднього й підсумкового тестування, використовували t-критерій Стюдента для парних вибірок.

Результати. Статистично значущої різниці в показниках результативності до та після проведення ТФП між різними віковими групами не спостерігалось. За винятком результатів тесту на стрибок угору, статистично значущої різниці між гендерними групами не спостерігалось. Чоловіки показали кращу результативність, ніж жінки. Зрештою, після п'яти тижнів виконання рекомендованих ТФП, результати підсумкового тестування були статистично значущі вищими за результати попереднього тестування.

Висновки. Вибрані ТФП виявилися корисними в дистанційному навчанні, особливо у філіппінському місцевому закладі освіти. Це дослідження підтверджує припущення про те, що за допомогою вищевикладених методів оцінювання викладачі фізичного виховання в коледжах можуть регулярно перевіряти рівень фізичної підготовленості своїх студентів.

Ключові слова: дистанційна освіта, ефективність, місцевий коледж, фізичне виховання, тести фізичної підготовленості.

Information about the authors:

Lobo, Joseph: jtdlobo@gmail.com; <https://orcid.org/0000-0002-2553-467X>; Independent Researcher, Angeles City, Pampanga, 2009, Philippines.

Prevandos, Francisco Gabriel: franciscogabriel_prevandos@psau.edu.ph; <https://orcid.org/0000-0002-2991-3941>; Physical Education, Recreation, and Sports, Pampanga State Agricultural University, San Agustin, Magalang, 2011 Pampanga, Philippine.

Bautista, Clarenz: clarenz_bautista@psau.edu.ph; <https://orcid.org/0000-0001-8751-3674>; Physical Education, Recreation, and Sports, Pampanga State Agricultural University, San Agustin, Magalang, 2011 Pampanga, Philippine.

De Dios, Don Al: donal_dedios@psau.edu.ph; <https://orcid.org/0000-0002-6987-1301>; Physical Education, Recreation, and Sports, Pampanga State Agricultural University, San Agustin, Magalang, 2011 Pampanga, Philippine.

Dimalanta, Genesis: genesis.dimalanta@mcc.edu.ph; <https://orcid.org/0000-0003-4230-0098>; Institute of Arts and Sciences, Mabalacat City College, Rizal, Barangay Dolores, Mabalacat, Pampanga, Philippine.

Gazali, Novri: novri.gazali@edu.uir.ac.id; <https://orcid.org/0000-0002-7968-1544>; Faculty of Education, Universitas Islam Riau, Jl. Kaharuddin Nst, Kota Pekanbaru, Riau 28284, Indonesia.

Cite this article as: Lobo, J., Prevandos, F.G., Bautista, C., De Dios, D.A., Dimalanta, G., & Gazali, N. (2023). Exploring the Efficiency of a Battery of Physical Fitness Tests via Virtual Learning Environment. *Physical Education Theory and Methodology*, 23(4), 487-498. <https://doi.org/10.17309/tmf.2023.4.01>

Received: 21.02.2023. Accepted: 18.06.2023. Published: 30.08.2023

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ORIGINAL SCIENTIFIC ARTICLE

EFFECT OF CIRCUIT AND INTERVAL TRAINING METHODS ON THE AGILITY AND VO₂max OF PORPROV FOOTBALL PLAYERS IN PATI REGENCY IN TERMS OF LEG MUSCLE ENDURANCE

Ahmad Badawi^{1ABCDE} and Ahmad Nasrulloh^{1ABCD}

¹Universitas Negeri Yogyakarta

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Ahmad Badawi, E-mail: abadawi938@gmail.com

Accepted for Publication: July 14, 2023

Published: August 30, 2023

DOI: 10.17309/tmfv.2023.4.02

Abstract

This study aimed to determine: (1) the effect of circuit and interval training methods on agility and VO₂max; (2) the difference in the effect of high leg muscle endurance and low leg muscle endurance on agility and VO₂max; (3) the interaction between circuit training, interval training and leg muscle endurance (high and low) on agility and VO₂max.

Materials and methods. This research is an experiment with a 2×2 factorial design. In this study, the number of samples used was 20 players selected by purposive sampling. Agility was measured with the Illinois agility test instrument, VO₂max was measured with a multistage fitness test, and leg muscle endurance was measured with a wall sit test. Data analysis used a two-way ANOVA test with a significance level of $\alpha < 0.05$.

Results. The results of this study are as follows: (1) there is no difference in the effect of the circuit and interval training methods on the agility of football players, there are significant differences between the circuit and interval training methods in their effect on the VO₂max of football players; (2) there is a difference between high and low leg muscle endurance for agility and VO₂max, $\alpha < 0.05$; (3) there is an interaction between the circuit, interval training, and leg muscle endurance (high and low) on agility, $\alpha < 0.05$.

Conclusions. There is an interaction between circuit training, interval training, and leg muscle endurance (high and low) on the agility of Porprov soccer players in Pati Regency. Meanwhile, there was no interaction between circuit training, interval training, and leg muscle endurance (high and low) on the VO₂max of Porprov football players in Pati Regency.

Keywords: circuit training, interval training, agility, VO₂max, football.

Introduction

Football is the most watched and complex sport, and it has developed and become more modern as science and technology have advanced. Currently, women's football players are treated the same as men. Professional soccer players have very high levels of fitness, skill, strategy and mental toughness (Nayiroğlu et al., 2022; Dobrowolski et al., 2020). There has been a 9% growth from 242 million to 265 million active football players worldwide from 2006-2009, according to estimates by the Federation Internationale de Football Association (FIFA). Soccer is a team activity that requires not only physical strength but also mental acuity (the ability to "read the game") and fast reflexes (the ability to capitalize on scoring opportunities).

The fundamental component of a soccer player is their physical condition; if a player's physical condition is poor, they will get fatigued more quickly (Sulasmono, 2016). The evolution of contemporary football demonstrates that it is essential for

players to be in good physical shape in order for them to be able to move around efficiently while competing. When it comes to their physical preparation, soccer players often dedicate one week to working on their strength, endurance, and speed respectively (Gomez-Piqueras et al., 2019).

Physical fitness is a need for football players since it enables them to display their talent and skill without significant hurdles. Every training session requires frequent and intensive preparation (Paul et al., 2019).

Provincial Sports Week or often referred to as porprov is a party event held at the provincial level which competes for various sports, including football. Because soccer is the sport that is most easily recognized by the wider community, soccer is the sport that is most in demand by participants from various districts and cities. The reason is, football can make a district or city proud when it succeeds in donating a gold medal, so that football is the most anticipated sport by some participants. A huge amount of work remains to be done in order for athletes to achieve the levels of agility and VO₂max required by professional soccer players. Currently, these two physical components are still receiving

a lot of attention because there are still several gaps in their availability.

Based on the findings of observations made by researchers, which were then refined with tests to assess players' agility and VO₂max skills using the Illinois test to determine player agility and aerobic endurance tests using graded fitness tests. Measurement tests conducted on twenty porprov players in Pati Regency yielded the following results: one player was in the good category, nineteen players were in the sufficient category, and the VO₂max test results were as follows: fourteen players were in the sufficient category, five players were placed in the less category, and one player is placed in the very less category; these are the players who scored the highest. From the results of the examination that has been carried out, it can be concluded that players will need more practice to improve agility and VO₂max to achieve the goal of completing the Pati Regency Porprov qualification round.

Circuit training is a way of exercising that is broken down into several sections, each of which has a different purpose. Exercises are performed in a certain order, from the beginning of the exercise to the end, in sets of sessions or repetitions of the exercise (Gopinathan, 2019). Soccer players can increase their stamina and performance by taking part in circuit training. This kind of exercise improves the body's metabolic processes by increasing the efficiency of blood being pumped to and from the heart (Jannah et al., 2022). Circuit training is a great way for coaches to get their players to work on their talents all at once and in a short amount of time (Rahmat et al., 2021). Circuit training is a more diverse and more attractive training model for players, where the training is divided into several posts with different versions of the exercise at each post, so that players can make better use of their practice time.

The success of a soccer player is highly dependent on his physical fitness. The interval training paradigm that varies the duration, frequency and intensity of the exercise is one option for physical conditioning activities (Kholid et al., 2020). Physical conditioning using the interval training technique can greatly increase VO₂max. Increased VO₂max during high-intensity exercise (70% of maximum capacity) and more dramatic rest periods (2-3 minutes). Interval training is when players get a workout based on how long, how hard, and how often they need to rest. Interval training can help coaches improve the physical condition of soccer players in a number of ways. Based on the principles of training, one way is to increase the player's agility and VO₂ max (Busyairi & Ray, 2018).

Materials and methods

Study participants

Experiments using a design known as a 2×2 factorial are included in studies of this kind. A version of the experimental design known as the factorial design is one that takes into account the potential moderating factors that have an effect on how the independent variable is treated on the outcome of the dependent variable (Sugiyono, 2013). The sample of this study consisted of twenty soccer players from Pati province.

In this experimental investigation, two groups were used, each of which was given a unique treatment, namely the circuit training treatment and the interval training treatment

versus both groups. The following table presents the research design or design known as the 2×2 factorial design:

Table 2. 2×2 factorial design

Manipulation Variable	Training Method	
	Circuit Training (A1)	Interval Training (A2)
Leg Muscle Endurance (B)		
Height (B1)	A1.B1	A2.B1
low (B2)	A1.B2	A2.B2

Information:

A1B1: A group of Porprov football players in Pati Regency who have high leg muscle tone were given treatment circuit training.

A1B2: A group of Porprov soccer players in Pati Regency who had low leg muscle endurance were given treatment circuit training.

A2B1: A group of Porprov soccer players in Pati Regency who had high leg muscle endurance was given treatment interval training.

A2B2: A group of Porprov soccer players in Pati Regency who had low leg muscle endurance were given treatment interval training.

Study organization

This research was conducted with the Porprov football team in Pati Regency to find out how to use circuit training and interval training in soccer as a treatment. The research was conducted from 1 November 2022 to 30 November 2022 during 16 meetings which took place twice a week on Mondays and Wednesdays. Then a sample of 20 football players from Pati Regency.

Statistical analysis

This study used SPSS 22 data analysis. This study used two-way ANOVA. Using the Shapiro-Wilk test in SPSS 22, the distribution is said to be normal if $p > 0.05$ (5%) and abnormal if $p < 0.05$ (5%). Levene Test homogeneity test in this study. Suitability If $F_{count} < F_{table}$, then the test is homogeneous; otherwise, it is not homogeneous. Testing a hypothesis determines its acceptance. The Post Hoc test with a significance threshold of $p < 0.05$ is continued if the data is regularly distributed. If the data is not normally distributed, use a non-parametric test. The Kruskal-wallis test continues. Post-Hoc Test.

Results

The results of the research on agility and VO₂max training methods for soccer players in Porprov Pati Regency can be seen in the image below.

Discussion

Significant Influence Method Circuit And Interval Training Against Agility and VO₂max Football Players Porprov Pati Regency

Based on the results of the Comparison of variance analysis, the finding that there is no significant difference

between the effect of circuit and interval training on the agility and VO₂max of Porprov soccer players in Pati Regency shows the results of the proposed hypothesis. The F value for agility is 0.010, and the significance value is $0.923 > 0.05$. It can be said that there is no significant difference between the effect of interval training and circuit training on the agility of Porprov football players in Pati Regency.

While the VO₂max capacity produces an F value of 7.775 with a significance of $0.013 < 0.05$, it can be stated that the VO₂max capacity has an effect on circuit training and interval training for VO₂max soccer players in Porprov Pati Regency.

In this study, intermediate training techniques for agility showed that circuit training produced an average value of 15.98, while interval training produced an average value of

Table 2. Data pretest-posttest player agility

High Leg Muscle Endurance						
No	Circuit training (A1, B1)			Interval Training (A2, B1)		
	Pretest	Posttest	Selisih	Pretest	Posttest	Selisih
1	16.88	15.25	1.63	16.32	16.56	-0.24
2	16.64	15.73	0.91	16.49	16.15	0.34
3	16.91	15.21	1.7	16.32	16.10	0.22
4	16.55	15.11	1.44	16.93	16.52	0.41
5	16.80	15.29	1.51	16.84	16.26	0.58
Amount			7.19 %	Amount		1.31 %
Low Leg Muscle Endurance						
No	Circuit training (A1, B2)			Interval Training (A2, B2)		
	Pretest	Posttest	Selisih	Pretest	Posttest	Selisih
1	17.08	16.49	0.59	16.63	15.26	1.37
2	15.69	16.55	-0.86	16.74	15.89	0.85
3	16.59	16.64	-0.05	16.79	15.52	1.27
4	17.35	16.91	0.44	16.64	16.19	0.45
5	16.56	16.63	-0.07	17.08	15.24	1.84
Amount			0.06 %	Amount		5.78 %

Tabel 3. Data pretest-posttest VO₂ max player

High Leg Muscle Endurance						
No	Circuit training (A1, B1)			Interval Training (A2, B1)		
	Pretest	Posttest	Difference	Pretest	Posttest	Difference
1	44.80	53.70	8.9	44.50	50.80	6.3
2	47.40	52.50	5.1	46.80	48.70	1.9
3	46.80	51.91	5.11	45.90	44.50	-1.4
4	45.90	48.70	2.8	43.80	47.40	3.6
5	46.80	49.30	2.5	39.90	43.90	4
Amount			24.41%	Amount		14.4%
Low Leg Muscle Endurance						
No	Circuit training (A1, B2)			Interval Training (A2, B2)		
	Pretest	Posttest	Difference	Pretest	Posttest	Difference
1	39.90	47.40	7.5	37.40	43.30	5.9
2	43.90	43.30	-0.6	40.50	43.90	3.4
3	39.90	44.50	4.6	43.40	44.50	1.1
4	39.20	47.40	8.2	39.90	43.90	4
5	46.50	46.80	0.3	39.50	47.40	7.9
Amount			20%	Amount		22.3%

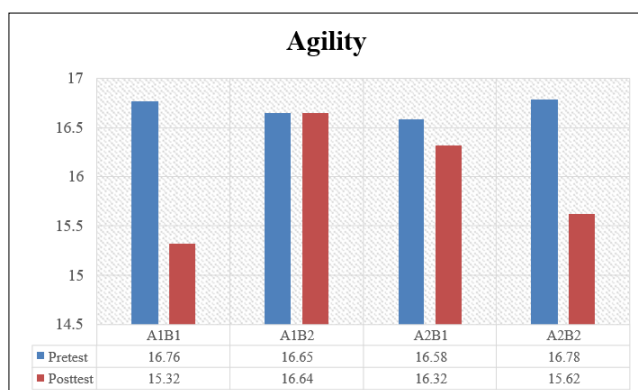


Fig. 1. Bar chart pretest and posttest agility

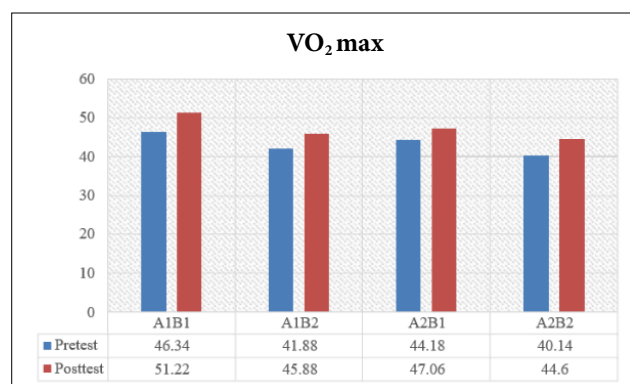


Fig. 2. Bar chart pretest and posttest VO₂ max

15.97; the difference between the two is 0.01. Due to the small findings from the analysis of the observed differences, it can be concluded that both circuit training and interval training increase the agility of Porprov football players in Pati Regency.

While the findings of data analysis on VO₂ max capacity show that circuit training produces an average value of 48.55, interval training produces an average value of 45.83 resulting in a difference of 2.72. Based on the difference value of 2.72 obtained from the results of the analysis, it can be concluded that both circuit training and interval training increase the VO₂max of Porprov football players in Pati Regency.

The findings of previous research (Sumerta et al., 2021) show that giving circuit training can increase the body agility of soccer players. Adoption of circuit model training can greatly increase agility (Chaudhary & Jadon, 2017). In this study it was shown that the application of circuit training and interval training can increase the agility of Porprov players in Pati Regency in accordance with the findings of previous studies. According to previous research on VO₂max capacity (Yunus & Raharjo, 2022) every player must have a good physical condition to play optimally. Maximum oxygen volume (VO₂max both circuit training and interval training increase VO₂max. However, circuit training is more effective than interval training in increasing VO₂max (Kachayut & Prachanban, 2020) Circuit training and interval training increase VO₂max efficiently. Circuit training is more useful than interval training to increase VO₂max football players in Porprov Pati Regency, according to the results of this study and previous studies.

Differences in Effect Between High Leg Muscle Endurance and Low Leg Muscle Endurance on Agility and VO_{2max} Football Players Porprov Pati Regency

Research on agility abilities revealed that there was a significant difference between high leg muscle endurance and low leg muscle endurance on the agility of Porprov soccer players in Pati Regency. The null hypothesis (H_0) can be rejected based on an F value of 6,607 and a significance value of $0.021 < 0.05$ obtained from the results of SPSS data analysis.

In conclusion, there is a significant difference in the endurance of high and low leg muscles on the agility of the Porprov football players in Pati Regency. While the VO_{2max} capacity shows a significant difference between high leg muscle endurance and low leg muscle endurance compared to the VO_{2max} of Porprov players in Pati Regency, this difference is not statistically significant. Based on the F value of 15.981 and a significance value of $0.001 < 0.05$, it can be concluded that the null hypothesis H_0 is rejected.

Previous research results (Prakoso & Sugiyanto, 2017; Adhi et al., 2017; Hidayat, 2021) claims that the results of athletes with high and low leg muscle endurance are drastically different. Karyono (2016), Yachsie (2021), Prakoso, (2016) states that athletes with high leg muscle endurance are more developed than those with poor muscle endurance. According to this study, the agility and VO_{2max} of soccer players with high and low leg muscle endurance are different.

Based on the analysis, players with high leg muscle endurance have an average score of 49.14, while players with low leg muscle endurance have an average score of 45.25 with a difference of 3.9. Because the difference is large, it can be concluded that there is a significant difference between VO_{2max} football players at Porprov Pati Regency with high and low leg muscle endurance.

Interaction Between Circuit Training, Interval Training and Leg Muscle Endurance (High and Low) Against Agility and VO_{2max} Football Players Porprov Pati Regency

Substantial interactions between circuit training, interval training, and leg muscle endurance (high and low) affect the agility of Porprov football players in Pati Regency, according to an analysis of agility ability study data.

Based on the findings of previous studies (Hidayat, 2021; Karyono, 2016) the researchers came to the conclusion that the two ways athletes were trained had a major effect on their agility. And from what we know (Prakoso, 2016) mengemukakan bahwa hasil VO_{2max} yang diperoleh dari metode latihan yang diterapkan tidak saling berinteraksi.

Shows that the VO_{2max} results from different training methods do not affect each other. In line with this study, the results of the form of factor interaction between paired groups showed a relationship between the players' quick movement abilities and each group. Groups that interact with each other in real life include the following:

1. A group of players who do circuit training with low muscle endurance have better agility than players who do circuit training with high leg muscle endurance, with a significance value of $0.000 < 0.05$.
2. The group of players who were trained with interval training had better leg muscle endurance compared to the group of players who were trained with circuit training. This is indicated by a significance value of $0.000 < 0.05$.

3. The group of players who did circuit training and had low leg endurance was better in agility than the group of players who did interval training and had low leg endurance, with a significance value of $0.005 < 0.05$.
4. The group of players who did interval training and low leg endurance was better than the group who did interval training and high leg endurance, with a significance value of $0.005 < 0.05$.
5. The results of analysis of VO_{2max} capacity data show that there is no significant difference between circuit training, interval training, and leg muscle endurance (high and low) in Porprov football players in Pati Regency with VO_{2max} .

Conclusions

Regarding the results of the research above, from the results of data analysis that has been carried out by researchers, there are the following conclusions:

- There is no significant effect of the method circuit and interval training on the agility and VO_{2max} of Porprov Soccer players in Pati Regency, Methods circuit and interval training have different effects significant against VO_{2max} football players Porprov Pati Regency.
- There is a significant difference between the endurance of high and low leg muscles on the agility and VO_{2max} of Porprov football players in Pati Regency.
- There is interaction between Interaction Between Circuit Training, Interval Training and Leg Muscle Endurance (High and Low) Against the Agility of Porprov Soccer Players in Pati Regency. Meanwhile between circuit training, interval training and leg muscle endurance (high and low) there was no interaction with the VO_{2max} of Porprov football players in Pati Regency.

The agility interaction pairs between the factors as follows:

- Method-trained group of players circuit training with low muscle endurance better than the group of players trained by the method circuit training with high leg muscle endurance to agility, with a significance value of $0.000 < 0.05$.
- Method-trained group of players interval training and had better leg muscle endurance than the group of players trained by the method circuit training and has high leg muscle endurance to agility, with a significance value of $0.000 < 0.05$.
- Method-trained group of players circuit training with low leg muscle endurance better than the group of players trained by the method interval training and has low leg muscle endurance to agility, with a significance value of $0.005 < 0.05$.
- Method-trained group of players interval training with low leg muscle endurance better than the group trained by the method interval training and has high leg muscle endurance, with a significance value of $0.005 < 0.05$.

Conflict of Interest

The authors declare that there is no conflict of interest.

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ВПЛИВ МЕТОДІВ КОЛОВОГО ТА ІНТЕРВАЛЬНОГО ТРЕНУВАНЬ НА СПРИТНІСТЬ ТА VO_{2max} ФУТБОЛІСТІВ-УЧАСНИКІВ ЧЕМПІОНАТУ ПОРПРОВ У РЕГЕНТСТВІ ПАТІ (ІНДОНЕЗІЯ) ЗА ПОКАЗНИКАМИ ВИТРИВАЛОСТІ М'ЯЗІВ НІГ

Ахмад Бадаві^{1ABCDE}, Ахмад Насруллох^{1ABCD}

¹Джок'якартський державний університет

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 6 с., 3 табл., 2 рис., 21 джерело.

Метою цього дослідження було визначити: (1) вплив методів колового та інтервального тренувань на спритність та МСК (VO_{2max}); (2) різницю у впливі високої витривалості м'язів ніг і низької витривалості м'язів ніг на спритність та МСК (VO_{2max}); (3) взаємовплив колового тренування, інтервального тренування та витривалості м'язів ніг (високої та низької) на спритність та МСК (VO_{2max}).

Матеріали та методи. Це дослідження є факторним експериментом, спланованим за схемою 2×2 . Чисельність вибірки в цьому дослідженні становила 20 гравців, відібраних методом цільової вибірки. Для вимірювання спритності використовували Іллінойський тест на спритність, показник МСК (VO_{2max}) вимірювали за допомогою багаторічного тесту фізичної підготовленості, а для вимірювання витривалості м'язів ніг використовували тест на присідання біля стіни. Для аналізу даних використовували двофакторний дисперсійний аналіз за рівня значущості $\alpha < 0,05$.

Результати. Результати цього дослідження є наступними: (1) різниці у впливі методів колового та інтервального тренувань на спритність футболістів не спостерігається, спостерігаються статистично значущі відмінності між методами колового та інтервального тренувань у впливі на показники МСК (VO_{2max}) футболістів; (2) спостерігається статистично значуща різниця між високою та низькою витривалістю м'язів ніг у впливі на спритність та МСК (VO_{2max}), $\alpha < 0,05$; (3) спостерігається взаємовплив колового тренування, інтервального тренування та витривалості м'язів ніг (високої та низької) на спритність, $\alpha < 0,05$.

Висновки. Існує взаємовплив колового тренування, інтервального тренування та витривалості м'язів ніг (високої та низької) на спритність футболістів-учасників чемпіонату Порпров у регентстві Паті (Індонезія). Тоді як взаємовплив колового тренування, інтервального тренування та витривалості м'язів ніг (високої та низької) на МСК (VO_{2max}) футболістів-учасників чемпіонату Порпров у регентстві Паті (Індонезія) відсутній.

Ключові слова: колове тренування, інтервальне тренування, спритність, максимальне споживання кисню (VO_{2max}), футбол.

Information about the authors:

Badawi, Ahmad: badawiahmad904@gmail.com; Universitas Negeri Yogyakarta, Jl. Colombo Yogyakarta No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia.

Nasrulloh, Ahmad: ahmadnasrulloh@uny.ac.id; <https://orcid.org/0000-0003-2859-7091>; Department of Sports Science, Universitas Negeri Yogyakarta, Jl. Colombo Yogyakarta No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia.

Cite this article as: Badawi, A., & Nasrulloh, A. (2023). Effect of Method Circuit and Interval Training Against the Agility and VO_{2max} of Porprov Football Players in Pati Regency in terms of Leg Muscle Endurance. *Physical Education Theory and Methodology*, 23(4), 499-504. <https://doi.org/10.17309/tmf.2023.4.02>

Received: 21.01.2023. Accepted: 14.07.2023. Published: 30.08.2023

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ORIGINAL SCIENTIFIC ARTICLE

REGULAR PHYSICAL ACTIVITY HELPS IMPROVE THE PHYSICAL FITNESS LEVEL OF ELEMENTARY SCHOOL STUDENTS DURING THE COVID-19 PANDEMIC

Ilmul Ma'arif^{1ABDE}, Risfandi Setyawan^{1BD}, Mohammad Zaim Zen^{1BD},
Kahan Tony Hendrawan^{1CD} and Joan Rhobi Andrianto^{1BD}

¹STKIP PGRI Jombang

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Ilmul Ma'arif, E-Mail: ma87arif@gmail.com

Accepted for Publication: July 14, 2023

Published: August 30, 2023

DOI: 10.17309/tmfv.2023.4.03

Abstract

The purpose of this study was to prove the effect of regular physical activity in helping to increase the physical fitness level of elementary school students during the coronavirus disease 2019 (COVID-19) pandemic.

Materials and methods. This research is true experimental with the randomized pretest-posttest control group design. A total of 48 students from the Kabuh District Public Elementary School, Jombang Regency, East Java, Indonesia, aged 10-11 years participated in the study. The students were divided into two groups, namely the control group (G1; n = 21) and the experimental group (G2; n = 27). Measurement of physical fitness level using a) body mass index (BMI); (b) sit-and-reach test; (c) lie down for 30 seconds; (d) pull-up modification; and (e) the 20-meter multistage shuttle run test was performed before and after treatment. The data analysis technique used the Statistical Package for Social Sciences (SPSS) software version 21.

Results. The results showed that there was a significant difference in the average level of physical fitness between the pretest and posttest in the experimental group (G2) ($p \leq 0.001$), while the control group (G1) did not show a significant difference ($p \geq 0.05$).

Conclusions. Based on the results of the study it was concluded that providing regular physical activity had a positive impact on increasing the level of physical fitness in elementary school students during the COVID-19 pandemic.

Keywords: physical activity, level of physical fitness, elementary school students, COVID-19.

Introduction

The coronavirus disease 2019 (COVID-19) pandemic has had an impact on all sectors of society, particularly as a result of restrictions on physical activities that are only permitted to be carried out at home (Ammar et al., 2020; Chtourou et al., 2020; Xiao et al., 2020). This is because COVID-19 can spread through direct means (droplet transmission and human-to-human) and indirect contact (contaminated objects and airborne transmission) (Lotfi et al., 2020). Google's COVID-19 Community Mobility Report shows that compared to pre-COVID-19 baselines (median values over the five weeks from 3 January 2020 to 6 February 2020), mobility trends during COVID-19 (as of 9 March

2021) show a decline in some Most locations including retail and recreation (-14%), transit stations (-34%), grocery stores and pharmacies (-5%), as well as workplaces (-31%), recent increases seen in parks (+9%) and residential place (+9%) (Park et al., 2022). Restricting physical activity due to a pandemic has the risk of causing a decrease in fitness levels (Ammar et al., 2020). Social distancing and self-isolation are characterized by movement restrictions and a reduced number of human-to-human interactions (Chtourou et al., 2020). Hawryluck et al. (2004) noted that there are emotional and psychological problems associated with this period of quarantine. Likewise, Reynolds et al. (2008) observed that quarantined individuals experience increased levels of anxiety and nervousness. This condition risks causing various health problems (Jurak et al., 2020).

Physical activity is known to provide important health benefits for school-age children (Pate et al., 2019). Increased physical activity during school hours is associated with

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better physical, psychological and social health and well-being (Smedegaard et al., 2016). Limited physical activity, or often no engaged in at all, causes a variety of health problems, including posture problems (such as idiopathic scoliosis), somatic conditions, overweight and obesity, circulation problems, and even premature death (Rejeki et al., 2022; Hillman et al., 2008; Kohl et al., 2012; Lipowski et al., 2009). Results by Chung et al. (2021) demonstrated that physical distancing policies and population compliance can slow the transmission of COVID-19. However, the impact of decreased physical activity is also a problem that requires special handling (Chaabna et al., 2022).

Physical activity is a drug commonly prescribed for people with conditions such as obesity and diabetes who are also at high risk of being hospitalized or seriously ill from COVID-19 (Park et al., 2022). Physical activity provides some health benefits, both physical and psychological (Cragg & Cameron, 2006; Warburton et al., 2006). The physical activity program serves to provide an overview of physical activity and learning habits for healthy living (Sibley & Etnier, 2003). High levels of sedentary behavior and insufficient levels of physical activity increase obesity among children and adolescents (Ahmad Bahathig et al., 2021). The findings by Fernández et al., (2017) show a correlation between being overweight or obese and having poorer physical fitness. The school environment is the context in which young people spend most of their time learning about various topics, including Health (Stabelini Neto et al., 2022). Most importantly, the level of physical fitness in childhood and youth has been considered a strong predictor of health later in life and an adequate level of PA is essential for the development and maintenance of health-related fitness (Stabelini Neto et al., 2022; Ortega et al., 2008). We hypothesize that regular physical activity interventions can help improve physical fitness levels in elementary school students during the coronavirus disease 2019 (COVID-19) pandemic.

Materials and Methods

Study design

This research is true experimental with the randomized pretest-posttest control group design. A total of 48 students

from the Kabuh District Public Elementary School, Jombang Regency, East Java, Indonesia, male and female, aged 9-12 years participated in the study. Students were randomly divided into two groups, namely the control group (G1; $n = 21$), and the experimental group (G2; $n = 27$). Students obtain information both orally and in writing about the research before participating. All students filled out their willingness to participate in the research and were approved by the school, parents, and students by signing the informed consent.

Physical activity protocol

Physical activity is implemented and supervised by professional officers from the Postgraduate Program, at Surabaya State University. The physical activity intervention was carried out for 60 minutes/session with a frequency of 3x/week for 4 weeks. Details of physical activity can be seen in Table 1.

Measurement of physical fitness level

Measurement of the level of physical fitness was carried out between the pretest and posttest using tests (a) body mass index (BMI); (b) sit-and-reach tests; (c) lying down for 30 seconds; (d) modification of pull-ups; and (e) the 20-meter multistage shuttle run test.

Statistic analysis

The data analysis technique used the SPSS software version 21. The Shapiro-Wilk test was used to analyze the normality test with a significant level ($p \geq 0.05$). To find out the difference in the level of physical fitness between the pretest vs. the posttest in each group was carried out by the Paired Sample t-Test, while to find out differences in the level of physical fitness between groups an Independent Samples t-Test was carried out. Overall data is shown with mean $\pm$ SD. All statistical analyzes used the 5% level of significance.

Results

The results of the analysis of the characteristics of the study subjects including age, height, weight, and body mass

Table 1. Physical activity program

No	Saturday	Time	Monday	Time	Wednesday	Time
1	Movement jump on one leg 5x repetitions		Movement jump in place 5x repetitions		Movement jump by swinging arms sideways 5x repetitions	
2	Jump with a zig-zag 5x repetitions		Movement jump forward with hands over 5x repetitions		Jump forward with the position of the hands holding the shoulders 5x repetitions	
3	Jumping movement by arranging box objects 5 x repetitions	60 minutes	Movement jump by touching the wall 5x repetition	60 minutes	jump by swinging your arms up 5 x repetitions	60 minutes
4	The movement jumps past boxed objects 5 x repetitions		Movement jump with the position of the hands on the waist 5x repetition		Jump by touching the feet with both hands 5 x repetitions	
5	The movement jumps and then rotates 5x repetitions		Moves move places by jumping quickly 5x repetitions		Jump forward with your hands above your head for 5 repetitions	

index showed that there were no significant differences between the two groups which can be seen in Table 1. The results of the physical fitness of students can be seen in Figure 1-2.

Table 2. Characteristics of research subjects

Parameters	G1 (n = 21)	G2 (n = 27)	p-value
Age (yrs)	10.33±0.66	10.11±0.97	0.352
Height (m)	1.35±0.06	1.34±0.08	0.980
Weight (kg)	38.52±5.39	40.15±7.63	0.393
BMI (kg/m2)	21.24±1.70	22.03±2.48	0.197

BMI: Body mass index. Data is presented with Mean ± SD.
p-value obtained by testing the Independent Samples t Test.

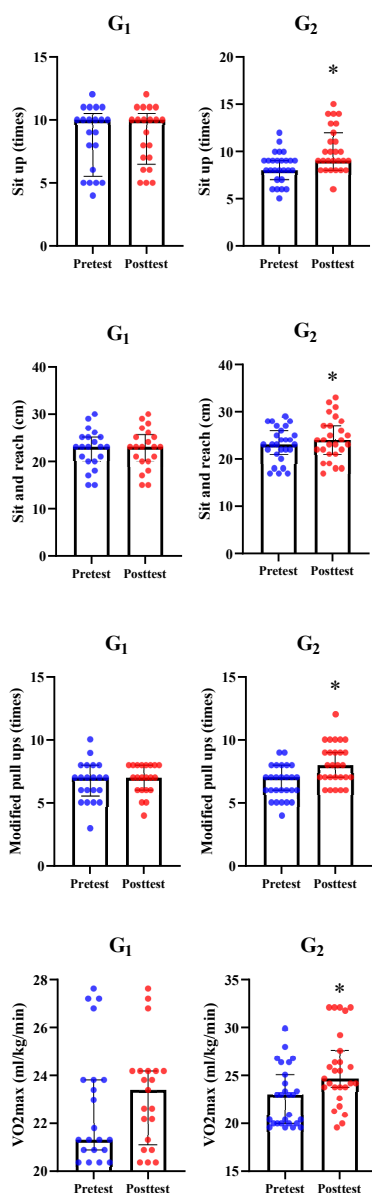


Fig. 1. The average level of physical fitness of students between the pretest vs. posttest in each group. (*)Significant with pretest ($p \leq 0.001$). The p-value is obtained by using the Paired Samples t-Test

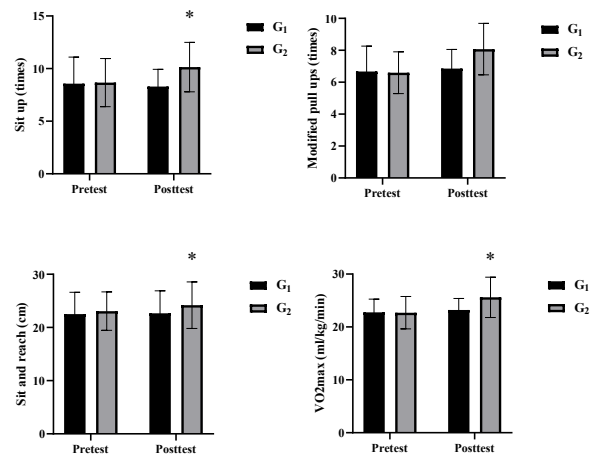


Fig. 2. The average level of physical fitness of students between the control group (G1) vs. experimental group (G2). (*)Significant with the control group (G1) ($p \leq 0.05$). p-value obtained by testing the Independent Samples t-Test

Discussion

The purpose of this study was to prove the effect of regular physical activity in helping to increase the physical fitness level of elementary school students during the coronavirus disease 2019 (COVID-19) pandemic. The main finding of the study was that there was a significant difference in the level of physical fitness between pretest vs. posttest in the experimental group, while the control group did not show any significant difference (Figure 1). This proves that regular physical activity has proven effective in increasing the physical fitness level of elementary school students during the COVID-19 pandemic. These results are in line with research by Kapoor et al. (2022) showed that the health benefits of physical activity are not limited to improvements in cardiorespiratory and muscle fitness, bone and cardiometabolic health, and positive effects on body weight status, but also improve mental health and social health. This is reinforced by the results of Kljajević et al. (2021) which state that subjects with satisfactory levels of physical activity have good physical fitness. Physical fitness is the physical ability to carry out daily activities without experiencing significant fatigue and having good physical and physiological conditions (Chen et al., 2002; Clark & Ferguson, 2000). Kapoor et al. (2022) explained that the level of physical fitness is the ability to carry out daily functional activities with optimal performance, endurance, and strength to overcome illness, fatigue, and stress, and reduce sedentary behavior.

Physical exercise is considered a miracle drug in the primary prevention of at least 35 chronic diseases, including obesity, insulin resistance, and type 2 diabetes (Susanto et al., 2022; Rejeki et al., 2021; Türkel et al., 2022). Exercise has benefits related to health-related quality of life, motivation for physical activity, and levels of depression in subjects with metabolic syndrome (Zupkauskienė et al., 2022). Glucose absorption into skeletal muscle increases during and in recovery from exercise, with exercise being effective in controlling glucose homeostasis in individuals with type 2 diabetes (Stocks & Zierath 2022). Marcocin et al. (2022)

stated that higher physical activity was associated with higher well-being, lower quality of life, and symptoms of depression, anxiety, and stress, regardless of age. Physical activity increases peripheral BDNF levels (Shobeiri et al., 2022). Evidence suggests that brain-derived neurotrophic factor (BDNF) plays a protective role in the brain (Pranoto et al., 2020; Soloey-Nilsen et al., 2022). Lower serum BDNF levels have been seen in patients with major depressive disorder, bipolar disorder, schizophrenia, eating disorders, obsessive-compulsive disorder, and alcohol dependence (Soloey-Nilsen et al., 2022; Nomoto et al., 2015). Participation in regular physical activity is associated with many health benefits, including improvements in cardiorespiratory fitness, body composition, cardiometabolic profile, and mental health (Stabelini Neto et al., 2022). The quality of health is an important symbol of progress and social civilization and contains the meaning of health from psychology, physiology, and society (Wu, 2022). Rather, what is more, worrying is the fact that periods of increasing physical inactivity are silently and aggressively taking over modern human life – at school, at work, at home, and even at leisure (Pišot, 2021). It has been shown that several components of the metabolic syndrome, including obesity, insulin resistance, and arterial hypertension, are associated with poorer health-related quality of life (Zupkauskienė et al., 2022; Schlotz et al., 2007; Søltøft et al., 2009; Zygmuntowicz et al., 2012). Results by Yin et al. (2022), stated that higher sedentary behavior time is associated with a higher risk of metabolic syndrome among children aged 6-14 years in Beijing. The Asian population shows excessive sedentary behavior and has a high susceptibility to metabolic syndrome (Kinoshita et al., 2022). These findings confirm that providing regular physical activity is effective in increasing the physical fitness level of elementary school students during the COVID-19 pandemic. Physical activity is beneficial for health because individuals who are healthy and fit both physically and mentally can participate in the learning process optimally. Based on the results of the study, it can be suggested that further research can use subjects with the age range of adolescents, adolescents are in a vulnerable phase of experiencing physical and emotional changes.

Conclusion

Based on the results of the study, it was concluded that providing physical activity for 60 minutes/session with a frequency of 3x/week for 4 weeks had a positive impact on increasing the physical fitness level of elementary school students during the coronavirus disease 2019 (COVID-19) pandemic.

Conflict of Interest

The authors declare that there is no conflict of interest.

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РЕГУЛЯРНА ФІЗИЧНА АКТИВНІСТЬ ДОПОМАГАЄ ПІДВИЩИТИ РІВЕНЬ ФІЗИЧНОЇ ПІДГОТОВЛЕНOSTI УЧНІВ ПОЧАТКОВИХ КЛАСІВ ПІД ЧАС ПАНДЕМІЇ COVID-19

Ілмул Макаріф^{1ABDE}, Рісфанді Сетьяван^{1BD}, Мохаммад Зейм Зен^{1BD},
Кахан Тоні Хендраван^{1CD}, Джоан Рхобі Андріанто^{1BD}

¹Джомбангський педагогічний коледж Асоціації вчителів Індонезії

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 2 табл., 2 рис., 45 джерел.

Метою цього дослідження було довести вплив регулярної фізичної активності на підвищення рівня фізичної підготовленості учнів початкових класів під час пандемії коронавірусної хвороби 2019 року (COVID-19).

Матеріали та методи. Це дослідження є істинним експериментом із рандомізованим планом попереднього та підсумкового тестування з використанням контрольної групи. У дослідженні брали участь загалом 48 учнів державної початкової школи в окрузі Кабух, регентство Джобанг, провінція Східна Ява, Індонезія, віком 10–11 років. Учні розділили на дві групи: контрольну (G1; n = 21) та експериментальну (G2; n = 27). Вимірювання рівня фізичної підготовленості з використанням а) індексу маси тіла (ІМТ); б) тесту «нахили тулуба вперед із положення сидячи»; в) вправи «прилягти на 30 секунд»; г) вправи «модифіковані підтягування»; та е) багатостанового тесту «човниковий біг на 20 метрів» проводили до та після експериментальних процедур. У методиці аналізу даних використовували програмне забезпечення Statistical Package for Social Sciences (SPSS) версії 21.

Результати. Результати показали наявність статистично значущої різниці в середньому рівні фізичної підготовленості між результатами попереднього та підсумкового тестування в експериментальній групі (G2) ($p \leq 0,001$), тоді як у контрольній групі (G1) статистично значущої різниці не виявлено ($p \geq 0,05$).

Висновки. На підставі результатів дослідження було зроблено висновок, що забезпечення регулярної фізичної активності позитивно впливає на підвищення рівня фізичної підготовленості учнів початкових класів під час пандемії COVID-19.

Ключові слова: фізична активність, рівень фізичної підготовленості, учні початкових класів, COVID-19.

Information about the authors:

Ma'arif, Ilmul: ma87arif@gmail.com; <https://orcid.org/0000-0002-8360-4760>; Physical Education Study Program, STKIP PGRI Jombang, Jl. Pattimura III No.20, Sengon, Kec. Jombang, Kabupaten Jombang, Jawa Timur 61418, Indonesia.

Setyawan, Risfandi: risfandi@stkipjb.ac.id; <https://orcid.org/0000-0001-5343-4601>; Physical Education Study Program, STKIP PGRI Jombang, Jl. Pattimura III No.20, Sengon, Kec. Jombang, Kabupaten Jombang, Jawa Timur 61418, Indonesia.

Zen, Mohammad Zaim: zenzaim994@gmail.com; <https://orcid.org/0000-0002-3789-7443>; Physical Education Study Program, STKIP PGRI Jombang, Jl. Pattimura III No.20, Sengon, Kec. Jombang, Kabupaten Jombang, Jawa Timur 61418, Indonesia.

Hendrawan, Kahan Tony: kahan.stkipjb@gmail.com; <https://orcid.org/0000-0002-4780-2786>; Physical Education Study Program, STKIP PGRI Jombang, Jl. Pattimura III No.20, Sengon, Kec. Jombang, Kabupaten Jombang, Jawa Timur 61418, Indonesia.

Andrianto, Joan Rhobi: joan.rhobi0587@gmail.com; <https://orcid.org/0000-0003-4450-4895>; Physical Education Study Program, STKIP PGRI Jombang, Jl. Pattimura III No.20, Sengon, Kec. Jombang, Kabupaten Jombang, Jawa Timur 61418, Indonesia.

Cite this article as: Ma'arif, I., Setyawan, R., Zen, M.Z., Hendrawan, K.T., & Andrianto, J.R. (2023). Regular physical activity helps improve their physical fitness levels in elementary school students during the COVID-19 pandemic. *Physical Education Theory and Methodology*, 23(4), 505-511. <https://doi.org/10.17309/tmfv.2023.4.03>

Received: 01.02.2023. Accepted: 14.07.2023. Published: 30.08.2023

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ORIGINAL SCIENTIFIC ARTICLE

THE EFFECT OF THE PYRAMID EXERCISE METHOD ON THE MAXIMUM STRENGTH OF THE WRESTLER'S ARM MUSCLES

Muhamad Ichsan Sabillah^{1ABC}, Tomoliyus^{1ABD}, Ahmad Nasrulloh^{1BCD},
Roxana Dev Omar Dev^{2CDE} and Fauzi^{1CDE}

¹Universitas Negeri Yogyakarta

²Universiti Putra Malaysia

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Muhamad Ichsan Sabillah, E-mail: muhamadichsan.2021@student.uny.ac.id

Accepted for Publication: July 14, 2023

Published: August 30, 2023

DOI: 10.17309/tmfv.2023.4.04

Abstract

Study purpose. The purpose of this study was to determine the effect of reverse grip barbell curls and barbell triceps extension exercises on increasing the maximum strength of the arm muscles of wrestling athletes.

Materials and methods. This type of research is quasi-experimental. The population in the study was 24 wrestling athletes. Sampling was carried out using purposive sampling techniques, namely 10 male wrestling athletes. The research instrument was carried out by lifting a load that was only able to be lifted 1 time or expressed ability (maximum strength) using a barbell. The data analysis technique used is hypothesis testing using the t-test formula.

Results. The results of this study showed that the exercises of reverse grip barbell curls and barbell triceps extension have an effect on the increase in the maximum strength of the arm muscles of wrestling athletes; from the initial test and the final test results, there was an increase with a difference of 1.04, namely from an average score of 29.9 kg in the pre-test to 32.3 kg in the post-test.

Conclusions. The conclusion in this study is that there is a significant influence of the reverse grip form of barbell curls and barbell triceps extension on the increase in maximum strength of the arm muscles in wrestling athletes.

Keywords: reverse grip barbell curls; barbell triceps extension; maximum strength.

Introduction

Physical exercise is very important for athletes because of a systematic process to improve physical qualities aimed at improving the appearance of sports. Athletes who have the good physical condition will have a great chance of getting a champion in a match. Physical condition is the ability to face the physical demands of a sport to perform optimally (Sabillah et al., 2022). Good physical condition is one of the supporting elements in the optimal achievement of various kinds of activities. Sports achievements are inseparable from the element of physical condition. Physical exercise and proper, regular and sustainable exercise are components that also affect the improvement of a person's physical fitness condition (Bile & Suharharjana, 2019; Fachrezzy et al., 2021)

Physical condition is a whole of components of interrelated components. Improving physical condition cannot be done casually, if you want to improve the physical condition of an athlete, then all components contained in the physical condition must also be developed and cannot be separated (Jäger et al., 2017). Physical condition is one of the physical components possessed by a person (Lloyd et al., 2014; Nugroho et al., 2021; Raiola & Aliberti, 2021).

Improving the physical condition of athletes aims to make physical abilities excellent and useful in supporting sports activities to achieve athletes' achievements. Mansur et al., (2018) said that to achieve great achievements in competitive sports, it takes a prime body condition according to the needs and demands of the sports branch. This is supported by citations by Gumantan & Fahrizqi (2020) which say that to achieve high achievements in competitive sports, an athlete urgently needs excellent physical condition according to the needs and demands of sports. Physical condition is the most important factor in exercise programs

aimed at achieving high abilities (Anderson et al., 2015; Petruk et al., 2021). Training is a process in sports activities to improve the abilities found in athletes most importantly in the skills and skills that are possessed systematically and tried to match the established period (Busch et al., 2013; Drain et al., 2017). Every exercise process always requires an exercise program of both physical and skill nature. The given exercise program must be appropriate due to the ever-changing human condition.

Training planning is an important factor in sports practice to improve performance. Intensive practice will increase the maximum skill. Athletes who are champions have good performance in terms of physique, technique, and motor abilities (Wiguna, 2017). Athletes who have good abilities and fitness can increase their self-confidence (Kuloor & Kumar, 2020). Athletes with good self-confidence, have high motivation, thus affecting their (Chaabene et al., 2017; Ihsan et al., 2015; Levine et al., 2022; Lochbaum et al., 2022).

Wrestling is one of the sports that rely on strength and endurance (Juhanis, 2016). The most dominant element of physical condition in wrestling is using the element of strength, so the strength parameters will certainly be different from other sports. In the sport of wrestling, more components of maximum muscle strength are needed. In addition to the strength of other physical condition elements needed in the sport of wrestling, namely the compensatory strength, muscular endurance, power, flexibility, and cardiovascular general endurance, it is the parameters of success as presented in the collection of physical condition training materials.

At the 2021 national sports week (known in Bahasa Indonesia as Pekan Olahraga Nasional or PON) in Papua, data showed that of the 10 classes of wrestling athletes who competed could not reach the expected target, which was targeted to get 5 gold medals but none of them got a gold medal. This is due to the lack of incentives for the exercises performed and the lack of well-programmed forms of arm muscle strength training, and the frequently carried out programs are aerobic exercises and infiltrating techniques. Thus, cardiovascular endurance is not balanced with the strength of the arm muscles.

Based on the results of observations with PGSI coaches in January 2022, it is known that during training and competitions, it turns out that there are still many athletes who perform improper pulling and rolling techniques due to the strength of the arm muscles that are still weak so that when doing matches athletes are easily pushed and locked by their co-stars. When the athlete performs the roll often fails due to the lack of strength of his arm muscles. According to information from wrestling coaches, athletes' ability to withstand pushes and pulls from opponents is not optimal due to the lack of training in the strength of their arm muscles. Researchers obtained the latest data in the field from a wrestling coach when athletes performed an attractive and pushing muscle strength test using an expanding dynamometer test showing that the average muscle strength of 24.50 kg, these results fall into the category of less. Therefore it needs to be improved through a physical exercise program that corresponds to the performance of the sport of wrestling to produce better physical condition in particular on the indicators of the muscle strength of the arm muscles of the arm muscles of wrestling athletes.

The maximum strength of the arm muscles is used to attract and encourage the opponent to eliminate the stability of the defense. Great strength is to allow a person to have a more suitable slam planned, to create optimal performance. Nasrulloh & Wicaksono (2020) said that muscle strength should be able to be trained by observing the number of sets in the training stage. Training is a process in sports activities to improve the abilities found in athletes most importantly in the skills and skills that are possessed systematically and tried to match the established period (Busch et al., 2013; Coledam & Ferraiol, 2017; Ridley et al., 2018). It is not easy for a person to have good arm muscle strength ability in wrestling, to have good strength ability certainly requires systematic, progressive, continuous, and programmatic training. This is done to achieve the desired goal.

This study focused more on increasing the maximum strength of the arm muscles of wrestling athletes. Sotiropoulos et al. (2022) The maximum force is the highest force that can be displayed by the system during maximum contraction. A suitable exercise method for increasing maximum strength is the pyramid system of training. The pyramid system or better known as pyramid training is a special method used to develop strength. Training with this pyramid system is characterized by a constant increase in external load (load intensity) accompanied by a decrease in the repetition of the repetition, in other words, an increase in the intensity of the load (weight of the load) is carried out in conjunction with a decrease in the repetition or repetition. For more details, you can pay attention to the following Figure1:

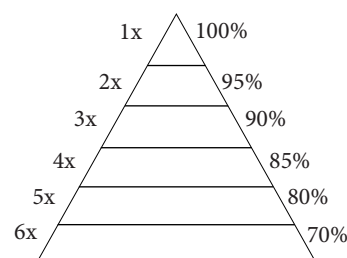


Fig. 1. Pyramid Method System

Source: Formation of physical condition (Bafirman & Wahyuri, 2019)

This strength is displayed with the highest load that can be lifted at one time. The maximum power in wrestling works when the athlete is about to attack to take down the opponent or by looking for points. The Maximum Strength assessment is carried out after the heating process, using the 1-RM test. 1RM is determined using a validated testing procedure and is defined as the heaviest load that a participant can lift once with the right lifting technique, without compensatory movement (Haff & Dumke, 2021). A general warm-up before testing consists of a light cardiovascular exercise that lasts about 5 to 10 minutes. This muscle strength strengthens athletes in carrying out movements in any sport (Suchomel et al., 2016, 2018). A person who has good muscle strength can carry out and carry heavy work for a long time. Nasrulloh & Wicaksono (2020) said that the increase in muscle work skills due to exercise is caused by physiological changes that are intertwined in the neuromuscular system (adjusting the neuromuscular system). The increase in muscle strength leads to more sturdy muscle contractions (increased power), more lightning repetition of contractions (increase speed),

as well as a long-lasting training period (increase muscle endurance).

It is not easy for a person to have a good maximum strength ability of arm muscles in wrestling, to have good strength abilities certainly requires systematic, progressive, continuous, and programmatic training. This is done to achieve the desired goal. Exercises that can increase the maximum strength of the arm muscles in wrestling are reverse grip barbell curls and barbell triceps extension exercises. Barbell curls reverse grip exercise is a form of exercise to strengthen the strength of an athlete's arm muscles. And barbell triceps extension exercise is a good form of exercise to strengthen the strength of an athlete's arm muscles (Nasrulloh et al., 2018).

The form of exercise above is a form of exercise to increase the strength of the arm muscles in wrestling. The increased strength of the arm muscles of the wrestling athlete can improve the achievements of wrestling athletes in West Sumatra. Therefore, the author wanted to conduct a study related to the maximum strength of the arm muscles, and according to the problem that the author saw in the field that the failure of wrestling athletes in some attack and defense techniques was due to the low maximum strength ability of the arm muscles of wrestling athletes. In addition to the strength of the arm muscles, the method of exercise, as well as the quality of the trainer greatly affects a feat. For this reason, it is necessary to conduct a study to find out the cause of the low achievement of wrestling athletes in the south coast district, because if this is allowed to continue, the maximum expected achievement will be difficult to achieve. The purpose of this study was to determine the effect of the exercise method of the pyramid system on the improvement of the maximum strength of the arm muscles of wrestling athletes.

Materials and methods

Study participants

The population in this study was 24 wrestling athletes. The sampling applied was Purposive sampling, which is with the following criteria: 1) athletes are not in a state of illness 2) athletes can follow the training program given 3) athletes who actively participate in training in wrestling gyms 4) athletes of the male sex, Researchers take samples of 10. This study has received approval from all samples who have filled out a statement of ability to become a research sample and have met the requirements of the research code of ethics.

Study organization

This study used a quasi-experimental type of experiment. The research design used in this study was a "one group pretest-posttest design". The research was conducted at the PGSI building in West Sumatra in November-December 2022. The method of collecting data in this research is to carry out tests and measurements. The form of the test is carried out by lifting a load that is only capable of being lifted 1 time or expressing the ability (maximum strength) with a barbell (Fenanlampir & Faruq, 2015). In the early stages of the meeting, the researchers took pre-test data aimed at finding out the initial data on the average maximum strength

of the arm muscles of wrestling athletes. After that, it is given treatment with an arm muscle strength training program for 18 sessions with freshness 3 times a week using the pyramid system method with a load of 70%-80%-85%-90%-95%-100% of the maximum load characterized by a constant increase in the external load (load intensity) accompanied by a decrease in the number of repeats of the series-preset in other words, an increase in the intensity of the load (weight of the load) is carried out simultaneously with a decrease in the number of repeats or reps. And ended with the final data collection by conducting a post-test to measure maximal muscle strength using a barbell to recognize the comparison of the maximum strength score of the arm muscles after the treatment.

Statistical analysis

The data analysis technique used in this study for hypothesis testing in this study is using a t-test formula that is related to a significant level of α : 0.05%. Data description using m.s excel by testing hypothesis testing analysis requirements in this study can be processed using the t-test formula. Before the t-test, a data normality test was carried out using the Liliefors test.

Results

Based on the explanations and descriptions that have been collected previously, in this case, an analysis of the research results and discussions obtained in the research will be carried out. The results of this study will be described according to the objectives of the previously proposed hypothesis.

Pre Test Ability

Pre-test measurements of the maximum strength of the arm muscles were carried out before being given treatment, which is a form of reverse grip barbell curls and barbell triceps extension exercises for 10 wrestling athletes. From the results of the pre-test measurement of the maximum strength of the arm muscles, the highest score was 34.00 kg and the lowest score was 26.00 kg. The distribution of scores produces an average (mean) of 29.9 and a standard deviation of 2.51 The distribution of more data can be seen in the Table 1.

Table 1. Frequency Distribution of Pre-Test Maximum Strength of Arm Muscles

No	Interval Class	Absolute Frequency	Relative Frequency	Information
1	<26,12	1	10%	Very Lacking
2	26.13-28.64	3	30%	Less
3	28.65-31.15	3	30%	Keep
4	31.16-33.67	2	20%	Good
5	>33.68	1	10%	Excellent
Sum		10	100%	

Source: (Fenanlampir & Faruq, 2015)

Based on the frequency distribution table above of the 10 people sampled, 1 person (10%) belonged to the interval of less than 26.12 kg classified in the category of very less, 3 people (30%) belonged to the interval 26.13-28.64 kg classified in the less category, 3 people (30%) belonged to the interval 28.65-31.15 kg belonged to the moderate category, 2 people (20%) belonged to the interval 31.16-33.67 classified in the good category, 1 person (10%) belonging to the interval of more than 33.68 kg belongs to the category of excellent. For more details, it can also be seen in the histogram Figure 2.

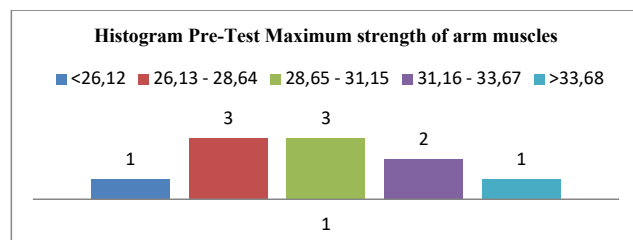


Fig. 2. Histogram Pre-Test Maximum strength of arm muscles

Post Test Ability

Post-test measurements of the maximum strength of the arm muscles were carried out after being given treatment, namely the form of reverse grip barbell curls and barbell triceps extension exercises to 10 wrestling athletes. From the results of the post-test measurement of the maximum strength of the arm muscles, the highest score was 36.00 kg and the lowest score was 28.00 kg. The distribution of scores yields an average (mean) of 32.3 and a standard deviation of 2.71. The full distribution of data can be seen in the Table 2.

Table 2. Frequency Distribution Post Test Maximum Strength of Arm Muscles

No	Interval Class	Absolute Frequency	Relative Frequency	Information
1	<26.12	0	0%	Very Lacking
2	26.13-28.64	0	0%	Less
3	28.65-31.15	4	40%	Keep
4	31.16-33.67	3	30%	Good
5	>33.68	3	30%	Excellent
Sum		10	100%	

Source: (Fenanlampir & Faruq, 2015)

Based on the frequency distribution table above of the 10 sample people, 0 people (0%) belonged to the interval of less than 26.12 kg classified in the very less category, and 0 people (0%) were included in the interval 26.13-28.64 kg were classified as less, 4 people (40%) were included in the interval 28.65-31.15 kg were classified in the moderate category, 3 people (30%) were included in the interval 31.16-33.67 were classified in the good category, 3 people (30%) belonging to the interval of more than 33.68 kg belong to the excellent category. For more details, it can also be seen in the histogram Figure 3.

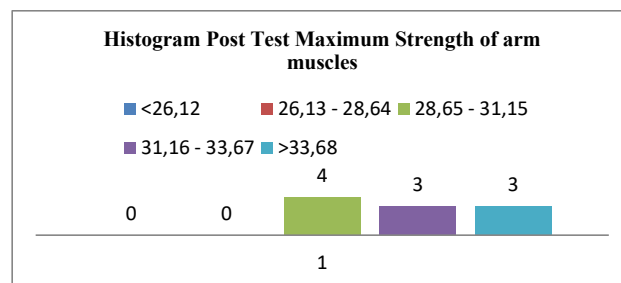


Fig. 3. Histogram Post Test Maximum Strength of arm muscles

The normality test was carried out using the killer's test with a real level (α) = 0.05. The test criteria are that reject the null hypothesis if the Lobservation (L_o) obtained from the observational data exceeds L_{table} (L_t) and instead accept the null hypothesis if the Lobservation (L_o) obtained is smaller than L_{table} (L_t) in simple terms can be used the following formula:

H_a rejected if, $L_{observation} (L_o) > L_{table} (L_t)$

H_a accepted if, $L_{observation} (L_o) < L_{table} (L_t)$.

Table 3. Normality Test The effect of reverse grip barbell curls and barbell triceps extension exercises and On The Increase in Maximum Strength of The Arm Muscles of Wrestling Athletes.

Group	Lilliefors Test		Conclusion
	L_o	L_{table}	
Pre-test	0.184	0.258	Usual
Post-test	0.143	0.258	Usual

Based on the summary Table 3 the normality test results of the reverse grip exercise data of barbell curls and barbell triceps extension, it can be seen that the difference between the initial test and the final test obtained by $L_o < L_t$, so can be concluded that the sample of the exercise group is normally distributed.

The proposed working hypothesis is that H_o has no effect on barbell curls and barbell triceps extension reverse grip exercises and On The Increase in Maximum Strength of Wrestling Athletes' Arm Muscles. H_a , there is an effect of reverse grip barbell curls and barbell triceps extension exercises On The Increase in Maximum Strength of The Arm Muscles of Wrestling Athletes. Based on the comparative analysis with the mean difference test formula (t-test) carried out, the results of the mean difference test analysis (t-test) are obtained as shown in Table 4.

Based on the Table 4, shows that H_o 's hypothesis is rejected while H_a 's hypothesis is accepted. This is seen from the results of the analysis, where it was obtained the $t = 7.894 > T_t = 1.833$ At the significance level $\alpha = 0.05$. In a sense of the word, there is an influence of reverse grip barbell curls and barbell triceps extension exercises on increasing the maximum strength of the arm muscles of wrestlers.

Discussion

The discussion in this study is carried out based on theoretical studies and statistical calculations and refers to the conclusions of the analysis that has been carried out,

Table 4. Hypothetical Test Results Summary

Variable			Average-Flat	N	T count	T table	Information
Maximum power Muscle Arm	Pre Test		29,9	10	7,894	1,833	Significant
	Post Test		32,3				

then the discussion will be carried out. This discussion will refer to the hypothesis proposed in the study:

“The effect of reverse grip barbell curls and barbell triceps extension exercises on increased maximum strength of wrestling athletes' arm muscles”.

From the results of the data analysis that has been described earlier, it can be said that the exercise of reverse grip barbell curls and barbell triceps extension increased the maximum strength of the arm muscles of wrestling athletes from the initial test and the final test there was an increase with a difference of 1.04, namely from an average score of 29.9 kg in the pre-test to 32.3 in the post-test. The occurrence of this increase is due to the physical adaptation of the application of the barbell reverse grip method and barbell triceps extension curls to the physical condition of the body which supports the maximum strength ability of the arm muscles. This was strengthened after the t-test was carried out, where a calculation result of 7,894 was obtained which was greater than the t table in the level of $\alpha = 0.05$ of 1,833. The results of this study mean that the hypothesis proposed is acceptable to be true, in another sentence, it can be concluded that the practice of reverse grip barbell curls and barbell triceps extension exerts a significant influence on the increase in the strength of the arm muscles of wrestling athletes. This is supported by previous research by Buckner et al., (2017) which explained that high load conditions cause a greater increase in maximum strength. These changes obtained after eight weeks can be attributed to the principle of specificity. Maximum strength is optimized by a combination of increased muscle CSA and increased nerve efficiency (Schoenfeld et al., 2015). The results of this study are also supported by the theory from (Baechle & Earle, 2019) said that the exercise of reverse grip barbell curls and barbell triceps extension is a type of weight training to increase, and develop strength, especially in the muscles of the arms. Reverse grip barbell curls and barbell triceps extension exercises are a form of exercise to strengthen the strength of an athlete's arm muscles. Nasrulloh et al. (2018) barbell curls and barbell triceps extension reverse grip exercises are a form of weight training variation by using barbells to increase muscle strength, especially the arm muscles.

In designing an exercise program, it is certainly inseparable from the principles of exercise. Bompa & Buzzichelli (2018) explained that there are several principles of strength training including the principle of the whole body, loading, progressive enhancement, stretching, utilization according to naivety, exercise sequence, and speciation.

In this study, researchers used the pyramid system exercise method to increase the maximum muscle strength of wrestling athletes which was carried out 3 times a week for 8 weeks. Baechle & Earle, (2019) explains that the pyramid exercise method is part of the maximum strength training method. This maximal strength training method is generally used for sports that are direct body contacts (body contact),

such as wrestling and weightlifting. The way to train the maximum strength that can be done is by training using the pyramid system method with a load intensity of 70%-80%-85%-90%-95%-100% of the maximum load.

The results of previous studies Fischetti et al., (2019) found that the strength training method using the pyramid system with freshness 3 times a week for 8 weeks can increase maximum muscle strength. The Pyramid System theoretically allows training with higher loads, at least during the final set of exercises, without reducing the volume of exercises from the point of view of the loading zone, thus maintaining a favorable anabolic environment for the improvement of muscle hypertrophy and thus strength gains (Fischetti et al., 2019). Strength is the ability of muscles to contract to generate stress against a prisoner (Hartmann et al., 2015).

Harsono (2015) arm strength is the ability of an arm to arouse the tension of a prisoner and lift weights. The role of arm muscle strength in wrestling has a very meaningful use, for example when athletes perform techniques in wrestling sports such as pulls, pushes, slams, rolls, and locks without being released by the opponent so that the athlete gets the maximum points (Maki et al., 2021; Özbay & Ulupinar, 2022; Podrihalo et al., 2020). The reverse grip exercises of barbell curls and barbell triceps extension can help wrestling athletes in developing the maximum strength of their muscles because, in wrestling sports, extra energy is needed. After all, in wrestling sports, physical contact between the two opposite athletes is needed. Therefore, it is very necessary to practice reverse grip barbell curls and barbell triceps extension in wrestling sports to get good muscle strength to be able to perform techniques in wrestling.

This study has some limitations that must be considered when extrapolating conclusions based on the results. The study period lasts only 8 weeks. While this duration is sufficient to produce a significant increase in maximum muscle strength, it is unclear whether the results between the groups will diverge for a longer time. In addition, our subject population consists exclusively of male wrestling athletes. Therefore, the findings cannot be generalized to other populations including adolescents, women, and the elderly. It is possible that the difference in hormonal influences. researchers concluded that the exercise of the pyramid system is an effective method of promoting a long-term positive adaptation of the maximum muscle strength of a wrestling athlete.

Conclusions

Based on data analysis and discussion, it can be concluded that there is a significant influence of reverse grip barbell curls and barbell triceps extension exercises on increasing the maximum strength of the arm muscles of wrestling athletes. With an average pre-test the maximum strength of the arm muscles of 29.9 kg while the post-test increased to

32.3 kg (an increase of 2.04 kg). This was strengthened after a t-test, where a calculation result of 7.894 was obtained which was greater than the t table in the level of $0.05 = 1.833$. Recommendations for researchers are further suggested to be able to examine other forms of exercises and compare them with barbell curls and barbell triceps extension reverse grip exercises that are related to the maximum strength ability of arm muscles in wrestling.

Acknowledgment

This research article can be carried out well thanks to the help of various parties, therefore the researchers express their deepest gratitude to all levels of lecturers at the faculty of sports science, Universitas Negeri Yogyakarta.

Conflict of interest

We as the author confirm that there is no conflict of interest in this publication and that the manuscript has been approved and submitted by all the authors mentioned above.

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ВПЛИВ ВИКОНАННЯ СИЛОВИХ ВПРАВ МЕТОДОМ ПІРАМІДИ НА МАКСИМАЛЬНУ СИЛУ М'ЯЗІВ РУК БОРЦЯ

Мухамад Ічсан Сабілах^{1ABC}, Томоліус^{1ABD}, Ахмад Насруллох^{1BCD},
Роксана Дев Омар Дев^{2CDE}, Фаузі^{1CDE}

¹Джок'якартський державний університет

²Малайзійський університет Путра

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 8 с., 4 табл., 3 рис., 40 джерел.

Мета дослідження. Метою цього дослідження було визначити вплив вправ на підйом штанги на біцепс зворотним хватом і французький жим штанги на трицепс на збільшення максимальної сили м'язів рук спортсменів-борців.

Матеріали та методи. Цей тип дослідження є квазіекспериментальним. Генеральна сукупність учасників дослідження складалася з 24 спортсменів-борців. Вибірку проводили за допомогою методів цілеспрямованого відбору, а саме 10 спортсменів-борців. Інструмент дослідження здійснювали шляхом підйому ваги, яку можна було підняти лише 1 раз, або яка виражала здатність (максимальну силу), за допомогою штанги. Як техніку аналізу даних використовували перевірку гіпотези за допомогою формули t-критерію Стюдента.

Результати. Результати цього дослідження показали, що вправи на підйом штанги на біцепс зворотним хватом і французький жим штанги на трицепс впливають на збільшення максимальної сили м'язів рук спортсменів-борців; за результатами початкового тесту та заключного тесту спостерігалось збільшення з різницею 1,04, а саме від середнього показника 29,9 кг під час попереднього тестування до 32,3 кг під час підсумкового тестування.

Висновки. Висновок цього дослідження полягає в тому, що форма зворотного хвату під час виконання вправ на підйом штанги на біцепс та французький жим штанги на трицепс значно впливає на збільшення максимальної сили м'язів рук у спортсменів-борців.

Ключові слова: підйом штанги на біцепс зворотним хватом; французький жим штанги на трицепс; максимальна сила.

Information about the authors:

Sabillah, Muhamad Ichsan: muhamadichsan.2021@student.uny.ac.id; <https://orcid.org/0000-0001-6081-8590>; Department of Sports Science, Universitas Negeri Yogyakarta, Jl. Colombo Yogyakarta No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia.

Tomoliyus: tomoliyus@uny.ac.id; <https://orcid.org/0000-0002-2793-6058>; Department of Sports Coaching, Universitas Negeri Yogyakarta, Jl. Colombo Yogyakarta No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia.

Nasrulloh, Ahmad: ahmadnasrulloh@uny.ac.id; <https://orcid.org/0000-0003-2859-7091>; Department of Sports Science, Universitas Negeri Yogyakarta, Jl. Colombo Yogyakarta No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia.

Dev Omar Dev, Roxana: rdod@upm.edu.my; <https://orcid.org/0000-0001-8456-5268>; Department of Sports Studies, Universiti Putra Malaysia, Jalan Universiti 1, 43400 Serdang, Selangor, Malaysia.

Fauzi: fauzi@uny.ac.id; <https://orcid.org/0000-0001-9170-3737>; Department of Sports Coaching, Universitas Negeri Yogyakarta, Jl. Colombo Yogyakarta No.1, Karang Malang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281, Indonesia.

Cite this article as: Sabillah, M.I., Tomoliyus, Nasrulloh, A., Dev Omar Dev, R., & Fauzi (2023). The Effect of the Pyramid Exercise Method on the Maximum Strength of the Wrestler's Arm Muscles. *Physical Education Theory and Methodology*, 23(4), 512-519. <https://doi.org/10.17309/tmfv.2023.4.04>

Received: 02.02.2023. Accepted: 14.07.2023. Published: 30.08.2023

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ORIGINAL SCIENTIFIC ARTICLE

FUNDAMENTAL MOVEMENT SKILLS IN CHILDREN IN MENTAWAI ISLANDS: INDIGENOUS TRIBES IN INDONESIA

Anton Komaini^{1ABCDE}, Yanuar Kiram^{1ABCD}, Gusril^{1ABCD},
Deby Tri Mario^{1ABCD}, Sri Gusti Handayani^{1ABD} and Erianjoni^{1ABD}

¹Universitas Negeri Padang

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Anton Komaini, E-mail: antonkomaini@fik.unp.ac.id

Accepted for Publication: July 14, 2023

Published: August 30, 2023

DOI: 10.17309/tmfv.2023.4.05

Abstract

Background and purpose. Various studies have investigated Fundamental Movement Skills (FMS) in children and factors that might improve them. However, studies examining FMS in children of indigenous tribes remain limited. Thus, this research aims to identify and analyze the relationship between sociocultural life, parenting, and level of education among indigenous tribe children who live on Mentawai Island. The research is also keen on comparing FMS between genders.

Materials and methods. This research employed qualitative and quantitative methods. It was grounded by phenomenology and FMS tests. A total of 15 parents, 3 teachers, and 70 young children (aged 5-7 years) participated voluntarily. The children's genders comprised boys (n=38) and girls (n=32). Data in this research were collected from observation, semi-structured interviews, and FMS tests (locomotor, non-locomotor and manipulative). Then, they were analyzed using a thematic method and t-test to compare the level of FMS among the children.

Results. Based on the analysis, parents stated they involved their children in socio-cultural life. Also, children were educated to live independently and given freedom to play. However, the study did not find any relationship between parent's educational level and FMS. This was evidenced by statistical analysis, in which the mean score of FMS among early childhood in Mentawai Island was 35.46 (good). Following that, boys had better FMS than girls ($P < 0.05$), with a mean score of $37.08 > 33.53$.

Conclusions. Children need to be given the freedom to actively take part in physical activities in order to gain physical experiences and better FMS. This study recommends future research involving other factors and comparing FMS between children of indigenous tribes and those who live in urban areas.

Keywords: fundamental movement skills, sociocultural, parenting, level of education, indigenous tribe, children.

Introduction

Indonesia is home to diverse tribes, religions, languages, cultures, and customs. Each region may have its own diversity, such as Dusun Buttui in Mentawai Island, which has an indigenous tribe called "inland people" or backwoodsman. For these people, the forest is inseparable from life as it is the place to meet economic, social, and cultural needs. Thus, they must have excellent body conditions to face all possibilities in their surroundings (Umar & Yulifitrya, 2017).

Most parents in the indigenous tribe of Mentawai Island are elementary school graduates. A lack of schools and

access on the island are often considered the main factors for this drawback. This level of education eventually affects the way they raise their children. A higher level of education is evidenced to positively impact children's cognitive development (Lundborg et al., 2014; Noble et al., 2015). This type of parents can quickly notice any abnormality in their children, so they can give stimulus as early as possible, including for their FMS development (Komaini, 2017).

FMS is important during early childhood as it affects physical and health development (Pranoto et al., 2023; Robinson et al., 2015). It is a mechanism that underlies physical activities (Holfelder & Schott, 2014; Jaakkola et al., 2015; Logan et al., 2015; Stodden et al., 2014) and serves as a correlation between BMI and fitness (D'Hondt et al., 2014). Various studies have investigated FMS and factors that might improve them. For example, there was a study reviewing how

parents selected physical activities for the motor and fitness development of children aged 4-5 years (Hu et al., 2021). The study summarized that children's participation in one or more sports activities would affect their motor development. Other scholars investigated an integrated program for FMS development and rhythmic abilities in early childhood aged 5-6 years (Marinšek & Denac, 2020). The study concluded that FMS development and rhythmic abilities would effectively integrate music and body movement. Interestingly, scholars found that FMS correlated with school achievement among preschool children aged 5-6 years (de Waal, 2019). The study claimed that FMS (especially dynamic and static movement) significantly impacted their academic achievement.

Furthermore, Hamilton et al. (2016) researched the relationship between body weight and motor skills among preschool children with low socioeconomic backgrounds. They summarized that Hispanic children with low socioeconomic backgrounds tended to have delayed motor development. This delay was associated with their body weight. Other scholars studied the effect of parenting for preschool children aged 3-5 on their FMS development (Adamo et al., 2016). The study argued that physical-related activities that were facilitated by nannies could increase FMS. Meanwhile, several studies researched motor skills in preschool children aged 3-5 with low socioeconomic status (Liu et al., 2015). The study summarized that children with low socioeconomic status significantly delayed their motor development (Robinson et al., 2012).

Further, other scholars examined the effect of teaching practice on increasing motor skills of children aged 3-5 years (Robinson et al., 2012). The study concluded that guidance and coaching in designing and applying movement programs can develop motor skills. Attitudes and practices of teachers and parents towards risky outdoor games were reported by McFarland and Laird (2017). Their study involved 26 early childhood teachers and 112 parents residing in remote and urban areas (Australia and the US). Other studies investigate the intervention of 'Go2Play Active Play' in increasing physical activities during school days and FMS for 7-year-old children (Johnstone et al., 2017) and the evaluation of video modelling on FMS performance among preschool children (Obrusnikova & Cavalier, 2017).

Although research on FMS is abundantly available, there seems little information can be found regarding FMS in indigenous tribes' young children. For this reason, this research aims to identify and analyze the relationship between sociocultural life, parenting, and parents' level of education on young children's FMS in indigenous tribes on the Mentawai Islands. In addition, it is keen on comparing FMS between boys and girls.

Indigenous Tribe in Mentawai Island

Communities in Mentawai Island hold a patrilineal system. They live in a big house (called Uma) or small houses next to it (Schefold, 1988; Tulus, 2013) (Figure 1.a). Uma is inhabited by 5 to 7 families, adhering to an egalitarian social system. They are usually led by a Rimata (the symbol of a respected leader or individual who is considered wise). The relationship in Uma is based on mutual consensus, democracy, and kinship due to marriage. According to customs, other members who have just married live in a

smaller house next to Uma called Lalep. The outer layer of Uma is a house called Rusuk. It is inhabited by youths, widows, and people exiled from the village (Kusbiantoro, 2016).

The policy of settlement programs initiated by the Mentawai government makes most people move to villages (Barasi). However, some families decide to stay in several houses or move around in the forest (where they can raise pigs, perform traditional ceremonies, and dance), as shown in Figure 1.b. As Several families (usually called Sikera or dukun) spend most or all of their time in the forest (see Figure 2.b). Meanwhile, families with school-age children tend to live in remote villages (Singh et al., 2019).



Fig. 1. (a) House (Uma), (b) Traditional Dance "Turuk Laggai"

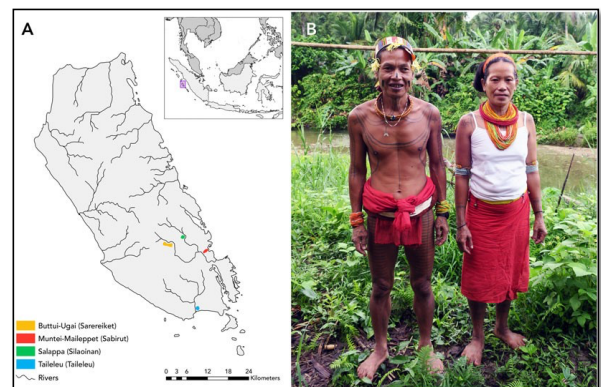


Fig. 2. (a) Siberut Island, the largest island in Mentawai Islands, Indonesia. Yellow spots represent the current study. Light grey represents Indonesia, while the dark one represents neighboring countries. (b) Dukun in Mentawai Island and his wife (Singh et al., 2019)

Siberut Island is the largest island in the Mentawai Islands (4.030 km², about 150 km west of Sumatera) (Tulius, 2013) (Figure 2.a). This island is divided into four regencies, South Siberut, Central Siberut, North Siberut, and West Siberut. To reach the island, there are two ports that can be accessed by ferry and fast boats, named Sikabalan Port in North Siberut and Muara Siberut in South Siberut. The distance between Siberut Island and Sumatera Island is about 100 km. It takes 10 to 12 hours to reach the island by ferry (Umar & Yulifitrya, 2017). The island covers 11 big rivers, each of which branches into dozens of small rivers. Due to distance and the history of Pengayuan, people rarely travel to other rivers because the culture of people who live in the next river valley is typically different (Schefold, 1988). The authors refer to the community that speaks the same dialect and lives in the same river valley as the cultural area. The cultural area in South Siberut covers Sabirut (dusun Maileppet and Muntei), Sarereiket (dusun Buttui and Ugai), Silaoinan (dusun Salappa), and Taileleu. The current research refers to observation and interviews conducted in Sarereiket in Dusun Buttui (see Figure 2.a).

Materials and methods

Study design

This research employed a mixed method, combining qualitative and quantitative methods. The qualitative method was designed in the phenomenological framework outlining certain phenomena and experiences (Bogdan & Biklen, 2007). After that, the quantitative method was employed to support the qualitative data obtained in the field. This design is in line with the opinion of Leech et al., who states that the combination of quantitative and qualitative enables the researchers to work in flexible, integrative, inclusive, and thorough ways when reviewing various research questions (Leech et al., 2011).

Participant

This research invited participants from indigenous tribes in the Mentawai Islands, Indonesia. The participants comprised 15 parents (male = 5, female = 10), 3 early childhood teachers (male = 1 and female = 2), and 70 young children

aged 5-7 years (male = 38 and female = 32). The parents were selected based on several criteria, such as taking part voluntarily and having young children. Meanwhile, teachers that were chosen must take part voluntarily, have 3-year teaching experiences, and have data about parents who have young children. Finally, the children were recruited based on these criteria, including taking part voluntarily, being 5-7 years old, and not being physically and mentally disabled. The characteristics of the children are presented in Table 1.

Table 1. Characteristics of participants

Characteristics	Male (n=38)	Female (n=32)
Age	6.42 ± 0.64	6.41 ± 0.71
Weight	22.22 ± 0.86	21.34 ± 1.38
Height	120.29 ± 1.99	118.94 ± 2.18
BMI	15.37 ± 0.75	15.08 ± 1.16

Procedures and Instruments

Qualitative data in this research were obtained from observation and interviews. These data included sociocultural life, parenting, and parents' level of education. Meanwhile, quantitative data were taken from FMS tests.

Observation

In this research, observation was used to investigate and observe what parents and children did while doing activities. This tool was also useful to see how they were involved in activities (such as sociocultural life, parenting, and physical activities that children did daily). Participant observation is used to obtain more detailed and sharp data, allowing the researchers to understand the meaning of every seen behavior. In this way, researchers were immersed in the daily activities of parents and children of indigenous tribes.

Interview

Interviews were conducted in certain cases or situations related to the observation. The interview was designed as semi-structured, as illustrated in Table 2. The semi-struc-

Table 2. Semi-structured interview

Aspect	Question
Sociocultural life	What are the sociocultural activities of the indigenous tribes in the Mentawai Islands?
	Are your children involved in sociocultural activities?
	What sociocultural activities did the young children do?
	Do sociocultural activities engage children's physical activities?
Parenting	What are the supports and obstacles for the children to do this activity?
	How do parents treat their young children?
	How do parents communicate with their young children?
	Are the children limited to play?
Level of education	What are the supports and challenges for children towards what they like?
	What is the parents' educational background in indigenous tribes in the Mentawai Islands?
	What are their occupations?
	Do parents provide guidance and supervision toward early childhood development?
Others	What are the supporting and inhibiting factors in the educational situation of the indigenous tribes in the Mentawai Islands?
	Do you have any other thoughts to share?

Table 3. Fundamental movement skills test

Indicators	Grade*		
	Can	Can with help	Cannot
Run in a straight line.	3	2	1
Horse Run (Gallop) back and forth in a straight line.	3	2	1
Walk forward on tiptoe on toes.	3	2	1
Jump forward on two feet.	3	2	1
Jump left and right, back up, and land on both feet at the same time.	3	2	1
Jumps in place on two feet.	3	2	1
Jump in place with one foot (3 times in a row with the left and right foot alternately).	3	2	1
Stand on one foot for 10 seconds.	3	2	1
The attitude resembles an airplane, that is, one leg is lifted, the arms are stretched out, and the body is slowly bent.	3	2	1
Ascend stairs alternating feet, but keeping the same foot down at each step.	3	2	1
Throwing the ball with one hand.	3	2	1
Catch the ball with two hands.	3	2	1
Kicking the ball.	3	2	1
Roll the ball with one hand.	3	2	1
Bouncing the ball with one hand.	3	2	1

Note*– Grade is given: (a) Category “can” (score 3). This score is obtained from 3 attempts, and at least participants can do it themselves twice; (b) Category “can with help” (score 2). This score is obtained from 3 attempts, and participants can do it with help twice; (c) Category “cannot” (Score 1). This score is obtained from 3 attempts, and participants cannot do it twice, even with help.

tured design allowed the researchers to explore participants’ responses. The interview protocol consisted of the main ideas of items that would be delivered to participants based on the research purposes. Particularly, it used interpretative approaches that focused on direct reports from parents and teachers about sociocultural life, parenting, and parents’ level of education (Brantlinger et al., 2005; Cresswell, 2007). In this research, participants’ data were treated securely. Their data were also published anonym to guarantee their confidentiality.

Fundamental movement skills test

When all qualitative data were collected, the FMS test was conducted on early childhood kids participating in this research. This test was used as a comparison that would support the qualitative data. The FMS test design is provided in Table 3.

Table 3 is an instrument developed by Komaini et al. (2022). This test involves locomotor, non-locomotor, and manipulative movements. The maximums score of FMS is 45, while the minimum score is 15. The score sums are classified as provided in Table 4.

Table 4. Classification of fundamental movement skill

Score	Classification
39-45	Very Good
33-38	Good
27-32	Acceptable
21-26	Poor
15-20	Very Poor

Data analysis

Qualitative data in this research were taken from observation and interviews. These data were analyzed following what participants said, why they said it, and what they would say.

The interview’s results were transcribed, read, and reread. After that, they were studied to identify categories and conceptualizations. Meanwhile, the quantitative data were collected from the FMS test. The test aimed to illustrate the sample holistically and was used as a comparison to support the qualitative data. These data were analyzed using descriptive statistics and t-tests to compare the FMS level between male and female participants. This stage was analyzed using the statistical program SPSS.

Results

Sociocultural life of indigenous tribes

Based on the observation and interview analysis, participants revealed that they always involved their young children in daily activities related to socio-culture. The children performed hunting down the river (3 to 5 km), breeding, farming, archery, fowling, and fishing (see Table 5 for parents, 1-15).

Parenting in parents of indigenous tribes

The observation and interview results indicated that parents in indigenous tribes had parenting styles. They taught their children to live independently with limitations and control over their actions. They provided freedom for the children. The children could play any games that they

Table 5. Sociocultural life aspects

Aspect	Sociocultural life of indigenous tribes.
Theme	The relationship between socio-culture and FMS in children of indigenous tribes.
Category	Sociocultural life.
Excerpts	"Sociocultural life of indigenous tribe in the Mentawai Islands includes tattoo, traditional dance (Turuk Laggai), concocting traditional medicine, breeding, fishing, making arrow poison, processing sago, and hunting (parents, 1-15).
Data Compaction	Tattoo, Turuk Laggai, concocting traditional medicine, breeding, fishing, making arrow poison, processing sago, and hunting.
Category	Young children engaged in sociocultural activities.
Excerpt	"We involved children in daily activities related to sociocultural life. Activities such as hunting, going down the forest for 3-5 km, breeding, planting crops, archery, fowling, and fishing always involved children (parents, 1-15).
Data Compaction	Children doing sociocultural activities involving physical activities.
Category	Supports and Inhibitions for children in sociocultural activities.
Excerpt	"We always support and teach children about our culture, hoping that they will do the same for future generations" (parents, 1,2,13-15).
Data compaction	Teach and support children about culture as a heritage for future generations.

Table 6. Parenting aspects

Aspect	Parenting in indigenous tribes.
Theme	The relationship between parenting and FMS in children in indigenous tribes.
Category	Parents' strategies in taking care of their children.
Excerpt	"We do not have time to control our children all day long. We look after them, but do not demand too much or control over them" (parents, 1,4,6,8-15). "From 5 am in the morning until 11 pm in the evening, we are busy with work, taking water, looking for firewood, and processing sago" (parents, 2-3). "The fathers worked hunting and farming" (parents, 5,7).
Data Compaction	Not fully controlling children.
Category	Communication between parents and children.
Excerpt	"Our relationship with the children is very good. Children always share what they do daily and take our advice (parents, 1-3,5,7-15).
Data Compaction	Harmonious communication and relationships.
Category	Children are given the freedom to play.
Excerpt	"We provide freedom for children to express their wishes. They usually do not wear sandals or clothes while playing. They play in the river or swim for hours, looking for clams and hunting. Some even walk for hours to sell to meet their family needs (parents, 1,6,7,9-15). "Children must play whatever they like" (parents, 4,5,8). "Children eve do not wear sandals or clothes" (parents, 2-3).
Data Compaction	Children are free to play whatever they like, which involves physical activities.
Category	Support and inhibition for children towards the things they like.
Excerpt	"We support children to do what they love because they are used to living independently" (parents, 1-15).
Data Compaction	Children are used to living independently.

liked. They sometimes did not wear sandals and clothes. They played in the river, swam for hours, and looked for clams. Some children even walked for 8 hours to sell to meet their family's needs (see Table 6 for parents, 1,6,7,9-15).

Parent's level of education in an indigenous tribe

As argued earlier, this research conducted interviews with teachers for children of indigenous tribes. These teachers stated that most parents in Dusun Buttui had a low educational level. On average, they were elementary school graduates. Some were even unschooled. The parents, especially wives

(Buibui), were busy working from morning to afternoon. They looked for woods to carry water from the river to their homes. Occasionally, they also found sago to be processed as food (see Table 7 for teachers of the children, 1-3). The lack of schools in Dusun Buttui made society stop going to school (see Table 7).

Fundamental movement skills in children of indigenous tribe

The descriptive analysis showed that the mean score of FMS in children of indigenous tribes was 35.46 (good classification). The minimum score is 26 for the poor

Table 7. Level of education aspects

Aspect	Parent's level of education in the indigenous tribe.
Theme	The relationship between parent's level of education and FMS of children in an Indigenous tribe.
Category	The educational background of parents in indigenous tribes.
Excerpt	"Parent's level of education here is elementary graduates" (early childhood teachers, 1-3).
Data Compaction	The average educational level of parents in the indigenous tribes is elementary school graduates.
Category	Occupation of parents in the indigenous tribe.
Excerpt	"Most fathers work as farmers. They also breed and hunt in the forest. Meanwhile, mothers take water from the river, look for firewood, search sago, and process the sago for daily food" (early childhood teachers, 1-3).
Data Compaction	Fathers work by farming, breeding, and hunting in the forest. Meanwhile, mothers utilize the forest to suffice their family needs.
Category	Parents guide and supervise the growth and development of children.
Excerpt	"Parents educate their children to live independently, yet under their supervision. Every day, children are free to play and spend their time playing in the river and forest" (early childhood teachers, 1-3)
Data Compaction	Children are taught to live independently but still under the supervision of their parents.
Category	Support and obstacles to the indigenous tribe's educational background.
Excerpt	"The limited school buildings caused the people in Dusun Buttui to stop going to school. They prefer farming and raising livestock (breed) to meet family needs" (early childhood teacher, 1). "It is expected to have junior and senior secondary schools in each sub-district, and accredited primary schools" (early childhood teachers, 2-3).
Data Compaction	Limites school buildings.

Table 8. Descriptive statistics for fundamental movement skills

Score	Frequency	Percentages	Classification
39-45	19	27.14	Very good
33-38	33	47.14	Good
27-32	16	22.86	Acceptable
21-26	2	2.86	Poor
15-20	0	0.00	Very poor
N	70		Good
Max	42		
Min	26		
M ± SD	35.46 ± 3.98		

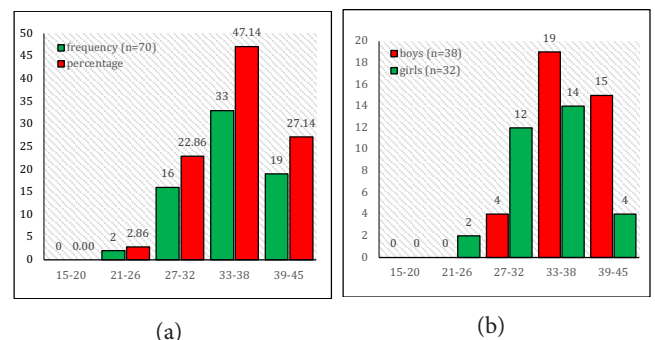


Figure 3. (a) Score and percentage of the fundamental movement skills, (b) Score difference of FMS between boys and girls

Table 9. Descriptive statistics of FMS between boys and girls

Score	Boys (n=38)		Girls (n=32)		Classification
	Frequency	percentages	Frequency	percentages	
39-45	15	39.47	4	12.50	Very good
33-38	19	50.00	14	43.75	Good
27-32	4	10.53	12	37.50	Acceptable
21-26	0	0.00	2	6.25	Poor
15-20	0	0.00	0	0.00	Very poor
N	38		32		Good (boys and girls)
Max	42		40		
Min	29		26		
M ± SD	37.08 ± 3.17		33.53 ± 4.02		
Difference	3.55				

Table 10. Summary of data normality and homogeneity tests

Gender	df	Normality test				Homogeneity test			
		Kolmogorov-smirnov		Shapiro-Wilk		Levene	df1	df2	P
		Statistic	P	Statistic	P				
Boys	38	0.123	0.158	0.950	0.091	3.699	1	68	0.059
Girls	32	0.136	0.136	0.955	0.194				

Note- Data is normally distributed and homogeneous ($P > 0.05$).

Table 11. Analysis of FMS differences between boys and girls

Data	df	t-test for equality of means				95%	
		P (2-tailed)	Mean difference	SED		Lower	Upper
FMS	Equal variances assumed	68	0.000	3.548	0.860	1.833	5.263
	Equal variances not assumed	58.43	0.000	3.548	0.877	1.792	5.304

Note- Significant difference ($P < 0.05$).

classification, and the maximum score is 42 for the very good classification. No child that had FMS was placed in the very poor classification, as illustrated in Table 8. Figure 3.a indicates that the most dominant score of FMS is 33-38 ($n=33$).

The difference in FMS between boys ($n=38$) and girls ($n=32$) indicated that the boy's FMS was 37.08. Meanwhile, the girl's FMS was 33.53 (see Table 9 and Figure 3.b). Both were classified as good.

Further, an analysis was conducted using the t-test independent sample to show the difference in FMS between both. As presented in Table 10, the results of the analysis requirements test showed that the data were normally distributed and homogeneous ($P > 0.05$). Then, the analysis also indicated a significant mean difference in FMS between both genders ($P < 0.05$) (Table 11). This proves that FMS boys are better than girls, with an average score of $37.08 > 33.53$. Meanwhile, the difference is 3.55.

Discussion

This finding shows that sociocultural life and parenting have impacts on FMS in children of indigenous tribes. This claim results from the quantitative analysis, where the mean score of FMS in children is 35.46 (good classification). After that, the FMS of boys is better than girls ($P < 0.05$), with a mean score of $37.08 > 33.53$. Although parents' level of education is very low, this seemingly does not affect the children's FMS. This is because parents always give their children the freedom to play whatever they love, either activities that engage socially or physically, such as walking down the forest, swimming in the river, fishing, performing traditional dances, and hunting. These activities unwittingly involve children's movements that might promote their movement and FMS experiences. This finding confirms earlier studies claiming that FMS needs to be reviewed from "geographical and sociocultural aspects" (Barnett et al., 2016; Hulteen et al., 2017). Then, scholars have seen myriad studies investigating factors and effects of physical activities in the last decade. To date, several factors have been identified, such as sociocultural factors (Harrington et al., 2016; Sterdt et al., 2014).

Other studies report that playing provides opportunities for children to promote physical activities and learn FMS

(Castelli, 2019; Gallahue et al., 2011; Valentini et al., 2016). A higher level of physical activities and active play can increase FMS in preschool and school children (Adamo et al., 2016; Johnstone et al., 2017; Lee et al., 2020). This review has supported a relatively long time series, from childhood through adolescence (Babic et al., 2014; Barnett et al., 2016; Holfelder & Schott, 2014; Logan et al., 2015). Previous studies also associate FMS with various health benefits, namely increased physical activity, cardiorespiration, self-confidence, and decreased risk of obesity (Hardy et al., 2012). FMS and children's involvement in physical activity enable children of indigenous tribes in the Mentawai Islands to lead productive lives. Therefore, it is not surprising that they have good FMS because they are physically active every day. The findings also analyze the differences in FMS rates between boys and girls in more detail. It was reported that the FMS of boys was better than that of girls. The results of this study are in accordance with previous studies that boys tend to show higher FMS than girls (Barnett et al., 2009; Graf et al., 2004).

Following that, this research confirms that the parenting styles of parents in indigenous tribes encourage their children to live independently. Nevertheless, the children are still under supervision to control their behaviour. This finding corroborates previous studies investigating the effect of the integral parenting method towards the manifestation of mental health disorders in children (Derakhshanpour et al., 2016). Many reports state that many uncooperative behaviour among children are usually stemmed from the parenting styles that parents apply at home (Muñoz-Silva et al., 2017; Ullsperger et al., 2016; Yousefia et al., 2011). Such children usually show impulsive behaviour that might violate parental rules, resulting in an autocratic parenting style (Wirth et al., 2019). Earlier reports show that factors triggering FMS are the lack of attention, inheritance, environment (Hinshaw & Ellison, 2016; Wirth et al., 2019), and family (Brunsek et al., 2017; Komaini, 2017; Manning et al., 2017; McClelland & Cameron, 2019; Wu et al., 2017). Fortunately, with the parenting style applied by parents in indigenous tribes, children are indirectly involved in daily physical activities.

Interestingly, the low level of education among parents of indigenous tribes in the Mentawai Islands seemingly does not affect their children's FMS. One of the reasons is that

children are given the freedom in which they are trained and taught to live independently. These findings are in line with prior research, where quality parenting and education in children play a vital role in children's development, especially those with low socioeconomic background (Dearing et al., 2009; Sylva et al., 2011; Ulferts et al., 2019; Van Huizen & Plantenga, 2018; Vandell et al., 2010). This may be because the children of the indigenous tribe in the Mentawai Islands are used to and trained to live independently. They are free to play whatever they like, so it impacts their FMS development. In this tribe, children carry out physical activities, play, and are involved in sociocultural life that depends on or coexists with nature or forests.

Limitations

We realize that indigenous tribes in one country might differ due to geographical and demographical factors. Thus, this research's findings cannot be generalized to indigenous tribes in other countries. This research is also limited in time because it was conducted for about three weeks. This limitation leads to difficulties to adapt with society's language, culture, and food.

Conclusions and Recommendations

FMS of tribal children in the Mentawai Islands, Indonesia, reported to have FMS in a good classification. This is because the activities they do every day involve physical activity. They are free to be actively engaged in social and cultural life. In addition, their parenting style teaches children to live independently. Even though their parents' education level is very low, this has no impact on FMS. This is proven by statistical analysis, where the FMS of children in rural areas is 35.46 (good classification). Then, boys' FMS is better than girls' ($P < 0.05$). This study recommends that children be free to actively participate in physical activity to experience good movement and FMS. Future research is still needed to include other factors and compare FMS between rural and urban children.

Acknowledgements

We would like to extend our deepest gratitude to LPPM of Universitas Negeri Padang, Indonesia, for supporting and funding this research (contract no: 093/E5/PG.02.00. PT/2022). We also thank the tribal chief, people, parents, teachers, and children of indigenous tribes in Dusun Buttui, the Mentawai Islands, Indonesia.

Conflict of Interest

The authors declare that there is no conflict of interest.

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ОСНОВНІ РУХОВІ НАВИЧКИ ДІТЕЙ НА ОСТРОВАХ МЕНТАВАЙ: КОРИННІ ПЛЕМЕНА ІНДОНЕЗІЇ

Антон Комайні^{1ABCDE}, Януар Кірам^{1ABCD}, Гусріл^{1ABCD},
Дебі Трі Маріо^{1ABCD}, Срі Густі Хандаяні^{1ABD}, Еріанджоні^{1ABD}

¹Падангський державний університет

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 8 с., 4 табл., 3 рис., 58 джерел.

Історія питання. Різноманітні дослідження вивчали основні рухові навички (ОРН) і пов'язані з ними фактори для покращення ОРН у дітей молодшого віку. Проте кількість досліджень, які включають дітей молодшого віку у корінних племенах як предмет дослідження, залишається дуже обмеженою.

Мета дослідження. Метою цього дослідження є вивчення та аналіз взаємозв'язку між соціокультурним життям, вихованням дітей і рівнем освіти батьків і впливом цих чинників на ОРН дітей молодшого віку у корінних племенах на островах Ментавай із наступним порівнянням ОРН хлопчиків і дівчат.

Матеріали та методи. використовують якісні методи на основі феноменології та кількісні методи на основі тесту ОРН. Загалом у цьому дослідженні взяли участь 15 батьків, 3 вчителі дошкільної освіти та 70 дітей молодшого віку (віком 5–7 років), серед яких були хлопчики ($n = 38$) і дівчатка ($n = 32$). Якісні дані були отримані під час спостереження та напів-структурованих інтерв'ю, а потім проаналізовані за допомогою тематичного аналізу. Тоді як кількісні дані були отримані з тесту ОРН (локомоторних, нелокомоторних і маніпуляційних), а потім проаналізовані за допомогою описової статистики та t -критерію Стюдента для їх порівняння.

Результати. Отримані дані свідчать, що батьки стверджують, що вони завжди залучають своїх дітей до соціокультурного життя, дітей навчають самостійного життя та дають їм вільно гратися. Однак ми не виявили жодного впливу рівня освіти батьків на ОРН. Статистичний аналіз свідчить про те, що показник ОРН дітей молодшого віку у корінних племенах островів Ментавай становить 35,46 (гарна класифікація). При цьому хлопці показали кращу результативність, ніж дівчата ($p < 0,05$), із середнім балом $37,08 > 33,53$ і різницею 3,55.

Висновки. Дітям потрібно давати свободу активно залучатися до фізичної активності, щоб вони отримували гарний досвід руху та ОРН. Потрібні наступні дослідження, щоб включити інші фактори та порівняти ОРН у дітей молодшого віку між корінними племенами та міськими етнічними групами.

Ключові слова: основні рухові навички, соціокультурні навички, батьківство, рівень освіти, корінне плем'я, діти.

Information about the authors:

Komaini, Anton: antonkomaini@fik.unp.ac.id; <https://orcid.org/0000-0002-2955-0175>; Department of Health & Recreation, Faculty of Sport Science, Universitas Negeri Padang, Jl. Prof. Dr. Hamka No.1, Air Tawar Bar., Kec. Padang Utara, Kota Padang, Sumatera Barat 25173, Indonesia.

Kiram, Yanuar: yanuar_kiram@fik.unp.ac.id; <https://orcid.org/0000-0001-9737-3484>; Department of Coaching, Faculty of Sport Science, Universitas Negeri Padang, Jl. Prof. Dr. Hamka No.1, Air Tawar Bar., Kec. Padang Utara, Kota Padang, Sumatera Barat 25173, Indonesia.

Gusril: gusril@fik.unp.ac.id; <https://orcid.org/0009-0003-2603-8912>; Department of Health and Recreation, Faculty of Sport Science, Universitas Negeri Padang, Jl. Prof. Dr. Hamka No.1, Air Tawar Bar., Kec. Padang Utara, Kota Padang, Sumatera Barat 25173, Indonesia.

Mario, Deby Tri: debytrimario91@gmail.com; <https://orcid.org/0000-0002-1945-7276>; Doctoral Program of Sport Science, Faculty of Sport Science, Universitas Negeri Padang, Jl. Prof. Dr. Hamka No.1, Air Tawar Bar., Kec. Padang Utara, Kota Padang, Sumatera Barat 25173, Indonesia.

Handayani, Sri Gusti: srigusti@fik.unp.ac.id; <https://orcid.org/0000-0002-6939-8876>; Department of Sport Education, Faculty of Sport Science, Universitas Negeri Padang, Jl. Prof. Dr. Hamka No.1, Air Tawar Bar., Kec. Padang Utara, Kota Padang, Sumatera Barat 25173, Indonesia.

Erianjoni: erianjoni@fis.unp.ac.id; <https://orcid.org/0009-0002-5854-8784>; Department of Sociology, Faculty of Social Science, Universitas Negeri Padang, Jl. Prof. Dr. Hamka No.1, Air Tawar Bar., Kec. Padang Utara, Kota Padang, Sumatera Barat 25173, Indonesia.

Cite this article as: Komaini, A., Kiram, Y., Gusril, Mario, D.T., Handayani, S.G., & Erianjoni (2023). Fundamental Movement Skills in Children in Mentawai Islands: Indigenous Tribes in Indonesia. *Physical Education Theory and Methodology*, 23(4), 520–530. <https://doi.org/10.17309/tmf.2023.4.05>

Received: 03.03.2023. Accepted: 14.07.2023. Published: 30.08.2023

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PLYOMETRIC HURDLE JUMP TRAINING USING BEACH SAND MEDIA INCREASES POWER AND MUSCLE STRENGTH IN YOUNG ADULT MALES

Arif Bulqini^{1ABDE}, Achmad Widodo^{1ABD}, Nurhasan^{1ABD}, Heriyanto Nur Muhammad^{1BD},
Shidqi Hamdi Pratama Putera^{1BD} and Anindya Maratus Sholikhah^{1CD}

¹Universitas Negeri Surabaya

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Arif Bulqini, E-mail: arif.20009@mhs.unesa.ac.id

Accepted for Publication: July 14, 2023

Published: August 30, 2023

DOI: 10.17309/tmfv.2023.4.06

Abstract

The study purpose was to analyze the effectiveness of the different effects of knee tuck jump and hurdle jump plyometric training using beach sand on power and leg muscle strength in young adult males.

Materials and methods. A total of 30 young adult males were enrolled in this study and were given plyometric knee tuck jump training (KTJT), and plyometric hurdle jump training (HJPT). Plyometric training is carried out with an intensity of 80-100% of 1RM, three sets with 12 repetitions each set, with a frequency of three times each week for six weeks. The measurement of leg muscle power uses the Jump Meter Digital (MD) Test, while the measurement of leg muscle strength uses the Back & Leg Dynamometer. Statistical analysis used one-way ANOVA and continued with the Least Significant Difference (LSD) post hoc test.

Results. The results of the analysis are as follows: the mean Δ increase in muscle power on CTRL (12.92 ± 2.51 joule) vs. KTJT (142.88 ± 35.21 joule) vs. HJPT (269.49 ± 138.06 joule), ($p=0.000$). The mean Δ increase in muscle strength on CTRL (11.61 ± 1.49 kg) vs. KTJT (75.49 ± 18.53 kg) vs. HJPT (137.43 ± 34.13 kg), ($p=0.000$).

Conclusions. Based on the results of the study, it was concluded that both types of plyometric training improve power and strength in young adult males.

Keywords: plyometric training, power, strength, muscle strength, young adult.

Introduction

Currently, the development of sports is not only pursued by a minority group, but sports have a wide range of lives and actively contribute to physical and spiritual training (Jona & Okuo, 2013). Because sports have several goals: leisure, health, education, and competitive sports, yet, due to some of these goals, sports achievement is the most sought-after as it aims to seek achievement/champions in sports (Malm et al., 2019). Achieving optimal performance requires programmed, regular, measurable, and continuous exercises involving various disciplines of science and technology (Adams et al., 2018).

Physical condition plays a dominant role in improving the performance and outcomes of athletes and non-athletes in popular sports (Xu, 2015). Good physical condition positively contributes to mass sports athletes mastering

excellent, precise techniques and tactics (Malm et al., 2019). In addition, the good physical condition will have a positive impact on improving mental health and being able to produce effective and efficient movement patterns (Falch et al., 2022). Therefore, the physical condition needs crucial attention because it affects the athlete's motor skills. According to Bafirman & Wahyuri (2018), physical condition is an indispensable prerequisite in efforts to increase performance and can even be said to be a basic need that cannot be postponed by an athlete. In line with Bompa & Buzzichelli (2019), achieving achievement is determined by four training factors, namely physical preparation, technical preparation, tactical preparation, and mental preparation.

One of the efforts to achieve prime health conditions and optimal performance in sports is to have a good physical condition (Malm et al., 2019). This is because physical condition is the basis for achieving optimal skills (Adams et al., 2018). Without good physical condition, it is hard to achieve peak fitness and optimal performance, as completing a training program is hampered (Malm et al., 2019). Leg muscle power is an integral part of generating

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strength, so it is an important component for athletes to express high levels of strength in dynamic movements ($\text{Power} = \text{Force} \times \text{Velocity}$) (Falch et al., 2022). Leg muscle power and strength training can induce neuromuscular adaptation in both adolescents and adults (Hammami et al., 2018). One of the training methods to increase leg muscle power and strength using self-weight is plyometric training (Davies et al., 2015). Plyometric training is very effective and efficient because it can help improve the achievement of excellent physical conditions in sports (Slimani et al., 2016). Plyometric training can be used by athletes in all sports, to improve their physical condition. To improve skills and physical conditions plyometric training has a significant impact on bio motor components, such as speed, strength, and agility (Arafat et al., 2018). This was evident by Godara (2016), who reported that plyometric training significantly increased strength by 15.44%, muscle endurance by 12.46%, speed by 11.13%, agility by 1.27%, and flexibility by 2.15%.

Plyometrics is a type of strength, speed, and agility training that is widely used in team and individual sports to improve sports performance (Ramírez-Campillo et al., 2014). Plyometrics involve multi-joint movements (jumping) that utilize stretch-shortening cycles, muscles are stretched quickly (eccentric phase) and then immediately shortened (concentric phase) (Marzouki et al., 2022). Plyometric training usually involves stopping, starting, and changing direction explosively (Miller et al., 2006). Plyometric training can improve motor skills and body composition, such as optimizing bone health and reducing fat mass (Wang & Zhang, 2016). The results of the research by Silva et al. (2019) reported that plyometric training significantly increases strength and speed, regardless of gender, and age during adolescence, and neuronal, muscular, and hormonal changes occur due to growth spurts that affect adolescent abilities. However, the effects of plyometric knee tuck jump and hurdle jump on power and leg muscle strength in young adult males have not been explored clearly. This study aims to analyze the effectiveness of the different effects of knee tuck jump and hurdle jump plyometric training using beach sand on power and leg muscle strength in young adult males.

Materials and methods

Study participants

This research is a true experimental randomized controlled trial (RCT). A total of 30 young adult males,

age (20.10 ± 1.32 years), normal body mass index ($21.17 \pm 1.35 \text{ kg/m}^2$), normal blood pressure (systolic: $115.23 \pm 5.48 \text{ mmHg}$; diastolic: $75.83 \pm 4.03 \text{ mmHg}$), resting heart normal rate ($64.23 \pm 5.41 \text{ bpm}$), normal oxygen saturation ($97.30 \pm 1.42 \%$) voluntarily participated in the study. Respondents were randomly divided into three experimental groups: CTRL (Control group) – $n = 10$; KTJT (Plyometric knee tuck jump training group) – $n = 10$; and HJPT (Plyometric hurdle jump training group) – $n = 10$. The procedures applied in the study complied with the Helsinki World Medical Association Declaration on the ethical conduct of research involving human subjects.

Study organization

The plyometric training intervention program implemented is supervised by professional officers from the Sports Science Fitness Center (SSFC), Universitas Negeri Surabaya. Plyometric training is carried out at the Out Door Sand Field, State University of Surabaya with an intensity of 80-100% 1RM, 3 sets of 12 repetitions, frequency 3x/week for 6 weeks. Warming up and cooling down were each carried out for 5 minutes with an low-intensity of 50-60% HRmax (Sugiharto et al., 2023; Pranoto et al., 2023) muscles undergo a rapid elongation followed by an immediate shortening (stretch-shortening contraction. Monitoring heart rate during plyometric training using polar (Polar H 10 Heart Rate Sensor, USA. Inc) (Susanto et al., 2023; Pranoto et al., 2023) muscles undergo a rapid elongation followed by an immediate shortening (stretch-shortening contraction).

Measuring leg muscle power uses the Digital Jump Meter (MD) Test while measuring leg muscle strength uses a Back & Leg Dynamometer (Putera et al., 2023) muscles undergo a rapid elongation followed by an immediate shortening (stretch-shortening contraction). Measurements of leg muscle power and leg muscle strength were carried out twice, namely 30 minutes pre-training and 1x24 hours after 5 weeks post-training at SSFC Universitas Negeri Surabaya.

Statistical analysis

Data analysis techniques used the Statistical Package for Social Science (SPSS) software version 21.0. The normality test was used to test the normality of the data using Shapiro-Wilk, while Levene's test was used to test whether the data came from populations with the same variance (homogeneity). The difference test was applied using a paired

Table 1. Criteria for research subjects

Variable	CTRL	KTJT	HJPT	p-value
Age (years)	20.00 $\pm$ 1.49	20.20 $\pm$ 1.32	20.10 $\pm$ 1.29	0.948
Body height (m)	1.66 $\pm$ 0.05	1.64 $\pm$ 0.03	1.65 $\pm$ 0.06	0.441
Body weight (kg)	58.80 $\pm$ 7.05	57.60 $\pm$ 5.34	57.30 $\pm$ 3.77	0.816
Body mass index (kg/m^2)	21.19 $\pm$ 1.44	21.51 $\pm$ 1.72	20.82 $\pm$ 0.76	0.538
Systolic blood pressure (mmHg)	115.80 $\pm$ 3.71	114.80 $\pm$ 7.98	115.10 $\pm$ 4.33	0.921
Diastolic blood pressure (mmHg)	76.00 $\pm$ 3.56	76.00 $\pm$ 4.39	75.50 $\pm$ 4.48	0.953
Resting heart rate (bpm)	63.90 $\pm$ 5.51	64.00 $\pm$ 4.99	64.80 $\pm$ 6.19	0.925
Oxygen saturation (%)	97.00 $\pm$ 1.25	97.50 $\pm$ 1.65	97.40 $\pm$ 1.43	0.720

Description: CTRL: Control group; KTJT: Plyometric knee tuck jump training; HJPT: Plyometric hurdle jump training. Presentation of data with Mean and standard deviation (mean $\pm$ SD).

sample t-test, and one-way ANOVA, and continued with the Least Significant Difference (LSD) post hoc test. The data is declared significant if the significant value is 5%.

Results

Based on the results of the analysis, showed that the average criteria for research subjects in the three groups (CTRL, KTJT, HJPT) did not show any significant differences which can be seen in Table 1 below. The results of the analysis of power and muscle strength before and after the intervention for 5 weeks can be seen in Figure 1, while the results of the analysis of power and muscle strength between groups (CTRL vs. KTJT vs. HJPT) can be seen in Table 1.

Discussions

This study aims to analyze the effectiveness of the different effects of knee tuck jump and hurdle jump plyometric

training using beach sand on power and leg muscle strength in young adult males. The main finding of this study was the effect of plyometric training of knee tuck jump and hurdle jump using beach sand on increasing power and leg muscle strength in young adult males (Figure 1, 2, and Table 2). This is in line with research conducted by Puspodari et al. (2022) who reported that training with an intensity of 80% HRmax with a frequency of 3x/week for 8 weeks found a significant increase in muscle power. Likewise, the study conducted by Putera et al. (2023) reported that plyometric training of jumping jacks, countermovement jumps, and tuck jumps carried out for 30 minutes/session, with an intensity of 70-90% 1-RM, a frequency of 3x/week for 6 weeks was effective in increasing leg muscle power, leg muscle strength, and speed. The same results have also been observed that plyometric training also significantly increases strength, speed, and agility in the hamstring and quadriceps muscles before and after plyometric training compared to the non-plyometric training group (Elnaggar et al., 2019). Previous

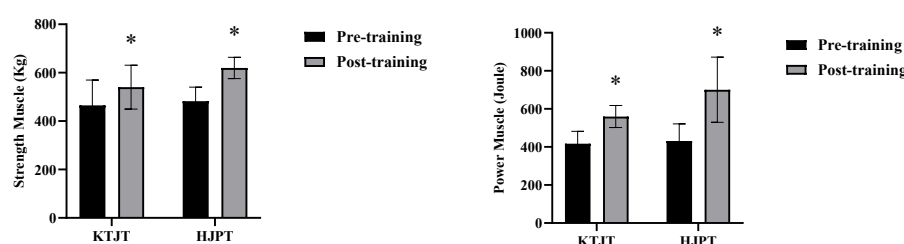


Fig. 1. The results of the analysis of the mean muscle strength between the pre- and post-training.
Description: (*) Significantly different from the pretest ($p \leq 0.001$). Presentation of data with mean±SD. p-value obtained by analysis of Paired Sample T-Test

Table 2. Results of analysis of power and muscle strength between groups (CTRL vs. KTJT vs. HJPT)

Variable	CTRL	KTJT	HJPT	p-value
Pre-training Muscle Power (joule)	436.65±152.12	416.81±65.32	431.11±90.32	0.916
Post-training Muscle Power (joule)	449.57±150.89	559.69±57.84	700.61±171.36*†	0.001
Δ Muscle Power (joule)	12.92±2.51	142.88±35.21*	269.49±138.06*†	0.000
Pre-training Muscle Strength (kg)	490.25±62.79	464.91±104.82	482.55±57.87	0.760
Post-training Muscle Strength (kg)	501.85±62.79	540.39±90.42	619.97±43.98*†	0.002
Δ Muscle Strength (kg)	11.61±1.49	75.49±18.53*	137.43±34.13*†	0.000

Description: CTRL: Control group; KTJT: Plyometric knee tuck jump training; HJPT: Plyometric hurdle jump training. (*)Significantly different at CTRL ($p \leq 0.05$). (†)Significantly different at KTJT ($p \leq 0.05$). Presentation of data with Mean and standard deviation (mean±SD).

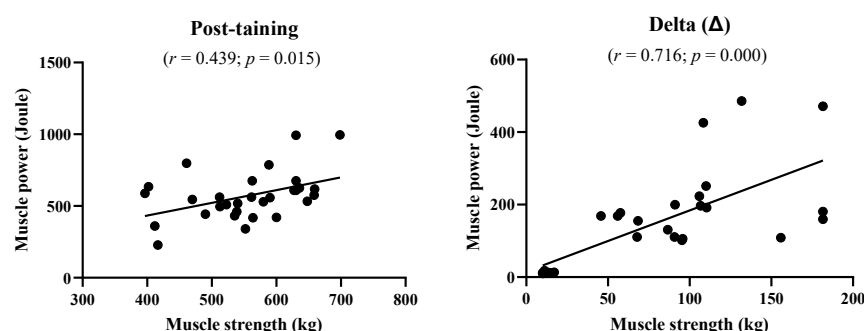


Fig. 2. Results of correlation analysis between muscle strength and muscle power.
Description: p-value was obtained by Pearson's correlation coefficient test ($p \leq 0.05$).

investigations also reported that there was an increase in 10-m, 30-m, and 40-m sprint speeds after undergoing six weeks of plyometric training (Beato et al., 2018). The increase in power and leg muscle strength is most likely due to the intervention factor of plyometric knee tuck jump training with hurdle jump. During plyometric training, there are cycles of shortening and stretching muscle contractions to produce speed and strength, resulting in an adaptation to increase leg muscle power (Turgut et al., 2016; Hrženjak et al., 2016; Bin Shamshuddin et al., 2020).

Plyometric training of knee tuck jumps with hurdle jumps using a sand base can stimulate the muscles to contract more explosively, resulting in a progressive increase in power and leg muscle strength (Kumar, 2015). Constant shifting underfoot involves small stabilizer muscles which can improve balance and reduce the risk of injury (Huxel Bliven & Anderson, 2013). In addition, training using the sand platform can be an option for exercising outside the fun. Sand training is a simple form of resistance training and has a low risk of injury (Ahmadi et al., 2021). Evidence shows that the physiological and biomechanical adaptations that occur during training using sand platforms can positively affect increased physical performance (Ahmadi et al., 2021), reduce the risk of muscle damage and muscle pain, and decrease physical condition (Binnie et al., 2014). The use of sand surfaces during training can increase greater adaptation during the training period and reduce the effects of negative impacts and heavy training loads (Binnie et al., 2013).

Plyometric training is an effective method for explosively developing the lower limbs and can optimize various dependent variables such as leg muscle strength, speed, and power (Buckthorpe & Della Villa, 2021). Plyometric training can be done on one leg or two legs. Plyometric training performed on one leg has a low impact on strength and movement speed (Kariyama et al., 2011), whereas plyometric training using two legs will provide a higher output on the hips so that it will have a much higher impact on strength and speed, and leg muscle power (Makaruk et al., 2011; Bubanj et al., 2010). Donald et al. (2013) in his study emphasized that plyometric training is an effective training program for increasing leg muscle power and strength. Fischetti et al. (2018) also confirmed that the minimum duration of plyometric training to produce a significant increase in leg muscle power and speed is six weeks.

Conclusions

Based on the research results, it can be concluded that both types of plyometric training increase muscle power and muscle strength, but plyometric hurdle jump training is more effective in increasing muscle power and muscle strength than plyometric knee tuck jump training in young adult males. This study found a positive relationship between increased muscle strength and muscle power.

Conflict of Interest

The authors declare that there is no conflict of interest.

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ПЛІОМЕТРИЧНІ ТРЕНУВАННЯ ЗІ СТИБКІВ ЧЕРЕЗ ПЕРЕШКОДУ З ВИКОРИСТАННЯМ ПЛЯЖНОГО ПІСКУ ПІДВИЩУЮТЬ ПОТУЖНІСТЬ І СИЛУ М'ЯЗІВ У МОЛОДИХ ЛЮДЕЙ ЧОЛОВІЧОЇ СТАТІ

Аріф Булкіні^{1ABDE}, Ахмад Відодо^{1ABD}, Нурхасан^{1ABD}, Херіянто Нур Мухаммад^{1BD}, Шадкі Хамді Пратама Путера^{1BD}, Аніндья Маркатус Шоліхах^{1CD}

¹Сурабайський державний університет

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 8 с., 4 табл., 3 рис., 58 джерел.

Метою дослідження було проаналізувати ефективність різних впливів пліометричних тренувань зі стрибків зігнувши ноги та стрибків через перешкоду з використанням пляжного піску на потужність і силу м'язів ніг у молодих людей чоловічої статі.

Матеріали та методи. До участі в цьому дослідженні було включено загалом 30 молодих людей чоловічої статі, які проходили курси пліометричних тренувань зі стрибків зігнувши ноги (ТСЗН) та пліометричних тренувань зі стрибків через перешкоду (ТСЧП). Пліометричні тренування проводять з інтенсивністю 80-100% одного повторення з максимальною вагою (1RM), три підходи по 12 повторень за підхід, із частотою три рази на тиждень протягом шести тижнів. Для вимірювання потужності м'язів ніг використовують тест на стрибок угору із цифровим вимірювачем висоти стрибка, а для вимірювання сили м'язів ніг використовують динамометр для м'язів спини та ніг. Для статистичного аналізу використовували однофакторний дисперсійний аналіз, після чого за одержаними результатами проводили апостеріорний тест на визначення найменшої значущої різниці (HЗР).

Результати. Результати аналізу є такими: середнє Δ збільшення потужності м'язів у контрольній групі ($12,92 \pm 2,51$ джоуля) порівняно з ТСЗН ($142,88 \pm 35,21$ джоуля) порівняно з ТСЧП ($269,49 \pm 138,06$ джоуля), ($p=0,000$). Середнє Δ збільшення сили м'язів у контрольній групі ($11,61 \pm 1,49$ кг) порівняно з ТСЗН ($75,49 \pm 18,53$ кг) порівняно з ТСЧП ($137,43 \pm 34,13$ кг), ($p=0,000$).

Висновки. На підставі результатів дослідження було зроблено висновок про те, що обидва типи пліометричних тренувань збільшують потужність і силу в молодих людей чоловічої статі.

Ключові слова: пліометричні тренування, потужність, сила, сила м'язів, молода людина.

Information about the authors:

Bulqini, Arif: arif.20009@mhs.unesa.ac.id; <https://orcid.org/0009-0009-6029-5799>; Doctoral Program of Sport Science, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Widodo, Achmad: achmadwidodo@unesa.ac.id; <https://orcid.org/0000-0002-3545-9837>; Department of Sport Science, Faculty of Sport and Health Sciences, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Nurhasan: nurhasan007@unesa.ac.id; <https://orcid.org/0000-0002-9192-2072>; Postgraduate Program of Sport Science, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Muhammad, Heriyanto Nur: heryantomuhammad@unesa.ac.id; <https://orcid.org/0000-0001-8878-3991>; Department of Physical Education, Health and Recreation, Faculty of Sport and Health Sciences, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Putera, Shidqi Hamdi Pratama: shidqi.20002@mhs.unesa.ac.id; <https://orcid.org/0000-0001-6811-3130>; Doctoral Program of Sport Science, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Sholikhah, Anindya Mar'atus: anindyasholikhah@unesa.ac.id; <https://orcid.org/0000-0003-4783-6182>; Department of Health Education and Recreation, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Cite this article as: Bulqini, A., Widodo, A., Nurhasan, Muhammad, H.N., Putera, S.H.P., & Sholikhah, A.M. (2023). Plyometric Hurdle Jump Training Using Beach Sand Media Increases Power and Muscle Strength in Young Adult Males. *Physical Education Theory and Methodology*, 23(4), 531-536. <https://doi.org/10.17309/tmfv.2023.4.06>

Received: 03.03.2023. Accepted: 14.07.2023. Published: 30.08.2023

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ORIGINAL SCIENTIFIC ARTICLE

EFFECT OF ONLINE VINYASA TRAINING ON HOUSEWIVES' LOWER AND UPPER BODY ENDURANCE: A RANDOMIZED POST-PANDEMIC COVID-19 TRIAL

Vikas Singh^{1ABCD}, Mahendra Kumar Singh^{1ABCD}, Nibu R Krishna^{1ABCD},
Tenzing Norzom Bhutia^{1ABCD}, Rajdeep Das^{1ABCD}, Vasile Catalin Ciocan^{2ACD}
and Ravindra Singh Rajpurohit^{3ACD}

¹Lakshmibai National Institute of Physical Education

²“Vasile Alecsandri” University of Bacău

³Swarnim Gujarat Sports University

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Vikas Singh, E-mail: vikaschoudhary0905@gmail.com

Accepted for Publication: July 14, 2023

Published: August 30, 2023

DOI: 10.17309/tmfv.2023.4.07

Abstract

Study purpose. The COVID-19 pandemic has a considerable impact on social and financial factors in addition to health outcomes. There is, however, still little information available as to how Covid-19 actually impacted housewives. Consequently, this paper aims to provide a new dimension to the study of how vinyasa could support mothers' fitness throughout the pandemic. This study sought to determine whether an online vinyasa programme for 8 weeks during Covid-19 pandemic could significantly influence housewives' upper and lower body muscle endurance.

Materials and methods. 24 housewives (between the ages of 26 and 36) from the NCR region of Delhi participated in the study. The participants were divided at random and put either into the experimental group (vinyasa) or the control group. Both upper and lower body muscular endurance was found to be the health-related variable. The longest-lasting bent knee push-ups were used to gauge upper body muscular endurance, while the longest-lasting bodyweight squat holds over a 90-degree angle were used to gauge lower body muscle endurance.

Results. To analyse the findings, tests were run both prior to and following the training. A substantial difference between the experimental group and control group was found using ANCOVA to compare them to the baseline after 8 weeks.

Conclusions. Thus, it was determined that the online/virtual vinyasa training programme was a successful way for housewives to increase their body muscular endurance (health-related fitness).

Keywords: vinyasa, physical fitness, muscular endurance, bent knee push-ups, squat, health-related fitness.

Introduction

“Muscular endurance” refers to a muscle's capacity to work out for a long period of time. You can maintain general health and fitness by having strong muscles (Sissons, 2021). An organism's capacity to sustain itself and contract a muscle or group of muscles against resistance – such as weights or body weight – for a prolonged length of time while worn out or depleted is known as muscular endurance. Endorphins are released when you increase your endurance, which improves

your mood. People who engage in physical activity are better able to manage their chronic illnesses, including anxiety, melancholy, and stress. Health benefits of complementary and alternative therapies that promote increased physical activity and discourage sedentary behaviour have been demonstrated (Keadle et al., 2017).

Yoga is comes from the Sanskrit root word yuj, which denotes the union of personal and cosmic consciousness. Yoga's original meaning is to understand one's own life's purpose (Singh, 2018). According to Maehle's definition of vinyasa from 2007, it is “sequential movement that connects postures to produce a continuous flow.” Vinyasa is a technique of motion meditation that makes all forms appear transient and warns against clinging to them. One

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should pay close attention to their breathing rhythm while practising vinyasa. Many research have demonstrated that practising yoga improves a number of both psychological and physical aspects (Singh et al., 2022). Vinyasa yoga, a style of Hatha yoga that places an emphasis on systematic practise (Beth et al., 2012) In essence, it is a powerful form built on a fast flow of sun salutations that are timed with breath. The popularity of this type of yoga has increased over the past few decades due to both its effectiveness and its flair. Studies show that the cardiovascular fitness profiles of yogis and runners are comparable, and sun salutations increase heart rate into zones associated with cardiovascular endurance. Yoga has also been employed as a complementary therapy for the treatment of insomnia, anxiety, and depression (Choi et al., 2018). Vinyasa yoga practise on a regular basis can improve general health and aerobic fitness (Tsopanidou, et al., 2020).

According to earlier studies (Fillmore et al., 2010), yoga can improve adolescent girls' balance, flexibility, and strength. It can also raise abdominal strength and improve body composition and cardiorespiratory fitness (Boraczyski et al., 2020). Despite the positive study outcomes, nothing is known about the short-term (8 weeks/6 weeks) impacts of online vinyasa training. Additionally, there is a dearth of evidence on the effectiveness of an online vinyasa training programme (8 weeks) on lower body muscular endurance.

Therefore, the purpose of this study was to determine whether an 8-week vinyasa programme had any impact on housewives' ability to maintain muscle endurance in their upper and lower bodies (health related fitness). In comparison to the control group, the study intends to determine whether an online vinyasa training programme has a significant influence on the upper body and lower body muscle endurance of the experimental group.

Purpose of the study. The current study's objective was to determine the effects of an eight-week online vinyasa training programme on housewives' upper and lower body muscular endurance after Post-Pandemic Covid-19.

Materials and methods

Study participants

In the present study 24 housewives (between the ages of 26 and 36) from Delhi's National Capital Territory participated in the study; none of them had ever received

official training. They readily agreed to engage in training after being informed about the procedure and any risks involved with the intervention/data collection. They also signed a written consent form. Following that, the participants were randomly split into two groups experimental (Vinyasa) and control (daily schedule). The health-related variable selected was muscular endurance. The longest body-weighted squat holding at 90 degrees were used to assess lower-body muscular endurance, whereas the longest bend knee push-up holds were used to assess upper-body endurance. Tests were run both before and after training to evaluate the outcomes. Subjects for this study had to be free of any recent practice that would have affected the training programme or collection of data in order to be eligible for inclusion criteria.

Study organization

To acquaint the participants with test procedures, 3 sessions were held before the intervention began. The subjects learned about the methods for gathering data and conducting training interventions during the familiarisation sessions. 40 training sessions of 30 minutes each made up the 8-week training programme. Each micro-cycle was seen and overseen by the student, and it consisted of five training sessions over the course of seven days (Monday, Tuesday, Wednesday, Thursday, and Friday; Table 1). To avoid interfering with their house's usual Covid-19 programming, the sessions took place in the early morning from 6:15 to 6:45 a.m. and lasted 30 minutes each. The subjects were specifically urged to attend all of scheduled sessions in a special request. Nevertheless, there were a few omissions. Through yogic poses that were intended to be as pleasurable as possible, the training intervention was developed with the aim of strengthening lower body muscular endurance. Two tests were conducted: one before and one after training (0 week apart) (8 weeks). Maximum number of bend knee push-ups were used to measure muscular endurance. A challenging isometric exercise that strengthens lower body is the squat hold. Using a standing body-weighted squat held at 90 degrees for as long as possible, lower body endurance of housewives was measured. The subject's upper body muscular endurance was measured with the ability to perform push-ups with a bent knee. Hands should be placed below shoulders, feet should be crossed, and the person's knees should be on the ground. Keep your back straight and tense your abdominals. As soon as your chest is about

Table 1. The housewives treatment group followed a vinyasa training session during a micro cycle

No.	Test Battery	Rounds	Duration (In Seconds)	Total Time (In Seconds)
1	Surya Namaskar (12 postures)	3	120	360
2	Standing Vinyasa Series (postures 11)	3	110	330
3	Plank Vinyasa Series (postures 5)	3	50	150
4	Prone Vinyasa Series (postures 7)	3	70	210
5	Supine Vinyasa Series (postures 5)	3	50	150

Note: Each subject was allowed to relax in Savasana for 3 minutes after performing every round of all the test batteries. 6 min (360 sec.).

Each position: 10 sec.

Asana Practice: 20 min (1200 sec).

Total training program schedule: 26 min (1560 sec).

parallel to the floor, start bending your elbows. Then, after a small break, return to the starting position. A squat hold was used to assess the subject's lower body muscular endurance with the ability to maintain their lower body muscles. The person should stand comfortably with his or her feet shoulder-width apart while slightly turned out. Set the shoulders and tense the midsection. Push your legs out and over your toes as you slowly crouch down while raising your arms forward in front of the chest. Squat until your waist line is well below knee level and keep your arms in front of you to stay balanced and stable. For the next few minutes, maintain this position, making sure your breathing is not difficult. Data was quickly obtained when the researcher did the test and showed it online (side angle view). The longest amount of time was required for subjects to hold a 90-degree squat position.

Training Method – The researcher himself taught Vinyasa and oversaw the practise sessions, with the assistance of an assistant to monitor the online class, which was run using the Zoom app for the training. Each step was discussed and shown ahead of time for the aim of instructing. The remaining instructions were supplied in the intervals between vinyasa training sessions.

The demographic information as follows:

Table 2. Demographic information of experimental and control group housewives

Group	Gender	Activity	No. of Participants	Percentage (%)
Experimental	Female	Housewives	12	50
Control	Female	Housewives	12	50
		Total	24	100

Statistical analysis

The study used IBM SPSS software (version 20.0.0) to analyse the data with an ANCOVA Single Pre-test and Post-test Group Design. The analyses were done using two groups (experimental and control), $p = 0.05$ was chosen as the statistical significance level.

Results

As stated in the study's objectives, Table 3 and Table 4 shows the descriptive features (mean and standard deviation) of both the experimental and control groups for upper body endurance and lower body endurance respectively. Table 5 and Table 6 shows the adjusted mean and standard error for data on upper body and lower body muscular endurance respectively for both experimental and control groups. The advantage of using the ANCOVA is that the differences in the post testing means are compensated for the initial differences in the scores. In other words, it may be said that the effect of covariate is eliminated in comparing the effectiveness of treatments on the criterion variable. Table 7 shows the findings of the ANCOVA analysis for upper body endurance. Table 8 shows the findings of the ANCOVA analysis for lower body endurance. After 6 weeks, ANCOVA demonstrated a significant difference in the targeted variables (upper body and lower body endurance) in the experimental group compared to the control group.

Table 3. Descriptive statistics of upper body endurance after training

Group	Mean	Std. Deviation	N
Experimental	9.75	1.95	12
Control	4.58	1.08	12
Total	7.16	3.05	24

Table 4. Descriptive statistics of lower body endurance after training

Group	Mean	Std. Deviation	N
Experimental	35.08	3.44	12
Control	21.91	4.64	12
Total	28.5	7.82	24

Table 5. Adjusted mean and standard error for the data on lower body endurance in different groups during

Groups	Mean	Std. Error	95% Confidence Interval	
			Lower bound	Upper bound
Control	21.97	0.77	20.36	23.57
Experimental	35.02	0.77	33.42	36.63

- a. Covariates appearing in the model are evaluated at the following values: Pre_Squat = 21.66.
b. Values have been rounded off

Table 6. Adjusted mean and standard error for the data on lower body endurance in different groups during

Groups	Mean	Std. Error	95% Confidence Interval	
			Lower bound	Upper bound
Control	9.792	.470	8.814	10.769
Experimental	4.542	.470	3.564	5.519

- a. Covariates appearing in the model are evaluated at the following values: Pre Knee Push-up = 4.00.
b. Values have been rounded off

Table 7. ANCOVA Table of upper body endurance After Training

Source	Type I Sum of Squares	Df	Mean Square	F	Sig.
Pre_Test	3.500	1	3.500	1.353	.258
Groups	157.500	1	157.500	60.874	.000
Error	54.333	21	2.587		
Corrected Total	215.333	23			

- a. R Squared = .748 (Adjusted R Squared = .724)
b. Computed using alpha = .05

Table 8. ANCOVA Table of lower body endurance After Training

Source	Type I Sum of Squares	Df	Mean Square	F	Sig.
Pre_Test	235.18	1	235.18	32.85	.00
Groups	1022.48	1	1022.48	142.82	.00
Error	150.33	21	7.15		
Corrected Total	1408	23			

- a. R Squared = .893 (Adjusted R Squared = .883)
b. Computed using alpha = .05

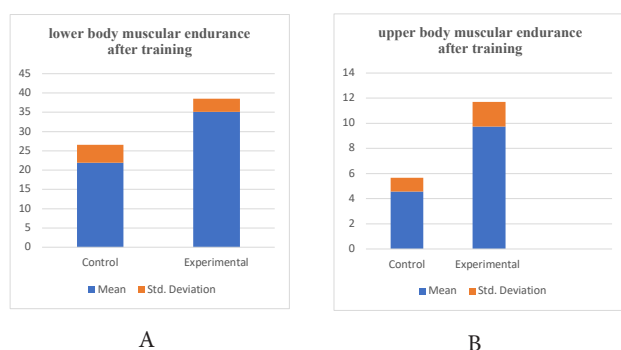


Fig. 1. Graphical representation of mean and standard deviation of (A) lower body muscular endurance among control and experimental group (B) upper body muscular endurance among control and experimental group

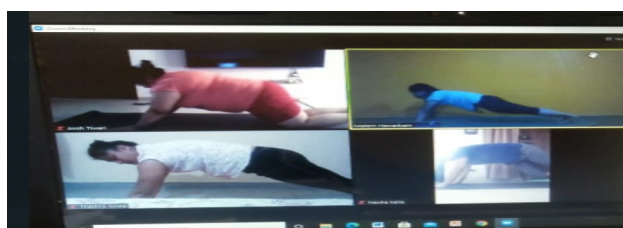


Fig. 2. Participants treatment group following online vinyasa training session during a micro cycle

Discussion

The current study's statistical results showed that an 8-week Vinyasa Training Program is beneficial in boosting housewives' upper body muscular endurance and lower body muscular endurance. The ANCOVA test for dependent variables revealed a significant difference in upper body muscular endurance as well as in lower body muscular endurance between the control and experimental training groups of women in Delhi's NCR region. The findings of our investigation are backed up by the findings of a previous study. Preliminary evidence of increases in strength, balance, aerobic fitness, and self-rated health following yoga practise has been published recently (Singh et al., 2021; Patel et al., 2012). These advantages may be especially important for persons who are unable or unwilling to engage in aerobic or resistance programs and activities. Cardiorespiratory endurance, muscular strength and endurance, and flexibility are all improved in Chinese adults after a 12-week Hatha yoga intervention (Lau et al., 2015). A systematic yoga practice increases upper-limb and abdominal muscular endurance. Muscle endurance is improved through isometric contractions in yoga postures (Shiraishi, 2016).

According to the results of our study, subjects who participated in an online vinyasa programme improved in a both upper body and lower body muscular endurance variable than those who did not. This may be explained in part by the fact that the women in our study were sedentary housewives with no prior experience with structured training. Furthermore, the structured vinyasa training programme may have aided housewives in improving the identified regulation, resulting in an increase in the motivation to put in more effort (Patel et al., 2012). The vinyasa programme,

which took place five days a week, may have provided enough stimulation to boost housewives' overall health capacities. Additionally, it's worth noting that even a short intervention of 8 weeks was enough to improve muscular endurance. In reality, it is well recognised that when a new stimulus is used as a training intervention, the greatest advantage can be obtained.

Previous research has also revealed efficacy of a 6-week Vinyasa Yoga Training Programme (VYTP) in improving dynamic body balance of male national level yoga players and it was observed that the male national yoga players had a substantial difference in dynamic body balance compared to the control group (Singh et al., 2022) and in other study it was found (Singh, et al., 2015) that an 8-week yoga training programme had a substantial impact on female hockey players' physical strength, endurance, flexibility, and agility. According to (Hosseini et al., 2018), prescription regular exercise regimens with controlled intensity and time, particularly resistance training and hatha yoga training, can enhance lower limb strength and balance in multiple sclerosis patients. Handgrip strength (Madanmohan et al., 1992), muscular endurance (Ray et al., 1986), flexibility (Gharote & Ganguly, 1979), and maximal oxygen uptake (VO_{2max}) have all been demonstrated to improve with yoga practice (Balasubramanian & Pansare, 1991). As a result, these data may support the argument that inactive people might improve their general physical fitness, cardiovascular health, and psychological well-being by practising Vinyasa yoga (Choi et al., 2018).

Conclusions

The current study is a noteworthy attempt to determine whether an 8-week online vinyasa training programme is useful in enhancing lower body muscular endurance in housewives during Post-Pandemic Covid-19. The results showed that there was a significant difference ($p < 0.05$) between the control and experimental groups after the implementation of the "8 week vinyasa training plan," rejecting the null hypothesis. Following are some recommendations given in light of the findings: The research could be useful in determining the impact of Vinyasa on other factors besides muscular endurance. The study's findings could help people understand Vinyasa yoga in a more authentic way. The research can be done on people of all ages and genders. A comparable study might be conducted by lengthening the training regimen under controlled settings. The findings of the study may be useful to ordinary people as well as athletes, particularly during pandemics like COVID-19 and also recommended to do for general health development, when we are advised to stay at home and stay healthy by practising Vinyasa yoga.

Acknowledgment

We are grateful to the Department of Yogic Science for their assistance in developing the vinyasa training programme.

Conflict of interest

Authors have no conflicts of interest to declare.

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ВПЛИВ ОНЛАЙН-ЗАНЯТЬ ВІНЬЯСА-ЙОГОЮ НА ВИТРИВАЛІСТЬ НИЖНЬОЇ ТА ВЕРХНЬОЇ ЧАСТИНИ ТІЛА ДОМОГОСПОДАРОК: РАНДОМІЗОВАНЕ ДОСЛІДЖЕННЯ В ПЕРІОД ПІСЛЯ ПАНДЕМІЇ COVID-19

Вікас Сінгх^{1ABCD}, Махендра Кумар Сінгх^{1ABCD}, Нібу Р. Кришна^{1ABCD},
Тензін Норзом Бхутія^{1ABCD}, Дас Раджееп^{1ABCD}, Васіле Каталін Чіокан^{2ACD},
Равіндра Сінгх Раджпурохіт^{3ACD}

¹Національний інститут фізичного виховання імені Лакшмі Бай

²Університет імені Василе Александрі в Бакеу

³Університет спорту Сварнім в Гуджараті

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 6 с., 8 табл., 2 рис., 19 джерел.

Мета дослідження. Пандемія COVID-19 має значний вплив на соціальні та фінансові фактори, окрім наслідків для здоров'я. Однак поки що мало інформації про те, як Covid-19 насправді вплинув на домогосподарок. Отже, метою цієї статті є забезпечення нового виміру дослідженню того, як віньяса-йога могла підтримувати фізичну форму матерів протягом пандемії. Метою цього дослідження було визначити, чи могла онлайн-програма занять віньяса-йоогою протягом 8 тижнів під час COVID-19 суттєво вплинути на витривалість м'язів верхньої та нижньої частини тіла домогосподарок.

Матеріали та методи. У дослідженні взяли участь 24 домогосподарки (віком від 26 до 36 років) з Національного столичного регіону Делі (Індія). Учасниць розподілили випадковим чином до експериментальної групи (віньяса-йога) або до контрольної групи. Установлено, що м'язова витривалість як верхньої, так і нижньої частини тіла є змінною, пов'язаною зі здоров'ям. Найтриваліші віджимання на колінах використовували для вимірювання витривалості м'язів верхньої частини тіла, тоді як найтриваліші утримання присіду із власною вагою під кутом 90 градусів використовували для вимірювання витривалості м'язів нижньої частини тіла.

Результати. Для аналізу отриманих результатів були проведені тести до та після тренування. Між експериментальною та контрольною групою було виявлено значну різницю за допомогою коваріаційного аналізу, який використовували для їх порівняння із вихідним рівнем через 8 тижнів.

Висновки. Таким чином, було визначено, що онлайн/віртуальна програма занять віньяса-йоогою є успішним способом для домогосподарок підвищити м'язову витривалість свого тіла (фізичну витривалість).

Ключові слова: віньяса-йога, фізична підготовленість, м'язова витривалість, віджимання на колінах, присід, фізична витривалість.

Information about the authors:

Singh, Vikas: vikaschoudhary0905@gmail.com; <https://orcid.org/0000-0001-7249-5370>; Department of Sport Psychology, Lakshmibai National Institute of Physical Education, Shakti Nagar, Mela Road, Gwalior, 474002, India.

Singh, Mahendra Kumar: mahendra30singh@yahoo.com; <https://orcid.org/0000-0001-9989-9420>; Department of Sport Psychology, Lakshmibai National Institute of Physical Education, Shakti Nagar, Mela Road, Gwalior, 474002, India.

Krishna, Nibu R.: nrkrishna@lnipe.edu.in; <https://orcid.org/0000-0003-2647-3909>; Department of Yogic Sciences, Lakshmibai National Institute of Physical Education, Shakti Nagar, Mela Road, Gwalior, 474002, India.

Bhutia, Tenzing Norzom: norzomtenzing07@gmail.com; <https://orcid.org/0000-0003-3141-6503>; Research Scholar, Department of Sport Psychology, Lakshmibai National Institute of Physical Education, Shakti Nagar, Mela Road, Gwalior, 474002, India.

Das, Rajdeep: rjdpdas94@gmail.com; <https://orcid.org/0000-0001-7837-3702>; Department of Exercise Physiology, Lakshmibai National Institute of Physical Education, Shakti Nagar, Mela Road, Gwalior, 474002, India.

Ciocan, Vasile Catalin: ciocan.catalin@ub.ro; <https://orcid.org/0000-0003-4357-0882>; Department of Physical Education and Sports Performance Faculty of Movement, Sport and Health Sciences, "Vasile Alecsandri" University of Bacău, Calea Mărășești 157, Bacău 600115, Romania.

Rajpurohit, Ravindra Singh: assistantprofessor.atc.sgsu@gmail.com; <https://orcid.org/0009-0005-8726-3616>; Department of Advance Training and Coaching, Swarnim Gujarat Sports University, Opp Taluka Seva Sadan Desai, Nr. Valavav Crossroad At Post-Desai Taluka, Dist, Desai, Gujarat 391774, India.

Cite this article as: Singh, V., Singh, M.K., Krishna, N.R., Bhutia, T.N., Das, R., Ciocan, V.C., & Rajpurohit, R.S. (2023). Effect of Online Vinyasa Training on Housewives' Lower and Upper Body Endurance: A Randomized Post-Pandemic Covid-19 Trial. *Physical Education Theory and Methodology*, 23(4), 537-542. <https://doi.org/10.17309/tmf.2023.4.07>

Received: 18.04.2023. Accepted: 14.07.2023. Published: 30.08.2023

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THE COACH LEADERSHIP STYLE: HOW IT IMPACTS ON THE SPORTS COMMITMENT AND PLAYING SKILLS OF STUDENT TENNIS ATHLETES?

Setiyo Hartoto^{1ABCD E}, Mochamad Ridwan^{1ABCD E}, Dony Andrijanto^{1BDE},
Joesoef Roepajadi^{1BD}, Muhamad Asrul Sidik^{1BE}, Armando Monterrosa-Quintero^{2ACD},
Dan Iulian Alexe^{3ACD}, Dragos Ioan Tohanean^{4ACD} and Edi Setiawan^{5ACD}

¹Universitas Negeri Surabaya

²Universidad Surcolombiana

³University of Bacau,

⁴Transilvania University of Brasov

⁵Universitas Suryakencana

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Setiyo Hartoto, E-mail: setiyohartoto@unesa.ac.id

Accepted for Publication: July 14, 2023

Published: August 30, 2023

DOI: 10.17309/tmf.v.2023.4.08

Abstract

Study purpose. The objective of this study was to investigate the effect of the coach's leadership style model on increasing the level of sports commitment and tennis skills.

Materials and methods. A mixed method was applied in this study. The participants (n=30) were student athletes at Surabaya State University. This study used the quantitative instrument which used the sports commitment grade scale to assess the level of sports commitment, the forehand and backhand tests were used to measure playing skills. While the qualitative instrument used in-depth interviews. The independent sample t-test was used to present differences in sports commitment scores and playing skills before and after the experiment in the experimental and control groups. The paired sample t-test was used to evaluate the effect of the coach's leadership style model on the experimental and control groups. Qualitative statistical analysis used qualitative thematic analysis.

Results. The quantitative study results showed that there was no difference in the level of sports commitment and playing skills between the experimental and control groups before the experiment ($p > 0.05$), but there was a difference after the experiment ($p < 0.05$). The paired sample t-test proved that the effect on increasing sports commitment and playing skills in the experimental group was better than in the control group ($p < 0.05$). In qualitative research, student athletes stated that the coach's leadership style had advantages and disadvantages.

Conclusions. Finally, student athletes emphasized that this program had a real and positive impact on the development of their sports commitment and playing skills.

Keywords: coach's leadership style, sports commitment, tennis skills, mixed method research.

Introduction

Tennis is one of the competitive sports that was negatively affected by the COVID-19 pandemic and there are many coaches make efforts to restore the declining performance of students-athletes so that their performance will be improved

in the future. Data reported the negative impact caused by COVID-19 among student-athletes, included psychological problems (Leyton-Román, de la Vega & Jiménez-Castuera, 2021; Samsudin et al., 2023), until decreased tennis playing skills. To achieve high achievements, psychological factors and skills in playing tennis must be fostered and improved significantly (Sobko, Koliesov & Ulaeva, 2019; Kozina, Yevtyfiyeva, Muszkieta, Krzysztof & Podstawski, 2020; Nugroho, Hidayatullah, Doewes & Purnama 2023).

Sports commitment is one of aspects that has been significantly affected by COVID-19 (Leyton-Román, de

© Hartoto, S., Ridwan, M., Andrijanto, D., Roepajadi, J., Sidik, M.A., Monterrosa-Quintero, A., Alexe, D.I., Tohanean, D.I., & Setiawan, E., 2023.



la Vega & Jiménez-Castuera, 2021), and this is proved by the large number of student-athletes who did not have a commitment to carry out sports post COVID-19. Sports commitment can be interpreted as a psychological state of a person who shows the desire or continuing to be involved in sports activities (Derakhshanpour, Mousavi & Taheri, 2018; Pulido, Sanchez-Oliva, Sanchez-Miguel, Amado & Garcia-Calvo, 2018; Sánchez-Miguel et al., 2019; Notario-Alonso, Prieto-Ayuso, García-Notario & Contreras-Jordán, 2023). According to Hagiwara (2017), sports commitment is a desire and determination to participate in sports activities. With a high level of commitment in student-athletes, they will carry out sports more often, while a low level of commitment will have an impact on the failure and cessation of student-athletes' careers in sports activities (Berki, Pikó & Page, 2020). Previous studies reported that the level of athlete commitment to carry out exercise was a parameter for having good performance potential to achieve higher success than other student athletes (Notario-Alonso, Prieto-Ayuso, García-Notario & Contreras-Jordán, 2023). In addition, according to the research of Ohji et al (2021), there was other benefit of having a commitment which can showed by students-athletes had greater adherence to rehabilitation.

It is needed to focus on the skills of current students-athletes and it must be improved (Tafaqur, Komarudin, Mulyana & Saputra, 2017; Kolman, Huijgen, van Heuvelen, Visscher & Elferink-Gemser, 2022), because it has an important role for students-athletes to achieve high achievements in tennis (Yevtyfiieva, Korobeinik & Kolisnychenko, 2019). According to Ngatman, Guntur, Gani and Broto (2023), the skill that is considered important and must be mastered by every student-athletes in tennis is forehand and backhand. A good playing skill has the potential to support student-athletes in winning the competition (Wang, 2022), whereas student-athletes with poor skills shows low achievement and failure (Nugroho, Hidayatullah, Doewes & Purnama, 2023). According to Xiao, Bai, Geok, Yu & Zhang (2023), nowadays, a student-athlete does not only require excellent physical condition but must be supported with good technical skills. In competitive tennis competition, to improve their skills, student-athletes must undergo various kinds of training guided by a different coach's leadership style.

The coach's leadership style is an important factor in a training activity. Implementing the coach's leadership style could create a fun and meaningful training for the athletes (Lameiras, Martins, Lopes-De-Almedia & García-Mas, 2017). According to Nascimento-Júnior et al (2018), the coach's leadership style has an important role in training sessions to create a conducive environment and can ultimately improve athlete performance. There are five models of coach's leadership styles, namely the training and instruction model, the democratic model, the autocratic model, the social support model and the positive feedback model (de Albuquerque, Scheeren, Vagetti & de Oliveira, 2021). The benefits of leadership style had been well documented in previous studies, for example, it could trigger motivation (Borghi, Borges, Menegassi & Rinaldi, 2017), and higher interaction in athletes, so that they could achieve goals optimally (Kim & Cruz, 2016; Kim, Park, Love & Pang, 2021; Park, Kim, Kim & Kim, 2021). However, other studies show that the coach's leadership style that provided threats and pressure to athletes can trigger stress and failure

(Moreno-Murcia, Hernández, Marín & Nuñez, 2019). Thus, the coach's leadership style during the training process is a parameter for student-athletes to succeed or fail in sports activities (Jin, Kim, Love, Jin & Zhao, 2022).

The data show that research on the coach's leadership style has been researched by previous studies (Shapie, Zenal, Parnabas & Abdullah, 2016; Ekstrand et al., 2018; Syed Ahmad & Parnabas, 2020; Huang, Lee, Lo, Chen & Hsu, 2021; Jawoosh et al., 2022). However, previous studies were carried out through correlation research, considering this gap, this study tried to present a novelty, namely to examine the effect of the coach's leadership style on increasing the level of sports commitment and playing skills in tennis students-athletes through mixed research methods. This research will contribute to the development of sports commitment and playing skills in tennis students in the future. Therefore, this study aims to assess the effect of the coach's leadership style model on increasing the level of sports commitment and playing skills.

Materials and Methods

Study participants

This study involved level 1 student athletes who were active in tennis course. They were male and came from Universitas Negeri Surabaya (n=30), which is one of the reputable universities in Indonesia. Participants were recruited through random sampling; invitations were sent to all student-athletes and only thirty who responded and willing to be involved in all research activities. Before the research was carried out, all participants and their parents were required to sign a statement letter which stated their willingness to become participants in this study. Participants were randomly allocated to the experimental group which had the coach's leadership style program (n=15, age: 19.06 ± 2.7 , weight: 51.43 ± 5.4 kg, height: 1.60 ± 0.5 cm) and the control group (n=15, age: 20.27 ± 0.8 , weight: 52.25 ± 6.8 kg, height: 1.62 ± 0.5 cm).

Instruments

Quantitative Instruments

Sports Commitment. The Sports Commitment Grade Scale was used to assess the level of commitment of athletes in carrying out sports training activities (Leyton-Román, de la Vega & Jiménez-Castuera, 2021). This instrument has two sub-indicators, namely current commitment which consists of 7 question items, for example "I will not quit, even though I experience defeat or injury", and future commitment which consists of 4 question items, for example "I devote 100% of my capability to focus in training activities in the future. To answer all of these question items, we used a Likert scale from 1 = strongly disagree to 5 = strongly agree.

Playing Skills. This instrument used to measure forehand and backhand drive skills which was adopted from the Hewitt test protocol (Nugroho, Hidayatullah, Doewes & Purnama, 2023). The test required participants to carry out forehand and backhand for 3 times, respectively, which targeted to the target number from 1 to 5 in the field. The score was calculated from the total score of the forehand and

backhand strokes. If the ball touched the net or came out of the target scoring area, the participant would get 0 score.

Qualitative Instruments

The qualitative instrument was carried out through in-depth interviews towards experimental group participants for 30 minutes per individual regarding the advantages, disadvantages and impacts of the coach leadership style model program. In addition, the interviews were conducted using Bahasa language and the results were analyzed by the researchers and 3 experts. The in-depth interview instrument has been used by several previous studies and has proven effective in uncovering a phenomenon issue (Gani et al., 2023).

Research Program

This research was conducted in February-March 2023 at Universitas Negeri Surabaya (09/UNESA-02/2023) which followed the rules and guidelines of the World Medical Association Code of Ethics for human subjects. In this mixed research there were several activities, namely carrying out quantitative research through experiments. In the first meeting (February 1, 2023) all participants carried out an initial test for filling in the Sports Commitment Grade Scale and a forehand and backhand skills test from 8.00 to 10.00 am at the Gymnasium Universitas Negeri Surabaya (Indonesia). In the second Meeting (February 3, 2023) the experimental group carried out the coach's leadership style program (training and instruction model, social support model and positive feedback model) and the control group only carried out their daily training activities, these activities were carried out 12th meeting (27 February, 2023). Then the 13th meeting (March 1, 2023) all participants carried out the final test by filling in the Sports Commitment Grade Scale and forehand and backhand test.

Whereas qualitative research was conducted through in-depth interviews on March 3, 2023 from 11.00 to 12.00 noon at the Gymnasium Universitas Negeri Surabaya. All participants from the experimental group were interviewed about the advantages, disadvantages and impacts of using the coach leadership style program. Direct interviews were conducted by the research team to the participants and the results of the interviews were recorded and analyzed.

Intervention Program

The intervention program carried out in this study was to provide a coach leadership style program with training and instruction models, social support models and positive feedback models to participants from meeting 2 to 12. The program was carried out during lectures from 8.00 to 9.00 in the morning at the Gymnasium Universitas Negeri Surabaya. The detail of the coach's leadership style program with training models and instructions presented in Table 1.

Statistical analysis

Quantitative analysis. The data obtained from the experimental research was analyzed with IBM SPSS (Armonk, New York, USA) (Gani et al., 2022). The first data presented statistical descriptive testing mean (M) and standard deviation (SD). The second data presented the results of the data normality test via Shapiro-Wilk ($p > 0.05$). The third data used the Independent sample t-test to present differences in scores before (pre-test) and after (post-test) on sports commitment, forehand and backhand variables in the experimental and control groups ($p < 0.05$). Paired sample t-test was used to see the effect of the coach's leadership style model in the experimental and control groups towards sports commitment and playing skills ($p < 0.05$).

Qualitative analysis. Data from in-depth interviews were analyzed through qualitative thematic (Gani et al., 2022). The thematic analysis procedure is to analyze the interview results based on word by word, the data was sorted based on category, coding, and highlighting based on their similarities and arranged into three major themes. In this study used 3 themes, such as advantages, disadvantages and the impact of the coach's leadership style model program.

Results

Quantitative results

This study shows that all data were normally distributed ($p > 0.05$). Table 2 presents the mean (M) and standard deviation (SD) of the experimental and control groups. Table 3 shows that there was no difference in the values of sports commitment and playing skills in the experimental and

Table 1. Coach's Leadership Style Model Program

Activities	Activity	Duration
Introduction	Before waming-up, coaches create a harmonious atmosphere between coaches and student-athletes	5 minutes
	The coach gives instructions to students-athletes to warm up the head to toe.	
Forehand and Backhand Exercises	Coaches give instructions to student-athletes to perform forehand and backhand movement exercises without rackets.	50 minutes
	The coach instructs student-athletes to perform forehand and backhand movement exercises with rackets.	
	The coach instructs student-athletes to perform forehand and backhand strokes to the cone target	
	The coach instructs the student-athletes to put the ball in the basket using forehand and backhand strokes	
	The coach provides positive attention and feedback to all student-athletes.	
Closing	The coach gives instructions to student-athletes to cool-down all limbs.	5 minutes

Table 2. Statistical descriptive value

Dependent Variable	Measuring unit	Experimental Group (n=15)		Control Group (n=15)	
		Pretest	Posttest	Pretest	Posttest
		M(SD)	M(SD)	M(SD)	M(SD)
Sports Commitment					
Current commitment	Score	23.07±1.43	26.47±1.06	21.73±1.28	22.73±1.53
Future commitment	Score	17.93±1.22	19.27±0.88	17.20±1.01	17.87±0.99
Playing Skills					
Forehand	Score	13.27±0.79	14.60±0.50	11.67±0.81	12.47±1.18
Backhand	Score	11.67±0.90	13.40±0.73	10.33±0.90	11.33±0.81

Table 3. The results of differences sports commitment and playing skills on the experimental (n=15) and control (n=15) groups before (pretest) the experiment

Dependent Variable	Measuring unit	Group	Statistical Indicators		
			M(SD)	t	p
		Sports Commitment			
Current commitment	Score	Experimental	23.07±1.43	1.76	0.089
		Control	22.00±1.85		
Future commitment	Score	Experimental	17.93±1.22	1.78	0.085
		Control	17.20±1.01		
		Playing Skills			
Forehand	Score	Experimental	13.27±0.79	1.80	0.082
		Control	12.53±1.35		
Backhand	Score	Experimental	11.67±0.90	1.69	0.101
		Control	11.07±1.03		

Table 4. The results of differences Sports Commitment and Playing Skills on the experimental (n=15) and control (n=15) groups after (posttest) the experiment

Dependent Variable	Measuring unit	Group	Statistical Indicators		
			M(SD)	t	p
Sports Commitment					
Current commitment	Score	Experimental	26.47±1.06	7.75	0.000
		Control	22.73±1.53		
Future commitment	Score	Experimental	19.27±0.88	4.08	0.000
		Control	17.87±0.99		
Playing Skills					
Forehand	Score	Experimental	14.60±0.50	6.40	0.000
		Control	12.47±1.18		
Backhand	Score	Experimental	13.40±0.73	7.27	0.000
		Control	11.33±0.81		

Table 5. The results of the Paired Samples t-test

Dependent Variable	Measuring unit	Experimental Group (n=15)			Control Group (n=15)		
		Pre-Post	t	p	Pre-Post	t	p
		M(SD)			M(SD)		
Sports Commitment							
Current commitment	Score	3.40±1.63	8.03	0.000	1.00±1.25	3.09	0.008
Future commitment	Score	1.33±0.61	8.36	0.000	0.66±0.81	3.16	0.007
Playing Skills							
Forehand	Score	1.33±0.48	10.58	0.000	0.80±0.86	3.59	0.003
Backhand	Score	1.73±0.45	14.66	0.000	1.00±0.84	4.58	0.000

control groups before the experiment ($p > 0.05$), but there were differences in the values of sports commitment and playing skills after the experiment ($p < 0.05$). Meanwhile, the paired sample t-test proved that the experimental group had a better effect than the control group on increasing sports commitment and playing skills ($p < 0.05$).

Qualitative Results

The results of qualitative research through in-depth interviews obtained the following findings:

Theme 1: Advantages

The advantage is important factor that must be revealed through in-depth interviews with participants. In this case the participants argued that:

"In our opinion, the advantage of the coach's leadership style model program is it can create an interesting training situation, because the trainer provides various kinds of training and instructions to athletes in order to complete several training tasks" (Results of interviews with participants 1, 4, 5, 8, 9, 10, 15).

"Yes!!...It is clear that the coach's leadership style model focuses on giving us several training assignments, so this is an advantage of the model" (Results of interviews with participants 2, 6, 7).

"We believe that this program has many advantages, for example we can do various forehand and backhand training assignments with various variations and even the trainers gave us direct attention and positive feedback" (Results of interviews with participants 3, 6, 11, 12, 13, 14).

Theme 2: Disadvantages

The second theme that should be revealed through this interview is the disadvantages of the coach's leadership style model program. Some participants argued that:

"In our opinion, the drawback in implementing this program is it requires a long duration for training, because the trainer has to provide several training assignments and feedback to individual participants" (Results of interviews with participants 2, 6, 7, 9, 10, 13, 14).

"This training style model will be less effective if it is not supported by adequate facilities such as rackets and balls. Therefore, the facility must be considered." (Results of interviews with participants 1, 3, 4, 5, 6, 8, 9, 11, 12, 15).

Theme 3: Impact program

The last theme related to the impact of the coach's leadership style model program towards sports commitment and tennis skills. Participants argued that:

"This program has a positive impact on us, for example we are more committed to carry out exercises in tennis, which cause our forehand and backhand skills gradually improved" (Results of interviews with participants 4, 7, 9, 12, 13, 14, 15).

"We agree!!...The coach's leadership style model program has significantly impacted on our sports commitment and playing skills, we are more serious and motivated to carry out training activities now and in the future. In addition, we feel that our forehand and backhand skills show an improvement" (Results of interviews with participants 1, 2, 3, 5, 6, 8, 10, 11).

Discussion

Our research aims to assess the effect of implementing the coach's leadership style model program on increasing the level of sports commitment and playing skills among student-athletes.

There are several findings in quantitative study. First, the coach's leadership style model was proven had positive effect in increasing sports commitment among student-athletes. This is because the coach leadership style model has advantages that can create harmonious relationships between coaches and student-athletes, with good relationships, student-athletes could be more enthusiastic, and happy in carrying out training activities (Huang, Lee, Lo, Chen & Hsu, 2021; Romão, Ribeiro, Gomes & Singh, 2022). This was also explained by Nascimento-Júnior et al. (2018) Confirmatory Factor Analysis and Structural Equation Modelling were conducted, as well as Latent Profile Analysis. Results showed significant relationships between leadership style and both social (10%, that coach leadership style has an important role in a training, because it can create cohesiveness and ultimately has the potential to improve team performance. The results of previous studies reported similar results that the coach's leadership behavior was closely related to motivation (Moreno-Murcia, Hernández, Marín & Nuñez, 2019), interaction (Park, Kim, Kim & Kim, 2021) among students-athletes in sports activities. On the other hand, other studies report that the coach's leadership style is an important factor, because it can motivate (Subijana, Martin, Tejon & Cote, 2021), and make student-athletes commit to a sports training activity (De Clerck, Willem, Morbée, Van Dyck & Haerens, 2022).

Second, the coach leadership style model has proven to positively have the strength to improve the playing skills possessed by student-athletes. This is because the coach leadership style model promotes a rich experience or forehand and backhand training assignments for student-athletes. In addition, student-athletes got positive feedback individually, which cause their forehand and backhand technique skills could increase significantly. The result of this study is in line with previous research which reported that the coach's leadership style is unquestionable and has proven to be an effective indicator of improving performance (Bum & Shin, 2015; Shapie, Zenal, Parnabas & Abdullah, 2016) and student-athlete satisfaction in sports activities (Jin, Kim, Love, Jin & Zhao, 2022). Another study explains that the coach leadership style model seeks to improve athlete performance by providing training and instructions on the basic techniques of a sport (Jawoosh et al., 2022). In addition, giving attention and positive feedback is claimed to have the potential to improve movement errors, so that student-athletes can learn movements optimally (de Albuquerque, Scheeren, Vagetti & Oliveira, 2021). Similar results were reported by Fouraki, Stavrou, Apostolidis & Psychountaki (2020), that the coach leadership style has a positive power to influence the performance of bad student-athletes to be good.

Whereas qualitative research through in-depth interviews found that the majority of student-athletes stated that the advantages of the coach leadership style model program could create an interesting training situation because the coach provided various kinds of training and

instructions to athletes in order to complete several training tasks, even the coach paid attention and immediate positive feedback (Soto Garcia, García Herrero, Carcedo & Sánchez García, 2021). Then student-athletes stated that this model also has drawbacks such as requiring a relatively long training time, because the coach has to give several training assignments and feedback to them individually. In addition, this training style model is less effective if it is not supported by adequate facilities such as a relatively large number of rackets and balls. Finally, the student-athletes emphasized that this program had a real and positive impact on the development of their sports commitment and playing skills.

The uniqueness and novelty of the findings of this study is that coach leadership style can promote an increase in the level of sports commitment and playing skills (forehand and backhand) of student-athletes through mixed research methods.

Conclusions

This study concluded that the coach's leadership style model program through this mixed research method is proven to have a positive effect on increasing the level of sports commitment and playing tennis skills of student-athletes. This research contributes to the innovation and development of tennis sports training models, so that coaches can apply them in the present and in the future to obtain high achievements in student-athletes. Although this study has successfully demonstrated that the coach's leadership style has increased the level of sports commitment and tennis skills, it has certain limitation in terms of the limited number of student athletes from one kind of sports which is tennis. Thus, it is recommended that future research needs to be carried out by involving a large number of students-athletes from other sports.

Acknowledgement

We also thank all parties who have contributed to the implementation of this research.

Conflict of Interest

We as the authors of this manuscript emphasize that there is no conflict of interest in this research.

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СТИЛЬ ЛІДЕРСТВА ТРЕНЕРА: ЯК ВІН ВПЛИВАЄ НА ВІДДАНІСТЬ СПОРТУ ТА ІГРОВІ НАВИЧКИ СТУДЕНТІВ-ТЕНІСІСТІВ?

Сетійо Хартото^{1ABCDE}, Мохамад Рідван^{1ABCDE}, Доні Андріджанто^{1BDE},
 Джузуф Рупаяді^{1BD}, Мухаммад Асрул Сідік^{1BE}, Армандо Монтерроса-Кінтеро^{2ACD},
 Ден Юліан Алексе^{3ACD}, Драгос Йоан Тоханян^{4ACD}, Еді Сетіаван^{5ACD}

¹Сурабайський державний університет

²Південно-Колумбійський університет

³Університет імені Василе Александрі в Бакеу

⁴Трансільванський університет Брашова

⁵Університет Сур'яканчана

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 9 с., 5 табл., 40 джерел.

Мета дослідження. Метою цього дослідження було вивчення впливу моделі стилю лідерства тренера на підвищення рівня відданості спорту та навичок гри в теніс.

Матеріали та методи. У цьому дослідженні застосовували змішаний метод. Учасниками (n=30) стали студенти-спортсмени Державного університету Сурабая (Індонезія). У цьому дослідженні використовували кількісний інструмент, який передбачав використання шкали оцінки відданості спорту для оцінки рівня відданості спорту, а для вимірювання навичок гри використовували тести на удари ракеткою справа і зліва. Тоді як якісний інструмент передбачав використання глибинних інтерв'ю. Для представлення відмінностей у показниках відданості спорту й ігрових навичок до та після експерименту в експериментальній і контрольній групах використовували t-критерій Стюдента для незалежних вибірок. Для оцінки впливу моделі стилю лідерства тренера на експериментальну та контрольну групи використовували t-критерій Стюдента для парних вибірок. Для якісного статистичного аналізу використовували якісний тематичний аналіз.

Результати. Результати кількісного дослідження показали, що до початку експерименту різниці в рівні відданості спорту та ігрових навичок між експериментальною та контрольною групами не було ($p > 0,05$), але після завершення експерименту різниця була ($p < 0,05$). За допомогою t-критерію Стюдента для парних вибірок було доведено, що вплив на підвищення рівня відданості спорту й ігрових навичок в експериментальній групі був сильнішим, ніж у контрольній групі ($p < 0,05$). У якісному дослідженні студенти-спортсмени заявили, що стиль лідерства тренера має переваги та недоліки.

Висновки. Зрештою, студенти-спортсмени підкреслили, що ця програма мала реальний і позитивний вплив на розвиток їхньої відданості спорту та їхніх ігрових навичок.

Ключові слова: стиль лідерства тренера, відданість спорту, навички гри в теніс, дослідження з використанням змішаного методу.

Information about the authors:

Hartoto, Setiyo: setiyohartoto@unesa.ac.id; <https://orcid.org/0000-0003-1310-3570>; Faculty of Sport Sciences and Health, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Ridwan, Mochamad: mochamadridwan@unesa.ac.id; <https://orcid.org/0000-0001-7385-0960>; Department of Sports Education, Faculty of Sports Sciences, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Andrijanto, Dony: donyandrijanto@unesa.ac.id; <https://orcid.org/0000-0002-6209-3770>; Faculty of Sport Sciences and Health, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Roepajadi, Joesoef: joesoefroepajadi@unesa.ac.id; <https://orcid.org/0009-0005-7716-7719>; Faculty of Sport Sciences and Health, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Sidik, Muhamad Asrul: muhammadsidik@unesa.ac.id; <https://orcid.org/0009-0004-4282-1007>; Faculty of Sport Sciences and Health, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Monterrosa-Quintero, Armando: armando.monterrosa@usco.edu.co; <https://orcid.org/0000-0002-7150-4834>; Department of Physical Education and Sports, Universidad Surcolombiana, Avenida Pastrana Borrero, Carrera 1, Neiva, Huila, Colombia.

Alexe, Dan Iulian: alexedaniulian@ub.ro; <https://orcid.org/0000-0002-6396-761X>; Faculty of Movement, Sports and Health, Sciences, "Vasile Alecsandri" University of Bacău, Calea Mărășești 157, Bacău 600115, Romania.

Tohanean, Dragos Ioan: dragos.tohanean@unitbv.ro; <https://orcid.org/0000-0002-6740-1867>; Faculty of Physical Education and Mountain Sports, Transilvania University of Brasov, Bulevardul Eroilor 29, 500036, Brasov, Romania.

Setiawan, Edi: edisetiawanmpd@gmail.com; <https://orcid.org/0000-0001-7711-002X>; Faculty of Teacher Training and Education, Universitas Suryakencana, Jl. Pasirgede Raya, Bojongherang, Kec. Cianjur, Kabupaten Cianjur, Jawa Barat 43216, Indonesia.

Cite this article as: Hartoto, S., Ridwan, M., Andrijanto, D., Roepajadi, J., Sidik, M.A., Monterrosa-Quintero, A., Alexe, D.I., Tohanean, D.I., & Setiawan, E. (2023). The Coach Leadership Style: How it Impacts on the Sports Commitment and Playing Skills of Student Tennis Athletes?. *Physical Education Theory and Methodology*, 23(4), 543-551. <https://doi.org/10.17309/tmfv.2023.4.08>

Received: 25.04.2023. Accepted: 14.07.2023. Published: 30.08.2023

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ORIGINAL SCIENTIFIC ARTICLE

COMPARING SITUATIONAL AND MOTOR ABILITIES AMONG KOSOVO JUNIOR BASKETBALL PLAYERS IN SUPER AND UNIQUE LEAGUES

Bujar Begu^{1ABCDE}, Florian Miftari^{1ABCD}, Metin Dalip^{2ABCD} and Labinot Haxhnikaj^{1BCD}

¹University of Pristina "Hasan Pristina"

²University of Tetovo

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Florian Miftari, E-mail: florian.miftari@uni-pr.edu

Accepted for Publication: July 14, 2023

Published: August 30, 2023

DOI: 10.17309/tmfv.2023.4.09

Abstract

Study purpose. The aim of this study is to differentiate the situational and motor abilities between two leagues of junior basketball players in Kosovo. A total of 120 players, aged 18, were assessed in this research, with 60 players belonging to the Super League and the remaining 60 players from the Unique League.

Materials and methods. In this research, the measuring instruments employed included a set of 12 basic motor variables and 5 situational motor variables. To ensure precise speed and agility data, electronic sensors in the form of Witty timer (Microgate) were utilized. The statistical analyses conducted involved the application of the t-test to identify significant differences between the leagues for individual variables, while the canonical discriminant analysis was employed to differentiate between the two leagues based on the comprehensive set of measured variables.

Results. Differences were observed in specific variables, favoring the Super League players in areas such as abdominal muscles endurance ($p < 0.05$) and throwing the medicine ball ($p < 0.01$), while the Unique League players excelled in jump height and agility tests. T-test and discriminant analysis confirmed significant distinctions between the leagues ($p < 0.01$). These findings provide valuable insights into the contrasting abilities of players in the two leagues.

Conclusions. This study found significant differences between the Super League and Unique League among U18 basketball players in Kosovo. The Super League players showed superior performance in explosive upper body strength, repetitive strength, and agility, while the Unique League players displayed higher physical preparedness in basic motor skills.

Keywords: basketball players, age U18, situational and motor abilities, differences between leagues.

Introduction

The basketball game consists of intricate motor movements, with fast movements and runs, high explosive jumps, with different duels during contact with the opponent. Basketball by the nature of moves it consists in the group of complex multi-structural sports, consist of cyclic movements (different types and movements of direction and ball direction) not cyclical (with application of tactical elements and tactical) (Šeparović, 2012). The training and refinement of motor features is carried out during the training process so the main task is the physical preparation of the basketball players. In the theory and practice of basketball, the issues of planning and managing the modern

training process have not been sufficiently studied and do not have adequate scientific substantiation (Koryahin, Blavt, Doroshenko, Prystynskyi, & Stadnyk, 2020). In team sports is essential to optimize the training program through the study and workload analysis (Altavilla, D'Isanto, Raiola, & D'Elia, 2023). In this context, motor abilities refer to a person's potential movement competency and are described as not being directly observable, but are derived from a set of movement tasks (Machowska Krupa & Cych, 2023). Physical training improves the functional state of the organism and all systems, especially the central nervous system. The influence of motor coordination on performance in sports has already been studied by many researchers in many fields (Mullineaux & Uhl, 2010). Basketball as a collective sport should be geared towards maintaining the high level of basic features so that they can be performed quickly during the game, it is the combination of health and skill related aspects

of physical abilities (Kariyawasam, et al., 2019). Explosive strength, jumping power, speed, and agility are crucial factors that significantly contribute to effective movement both with and without the ball. These abilities considerably influence the proper execution of technical and tactical elements and thus also the playing performance of all types of players (guards, forwards and centres) (Erčulj & Bračič, 2007). On the one hand motor skills are genetic while on the other hand they are mainly acquired through the training process. Specific training methods present opportunities to influence the development of these abilities. Motor skill is the basis for any learning of motor tasks of a given technique, so it can be considered to represent a fundamental value in the total human motor skill space (Pržulj, 2006). Motor abilities play an important role in the selection of young basketball players and the progress in their playing performance (Erculj, Blas & Bračič, 2010). Based (Trninić, 1996) Basketball is a game of moves, mistakes, habits, reflexes, reactions, tasks is a game in which players solve typical and atypical problems in game situations, is a game of cooperation and communication, is a game of centimeters and seconds, is a game of timing and space in certain actions. Basketball is both individual and group play, basketball is a game of psycho-motor skills.

Materials and Methods

Study participants

The samples of the entities tested in this research paper in total are 120 active junior players under the age of 18 divided into two leagues by the Basketball Federation of Kosovo. Superleague with six teams on the level of the best quality players who have been selected 60 players from the best teams, and Unique League with five teams who also selected the best 60 players of the teams from this league which are the first in their ranking list on the table of the season 2018-2019.

The total number of sample entities tested in this research are 120 active junior players under the age of 18 of Kosovo teams divided into two leagues. Super league is with six teams' 60 players and unique league is with five teams also 60 players who are the first on the table list of the 2018-2019 season.

Study organisation

Super league U-18-Basketball Club "Keresan Prishtina" from Pristina, Basketball Club "M-Junior" from Pristina, Basketball Club "Prishtina e re" from Pristina, Basketball Club "Trepça" from Mitrovica, Basketball Club "Borea" from Peja, Basketball Club "Vushtrria basket" from Vushtrri.

Unique league U-18-Basketball Club "Z Mobile Prishina" from Pristina, Basketball Club "Penza" from Peja, Basketball Club "Rahoveci" from Rahoveci, Basketball Club "Istogu" from Istogu, Basketball Club "Lipjani" from Lipjan.

Variable samples

In this research paper are included in total 17 variables from basic motor space and situational motor skills and those tests are mainly taken from Eurofit.

Electronic sensors were used to obtain the most accurate running speed and agility data "Witty timer" (Microgate).

In basic motor spaces are treated 12 basic motor tests, and 5 situational motor tests.

Samples of basic motor measuring instruments were treated with 12 basic motor tests and 5 situational motor tests.

Basic motor

Explosive leg strength tests

1. Jump length from the place; 2. Jump high above the place; 3. Jump from the place with the step height.

Speed tests

4. Speed running 10 m; 5. Speed running 20 m.

Repetitive force tests

6. Abdominal muscles 30 sec; 7. Arms push up.

Hand strength tests

8. Throwing the medicinball from the chest;

Test of flexibility

9. Profound warp (flexibility);

Agility tests

10. Line agility test; 11. Illinois agility; 12. 6x5 meters running.

Situational motor

1. Dribble ball 20 m with the right hand;

2. Dribble ball 20 m with left hand;

3. Ball dribble between cones (zig-zag);

4. 6 x 5 meters ball dribble;

5. Illinois agility with ball dribble.

Results

Table 1 presents the basic statistical parameters of distribution results of motor and situational variables of U18 basketball players of super league and the unique league.

If we compare the arithmetic averages of basketball players of super league and unique league the values are roughly similar in this area as well, but some of the variables that are in favor of super league basketball players are: MABMU30'' – Abdominal muscles 30 sec, for (1.91), MARMPUP – arms push up for (35.33), MMEDCH- Throwing the medicinball from the chest for (48.51 cm). While the tests in favor of basketball players of unique league are: MJHULEP- Jump high above the place for (2.41 cm), MPROAR- Profound warp (flexibility) for (1.32 cm), MLAGILT-line agility test for (0.42 sec), SMIABD – Illinois agility with ball dribble for (0.41 sec).

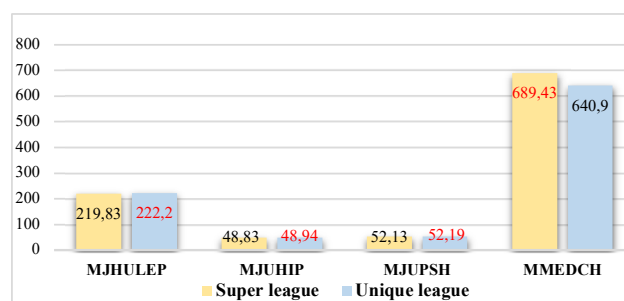
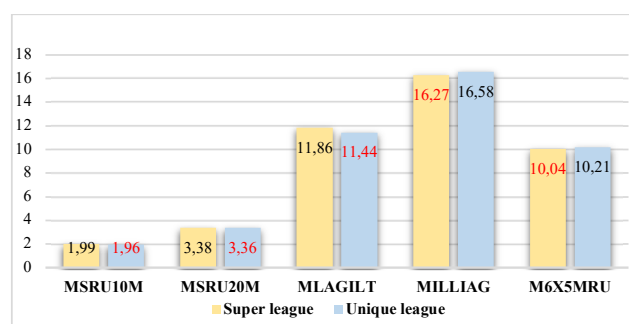
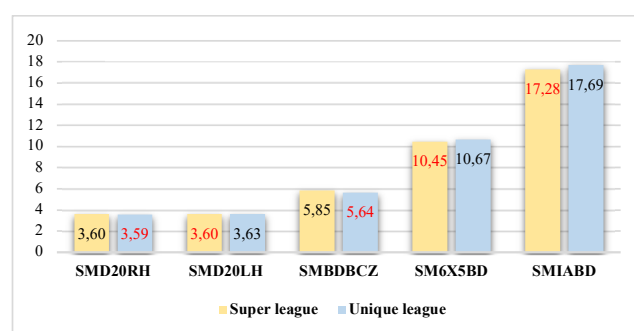
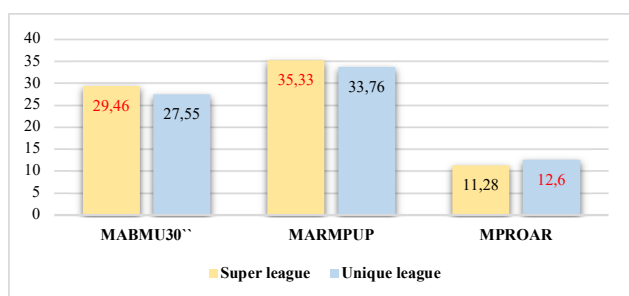


Fig. 1 Evaluation of explosive strength of legs and hands

Table 1. Basic statistical indicators in the motor and situational space of the super league and unique league of basketball players

Variable	Super league, N=60				Unique league, N=60			
	Mean	Min	Max	Std. Dev.	Mean	Min	Max	Std. Dev.
MJHULEP	219.83	187.0	291.0	22.766	222.24	183.0	270.0	21.900
MJUHIP	48.83	30.0	76.0	8.669	48.94	32.0	71.5	7.651
MJUPSH	52.13	35.0	76.0	9.062	52.19	35.0	71.5	7.764
MSRU10M	1.99	1.7	2.3	0.128	1.96	1.8	2.2	0.116
MSRU20M	3.38	2.9	3.8	0.200	3.36	3.1	3.8	0.179
MABMU30''	29.46	20.0	43.0	4.307	27.55	18.0	40.0	5.063
MARMPUP	35.33	12.0	59.0	11.029	33.76	18.0	54.0	7.855
MMEDCH	689.43	510.0	914.0	83.387	640.90	480.0	787.0	68.539
MPROAR	11.28	0.0	32.0	7.360	12.60	1.0	30.0	6.822
MLAGILT	11.86	9.7	14.5	1.050	11.44	9.9	13.4	0.995
MILLIAG	16.27	13.2	18.3	0.972	16.58	14.6	18.2	0.789
M6X5MRU	10.04	8.5	11.6	0.620	10.21	9.1	12.0	0.564
SMD20RH	3.60	3.1	4.5	0.238	3.59	3.2	4.5	0.239
SMD20LH	3.60	3.0	4.5	0.267	3.63	3.2	4.6	0.233
SMBDBCZ	5.85	4.7	7.1	0.495	5.64	4.8	6.4	0.376
SM6X5BD	10.45	7.7	12.0	0.689	10.67	9.4	12.2	0.577
SMIABD	17.28	14.6	19.8	1.145	17.69	15.6	19.7	0.9461

Legend: MJHULEP – Jump length from the place; MJUHIP – Jump high above the place Jump; MJUPSH – from the place with the step height; MSRU10M – Speed running 10 m; MSRU20M – Speed running 20; MABMU30'' – Abdominal muscles 30 sec; MARMPUP – Arms push up; MMEDCH – Throwing the medicinball from the chest; MPROAR – Profound warp (flexibility); MLAGILT – Line agility test; MILLIAG – Illinois agility; M6X5MRU – 6×5 meters running; SMD20RH – Dribble ball 20 m with the right hand; SMD20LH – Dribble ball 20 m with left hand; SMBDBCZ – Ball dribble between cones (zig-zag); SM6X5BD – 6×5 meters ball dribble; SMIABD – Illinois agility with ball dribble.

**Fig. 2** Evaluation of speed and agility**Fig. 4** Evaluation of situational motor skill**Fig. 3** Evaluation of repetitive force and flexibility

In table 2. Comparisons of arithmetic averages in each variable of the two leagues were made possible by the T-test method. Table 1 gives obtained results for the motor and situational space, by analyzing the obtained values in this table we might see that there are statistically significant differences in the probability level ($P < 0.01$). MMEDCH – Throwing the medicine from the chest is the variable 0.001, which is in favor of the unique league. While in the level of probability ($P < 0.05$) are these variables MABMU30'' – Abdominal muscles per 30 sec) 0.027, MILLIAG – Illinois agility test 0.026, and MLAGILT – Line agility test 0.056 these variables are in a benefit of super league basketball players.

Table 2. Interpretation of T-test values in the space of motor variables and motor and situational motor of super league and unique league.

Variables motoric	Groups	N	Mean	Std. Dev.	t	df	Sig. (2-tailed)
MJHULEP	Super league	60	219.835	22.7663	-0.590	118	0.557
	Unique league	60	222.240	21.9006	-0.590	117.823	0.557
MJUHIP	Super league	60	48.832	8.6698	-0.078	118	0.938
	Unique league	60	48.948	7.6513	-0.078	116.204	0.938
MJUPSH	Super league	60	52.132	9.0626	-0.040	118	0.968
	Unique league	60	52.193	7.7647	-0.040	115.289	0.968
MSRU10M	Super league	60	1.990	0.128	1.103	118	0.272
	Unique league	60	1.965	0.1168	1.103	117.012	0.272
MSRU20M	Super league	60	3.383	0.2001	.470	118	0.639
	Unique league	60	3.367	0.1798	.470	116.682	0.639
MABMU30''	Super league	60	29.467	4.3079	2.233	118	0.027
	Unique league	60	27.550	5.0637	2.233	115.045	0.027
MARMPUP	Super league	60	35.333	11.0295	.896	118	0.372
	Unique league	60	33.767	7.8554	.896	106.607	0.372
MMEDCH	Super league	60	689.433	83.3877	3.483	118	0.001
	Unique league	60	640.900	68.5397	3.483	113.736	0.001
MPROAR	Super league	60	11.283	7.3608	-1.021	118	0.309
	Unique league	60	12.607	6.8227	-1.021	117.327	0.309
MLAGILT	Super league	60	11.863	1.0502	2.260	118	0.026
	Unique league	60	11.441	0.9954	2.260	117.663	0.026
MILLIAG	Super league	60	16.270	0.9725	-1.926	118	0.056
	Unique league	60	16.581	0.7897	-1.926	113.232	0.057
M6X5MRU	Super league	60	10.043	0.6203	-1.616	118	0.109
	Unique league	60	10.218	0.5649	-1.616	116.984	0.109
SMD20RH	Supper league	60	3.602	0.2382	0.279	118	0.781
	Unique league	60	3.590	0.2397	0.279	117.995	0.781
SMD20LH	Super league	60	3.605	0.2674	-0.681	118	0.498
	Unique league	60	3.636	0.2332	-0.681	115.855	0.498
SMBDBCZ	Super league	60	5.854	0.4956	2.592	118	0.011
	Unique league	60	5.646	0.3769	2.592	110.146	0.011
SM6X5BD	Super league	60	10.456	0.6895	-1.895	118	0.061
	Unique league	60	10.676	0.5776	-1.895	114.485	0.061
SMIABD	Super league	60	17.288	1.1458	-2.096	118	0.038
	Unique league	60	17.690	0.9461	-2.096	113.922	0.038

Table 3. Discriminant analysis of motor basic variables and situational

Function	λ	Rc	Wilks' λ	X^2	df	Sig.
1	0.404	0.537	0.712	37.183	17	.003

Whereas in situational motors with statistically valid values between two leagues in a variable are these variables, SMBDBCZ – Ball dribble between cones zig-zag 0.011, SM6X5BD – 6x5 meters with ball dribble 0.061, SMIABD – Illinois agility with ball dribble 0.038.

Even in table 3. of the discriminant analysis between the two groups of basketball players in the motor and situational space where can be observed differences between the two researched leagues where a discriminatory function is acquired.

The discriminant function between these two groups has the characteristic root value $\lambda = 0.404$.

The canonical correlation discrimination coefficient has a Rc value = 0.537.

The criterion for discriminant strength of the anthropometric variables applied is set through Wilks 'lambda' $\lambda = 0.712$. Whereas the statistical significance of the discriminant equation was tested with Barlet's test $X^2 = 37.183$, for $df = 17$, degree of freedom. The significance level of this function is (Sig. = 0.003), which indicates the statistical validity of this discriminant function, we conclude that basketball players of these two leagues have statistically significant differences in motor and situational variables.

In table 4. Significant correlation with discriminatory function has been realized by the variables that mainly indicate the throwing of two-handed medicine ball from the chest, ball guidance 20m between zig-zag cones, line agility test, abdominal muscles per 30 sec, illinois agility test, 6x5 meters with the dribble ball and 6x5 meters running.

Table 4. Structural matrix

Variables	Function 1
MMEDCH	0.504
SMBDBCZ	0.375
MLAGILT	0.327
MABMU30``	0.323
SMIABD	-0.303
MILLIAG	-0.279
SM6X5BD	-0.274
M6X5MRU	-0.234
MSRU10M	0.160
MPROAR	-0.148
MARMPUP	0.130
SMD20LH	-0.099
MJHULEP	-0.085
MSRU20M	0.068
SMD20RH	0.040
MJUHIP	-0.011
MJUPSH	-0.006

Legend: MJHULEP – Jump length from the place; MJUHIP – Jump high above the place; MJUPSH – from the place with the step height; MSRU10M – Speed running 10 m; MSRU20M – Speed running 20; MABMU30`` – Abdominal muscles 30 sec; MARMPUP – Arms push up; MMEDCH – Throwing the medicinball from the chest; MPROAR – Profound warp (flexibility); MLAGILT – Line agility test; MILLIAG – Illinois agility; M6X5MRU – 6x5 meters running; SMD20RH – Dribble ball 20 m with the right hand; SMD20LH – Dribble ball 20 m with left hand; SMBDBCZ – Ball dribble between cones (zig-zag); SM6X5BD – 6x5 meters ball dribble; SMIABD – Illinois agility with ball dribble.

Table 5. Centroids of basal and situational motor groups

Groups	Function 1
Super League	0.631
Unique League	-0.631

The arithmetic mean of the discriminatory values of the groups represent the centroids of the motor basic and situational motor groups which are given in the table 5 which makes group discrimination better.

In table 5 concentration of group centroids in discriminatory function, divided into two groups, first group Super League of basketball players has a greater centroid value 0.631, while the second group the Unique League of basketball players has the least centroids value of -0.631.

Based on centroid values we can conclude that: Basketball players of Super League have higher values in the explosive force of the hands, agility of ball guidance and ability of agility without ball.

Discussion

The data presented below of arithmetic averages in basic statistical indicators of the basic motor space and situational motor space between super league and unique league, in

juniors we might see that the results in the variables of the explosive force (Miftari, Selimi, Badau & Kelmendi, 2021) of legs in small differences dominate basketball players of unique league in addition to variable which estimates the explosive force of the hands that is in favor of junior of super league. If we evaluate basketball players while running at speed and in agility in small differences basketball players of unique league dominate in three variables such as: speed running 10 m, speed running 20 m the line agility test while in two other variables of agility better results have showed super league in variables illinois agility test and 6x5 meters running. In repetitive force, the basketball players of super league are favored, while in flexibility the best result was by the unique league. The results of this research shows that basketball players of super league have jumped from the place at a height of 48.83 cm, while the unique league 48.94 cm, while the performance of the running test at a speed of 20 m, have run in average of 3.38 seconds to super league, while in unique league for 3.67 seconds. According to previous works of other authors, the results of the players included in this research will be compared with the results of players from other European countries, will be observed whether they have equal or better values in favor of the players included in this research. In long jump spot test we see that they showed identical values while in the Illinois agility test our basketball players showed better values in the result when executing this agility test (Asadi, 2016), while in the jump length tests from the place are showed lower values compared to the players from Montenegro (Ljubojević & Nikolić, 2012), while those from Brazil showed lower values with a result of 44 centimeters (Gledson et al., 2018), while our results have a value of 48.83 centimeters for the super league and 48.94 centimeters for unique league. The performance of the running test when it is compared with other basketball players, we might see that we have lower values of results compared to other authors. (Schiltz et al., 2009), while players from Croatia in 3.2 seconds (Milanović, Jukić & Marković, 2004) while players from Montenegro manage to run for 3.24 seconds (Vukasevic, et al., 2019), while players from Kosovo manage to run for 3.63 seconds (Kryeziu & Asllani, 2016) meanwhile from Albania reached values of 3.49 seconds (Spahi, Jarani, Bilali, 2015) and our players we've had in this research have reach running in an average of 3.38 seconds in the Super League and 3.67 seconds in the Unique League. Indicator of repetition strength, abdominal muscles have shown identical values on the results of Slovenian basketball players (Klemenčič, 2010) while other basketball players have shown lower scores (Cheryll, 2008), as well as basketball players from Bosnia and Herzegovina showed the lowest results (Pojskić et al., 2014). The performance of the line agility test has shown similar results to those authors of Finnish basketball league (Stojanovic et al., 2018). From results of basic indicators in situational motor skills at juniors of Super League are favored in three variables: Dribble ball 20 m with left hand, 6x5 meters ball dribble and Illinois agility test while two variables with small differences belong to the Unique League Dribble ball 20 m with the right hand and Ball dribble between cones (zig-zag) (Begu, 2012). Further we will compare and analyze with previous publications of other authors in motor situational space of the basketball game. We have compared in test dribble ball 20 m with the right hand and dribble ball 20

m with left hand who have succeeded to have better results than basketball players from different European countries (Erčulj et al., 2009), while with other basketball players they have shown higher values of results from this two variables of motor situational (Jakovljević et al., 2017).

Test 6x5 meters ball dribble of Super League have achieved results in 10.45 seconds, while Unique League 10.67 seconds, comparison of basketball players by authors (Erčulj et al., 2009), which is in a value 10.24 seconds we might say that they are approximately the same.

If we compare the Illinois agility test of basketball players of Super League who have achieved to realize in time of 16.27 seconds, and the basketball players of Unique League in time of 16.58 and Illinois agility with ball dribble of Super League 17.28 while the basketball players of Unique League 17.69 showed that Super League basketball players realized better dribble ball technique compared to basketball players of Unique League.

In this case, if we compare the results with other authors, we might see that the Illinois agility test with dribbling ball showed slightly better result compared to 17-year-old basketball players (Kamandulis et al., 2013). The optimization of basketball training system is a complex problem that requires further research (Koryahin et al., 2016).

Presented results in this research paper of these junior basketball players of two Kosovo leagues can be said they are relatively favorable, taking as a basis basketball players from the region, but in order to achieve higher results with our basketball players in future, it should be started earlier with measurements and tests to select the best players and working in a systematic and professional manner.

Conclusions

In general, the results of this paper shows that the indicators of explosive force in upper extremities, repetitive strength, agility and situational motor skills with the ball have shown significant differences between two leagues, while the indicators of expository strength of the lower extremities and speed, there weren't reported significant differences between Super League and Unique League among Juniors of Kosovo. However, the data presented between the Super League and Unique League in juniors it is seen that the results between average arithmetic in indicators of explosive strength of lower extremities, while the indicators of repetitive strength, explosive strength in upper extremities and agility are in favor of Super League. In general, the results of situational motor indicators have a mix between the two leagues, but most of the treated tests are in favor of Super League. According to this, it is seen that these basketball players of Unique League have higher physical preparation in indicators of basic motor skills, while basketball players of Super League have shown more favorable values in indicators of situational motor skills.

Acknowledgment

We would like to thank coaches and junior basketball players of Kosovo who understood us to carry out the measurements and tests of these basketball players who were always ready for measurements and understood the importance of this study who did not hesitate for their time and training that we have received.

Conflict of interest

The authors declare no conflict of interest.

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ПОРІВНЯННЯ СИТУАТИВНИХ І РУХОВИХ ЗДІБНОСТЕЙ БАСКЕТБОЛІСТІВ-ЮНІОРІВ КОСОВА В СУПЕРЛІЗІ ТА В УНІКАЛЬНІЙ ЛІЗІ

Буяр Бегу^{1ABCDE}, Флоріан Міттарі^{1ABCD}, Метін Даліп^{2ABCD}, Лабінот Хаджнікай^{1BCD}

¹Приштинський університет

²Тетовський університет

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 8 с., 5 табл., 4 рис., 28 джерел.

Мета дослідження. Метою цього дослідження є встановлення відмінностей у ситуативних і рухових здібностях між двома лігами баскетболістів-юніорів у Косово. Загалом у цьому дослідженні було оцінено 120 гравців віком 18 років, із яких 60 гравців належали до Суперліги, а решта 60 – до Унікальної ліги.

Матеріали та методи. Вимірювальні інструменти, які використовували в цьому дослідженні, включали набір із 12 основних рухових змінних і 5 ситуативних рухових змінних. Для забезпечення точних даних про швидкість і спритність використовували електронні датчики у вигляді таймера Witty (виробництва Microgate). Проведений статистичний аналіз включав застосування t-критерію Стюдента для визначення статистично значущих відмінностей між лігами для окремих змінних, тоді як для встановлення відмінностей між двома лігами на основі повного набору вимірюваних змінних використовували канонічний дискримінантний аналіз.

Результати. У конкретних змінних спостерігалися відмінності на користь гравців Суперліги в таких областях, як витривалість м'язів живота ($p < 0,05$) і кидок медболу ($p < 0,01$), тоді як гравці Унікальної ліги відзначилися у тестах на висоту

стрибка та спритність. Т- критерій Стьюдента та дискримінантний аналіз підтвердили статистично значущі відмінності між лігами ($p < 0,01$). Ці одержані результати дають цінне розуміння контрастних здібностей гравців у двох лігах.

Висновки. У цьому дослідженні були виявлені статистично значущі відмінності між Суперлігою та Унікальною лігою серед баскетболістів національної чоловічої баскетбольної команди спортсменів віком до 18 років у Косово. Гравці Супер-ліги продемонстрували чудові результати у вибуховій силі верхньої частини тіла, силі повторення та спритності, а гравці Унікальної ліги продемонстрували кращу фізичну підготовленість в основних рухових навичках.

Ключові слова: баскетболісти, вік до 18 років, ситуативні та рухові здібності, відмінності між лігами.

Information about the authors:

Begu, Bujar: bujar.begu@uni-pr.edu; <https://orcid.org/0009-0000-8368-3182>; Faculty of Physical Education and Sports, University of Pristina, Industrial Zone, Pristina, 10000, Kosovo

Miftari, Florian: florian.miftari@uni-pr.edu; <https://orcid.org/0000-0003-0242-1151>; Faculty of Physical Education and Sports, University of Pristina, Industrial Zone, Pristina, 10000, Kosovo

Dalip, Metin: metin.dalip@unite.edu.mk; <https://orcid.org/0000-0002-7142-8931>; Faculty of Physical Education, University of Tetovo, Street Ilinden, nn., 1200 Tetova, Republic of North Macedonia

Haxhnikaj, Labinot: labinot.haxhnikaj@student.uni-pr.edu; <https://orcid.org/0009-0007-7559-6346>; Faculty of Physical Education and Sports, University of Pristina, Industrial Zone, Pristina, 10000, Kosovo

Cite this article as: Begu, B., Miftari, F., Dalip, M., & Haxhnikaj, L. (2023). Comparing Situational and Motor Abilities Among Kosovo Junior Basketball Players in Super and Unique Leagues. *Physical Education Theory and Methodology*, 23(4), 552-559. <https://doi.org/10.17309/tmf.v.2023.4.09>

Received: 26.04.2023. Accepted: 14.07.2023. Published: 30.08.2023

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ORIGINAL SCIENTIFIC ARTICLE

EFFECT OF HIGH INTENSITY FUNCTIONAL WITH STRATEGY SPORTS TRAINING ON COGNITIVE PERFORMANCE FOR PHYSICAL EDUCATION ACHIEVEMENT IN HIGH SCHOOL STUDENTS

Amorntheap Wandee^{1ABCDE}, Ban Chabairam^{1BD} and Suchart Homjan^{1CD}

¹Buriram Rajabhat University

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Amorntheap Wandee, E-mail: amorntheap.wa@bru.ac.th

Accepted for Publication: July 14, 2023

Published: August 30, 2023

DOI: 10.17309/tmfv.2023.4.10

Abstract

Study purpose. This research aims to develop cognitive performance on the success of sports skills in physical education in Buriram Province.

Materials and methods. The sample group of 80 people was divided into 2 groups of 40 people each. The control group was taught a regular strategy of handball instruction. The experimental group was taught a strategy of handball instruction with high-intensity functional training. Both groups were taught for 1 hour per week according to the normal teaching schedule of the school for a period of 8 weeks. All students were assessed by a computerized cognitive test battery and Sports skills achievement test in pre- and post-experimental. Analysis of the research data was performed by testing differences between the groups using the parametric and non-parametric statistics.

Results. After 8 weeks of the experiment, analysis of the difference between the experimental group and the control group in the experimental data was carried out showing that the cognitive performance in terms of attention, executive function, cognitive flexibility, and working memory takes less time in the experimental group than in the control group, including Sports skills achievement scores in the test where the experimental group had more scores than the control group, which is statistically significant at .05.

Conclusions. High-intensity functional with strategy sports training program in physical education class can develop cognitive performance in terms of attention, executive functions, cognitive flexibility, and working memory in high school students.

Keywords: cognitive performance, achievement, sports skill, physical education.

Introduction

Cognitive performance is related to the highest sporting ability, consisting of 1) Attention, 2) Inhibition control, 3) Working memory, 4) Cognitive flexibility, 5) Creativity, 6) Information processing speed, and 7) Spatial ability (Belling & Ward, 2015; Vestberg et al., 2017; Woo & Yongtawee, 2018). In addition, sports ability does not only use strength to express abilities. However, also found that one of the stages of sports skills expression must also go through the brain processing process for the muscles to move systematically (Schmidt et al., 20016). Therefore, it will be able to develop learners to achieve sports expertise and success in physical education (Yongtawee et al., 2019).

Training for developing cognitive performance, when separated by composition, found that High-Intensity Interval Training can develop Cognitive flexibility (Mekari et al., 2020) and Inhibition (Kao et al., 2018; Sugimoto et al., 2020). Strategy Sports Training with High Intensity Functional Training can develop Spatial ability (Moreau, 2012; Ben-Zeev & Okun, 2021), Working memory (Zach & Shalom, 2016; Wilke, 2020), and Information processing (Audiffren et al., 2008; Lotfi et al., 2020).

At the same time, the basic education core curriculum of the Health and Physical Education Learning Group in Thailand has set indicators and learning subjects to be necessary, consisting of movement, exercise, gaming, Thai sports, and international sports. Focus on allowing learners to learn about various forms of movement. Learners must participate in physical and sports activities, both individual and team types, Thai and international. Compliance with

rules and agreements in participating in physical activities and sports activities, as well as being kind to athletes by requiring teaching 1 day, 1 hour per day (Ministry of Education, 2008).

Nevertheless, There is rarely focus on the development of cognitive performance in learners. cognitive performance is necessary for physical education in sports ability expression by using a systematic thinking process to make decisions and act in various situations. It can also be extended to sports talent. This study aims to develop cognitive performance for physical education achievement in high school students.

Materials and methods

Study participants

80 high school students in Krasang Pittayakom School were selected from a cluster random sampling. Participants were divided into two groups by a table to determine the sample size of Cohen (Cohen, 2013). Determine alpha values at the statistically significant level of 0.05, the effect size at 0.70, and the power of the test at 0.85, with 38 students per group, two groups totaling 76 students. Furthermore, to prevent mortality in participants, 4 students were added, a total of 80 students, 40 students per group as follows:

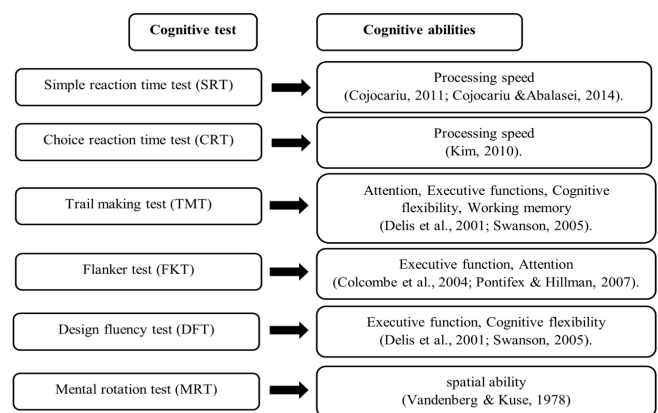


Fig. 1. Cognitive performance test

The control group received regular strategy of handball instruction. The experimental group received a strategy of handball instruction with high-intensity functional training. Criteria for inclusion of research required the participants to follow the entire program without any absence and voluntarily participate in research. All participants signed the consent form to participate in the research.

Table 1. Training program

Stage	Duration	Activity
Preparation	10 minutes	13 Dynamic warm-ups, 20 meters for each position. - High knee walk - Leg cradle - Walking heel to butt - Walking heel-up to butt with forward lean - Backward lunges walk with hamstring stretch - Backward straight-leg deadlift walks - High knee run - Butt kick - Straight leg walks - Straight leg skip - Backpedal - Backward run
Explanation and demonstration	5 minutes	The teacher explained with a demonstration of strategy game practice in handball.
Drills and practice	15 minutes	Students practiced handball strategy gameplay.
Application	20 minutes	Students rest for 5 minutes after completing handball strategy gameplay. After that, start practiced high-intensity training, consisting of as follows - Squat - Single-leg squat - Forward lunge - Side lunge - Backward lunge - Push up - Bird dog - Shoulder tap - Two-leg deadlift - Single-leg deadlift High-intensity functional training program 10 exercises, 17 sequences of exercises, using about 35 seconds, resting 10 seconds, repeating 20 rounds, totaling 15 minutes. Determine the intensity with the speed of the music rhythm 140-155 beats per minute by increasing the intensity level 5 times per minute every 2 weeks.
Conclusion	10 minutes	The teacher conducted a teaching summary together with static stretching.

Human research ethics

The research had been approved by the committee for the research ethics of Buriram Rajabhat University. The certificate issued was BRU: -rdi 002 (002/2566).

Study organization

The Quasi-experimental research design with two groups was designed to compare the effect of regular strategy games and strategy games with high-intensity functional training of handball instruction on cognitive performance for 8 weeks, 1 day per week, and 1 hour per day.

Measurement

The cognitive performance that affects physical education success test was divided into two tests as follows:

1. A computerized cognitive test battery was developed by the Department of Physical Education (Yongtawee et al., 2019), which modify from the previous study in Figure 1.

2. Sports skills achievement test in physical education courses (Handball sports) according to the basic education core curriculum of the Health and Physical Education Learning Group (Ministry of Education, 2008).

Procedure

Both groups received a cognitive performance and handball skills achievement test before training. After that, the experimental group began training according to Strategy Games with High-Intensity Functional Training of Handball instruction, as shown in Table 1. While as the control group began with regular strategy games training in

handball instruction. At the end of 8 weeks, participants in both groups were repeatedly tested as before the research.

Statistical analysis

Quantitative data were tested for normal distribution of cognitive performance and sports skills achievement by Shapiro-Wilk method. When found that 1) Normal distribution data, Analyze the difference between 2 groups by independent t-test and within the group between before and after 8 weeks of training by dependent t-test. 2) Non-normal distribution data, Analyze the difference between 2 groups by Mann-Whitney U Test and within the group between before and 8 weeks of training with Wilcoxon Sign Rank Test at the significant level .05 by SPSS 23.0 (SPSS Inc. Released 2015. IBM SPSS Statistics for Windows, Version 23.0 Armonk, NY: IBM Corp.).

Results

The characteristic data for the participants in control and experimental groups were shown in Table 2.

Table 2. Characteristic data of the participants

Parameter	Control group (n = 40)	Experimental group (n = 40)
	Mean $\pm$ SD	Mean $\pm$ SD
Age (year)	17.78 $\pm$ 0.48	17.95 $\pm$ 0.71
Height (cm)	168.80 $\pm$ 8.22	171.28 $\pm$ 5.71
Bodyweight (kg)	59.85 $\pm$ 8.29	63.05 $\pm$ 10.49
BMI (kg/cm ²)	17.70 $\pm$ 2.02	18.36 $\pm$ 2.70

Cognitive performance

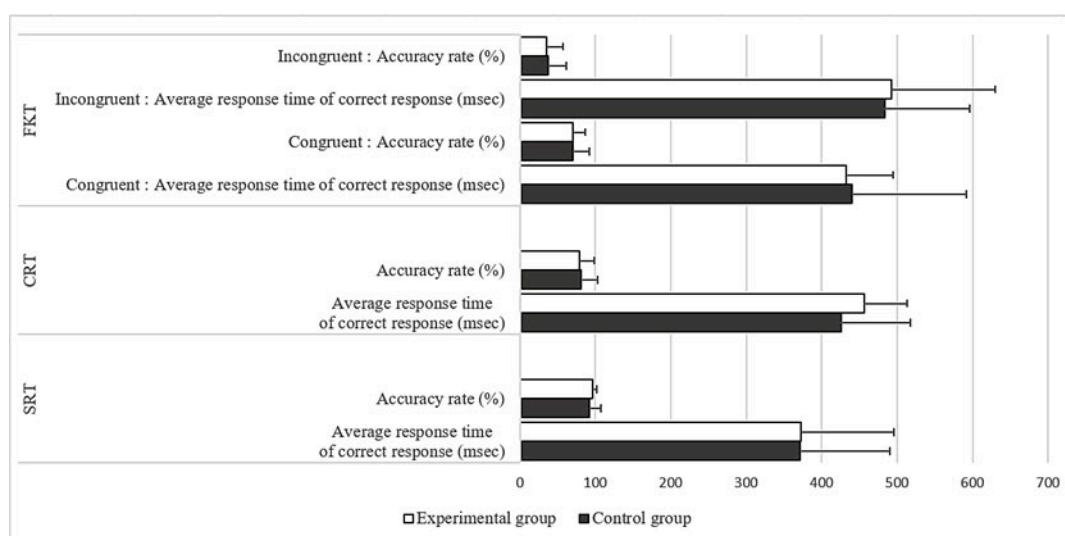


Fig. 2. In the pre-test: SRT, CRT, and FKT were no differences between the control and experimental groups, which were analyzed by the Mann-Whitney U test. At the same time, FKT (Incongruent: Accuracy rate) was analyzed by independent t-test

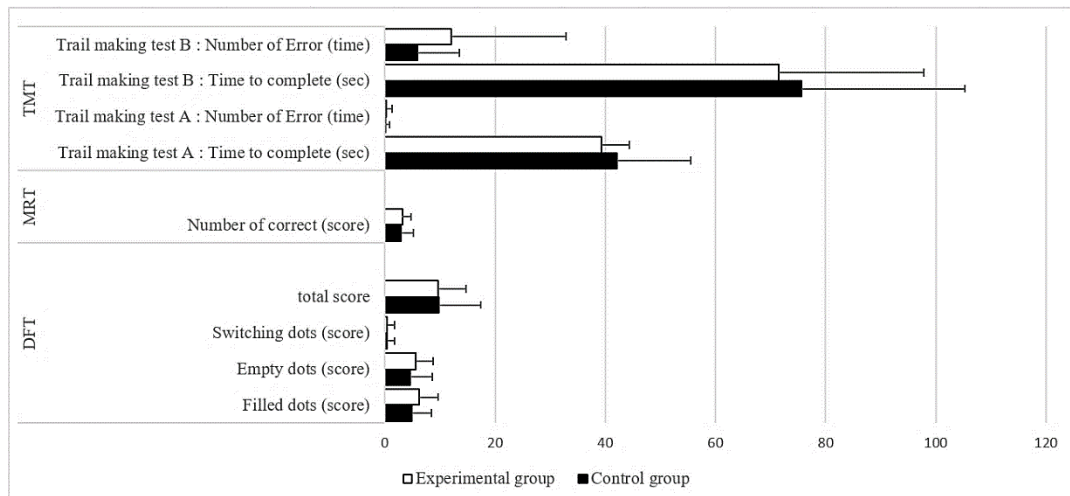


Fig. 3. In the pre-test: TMT, MRT, and DFT were no differences between the control and experimental groups, which were analyzed by the Mann-Whitney U test

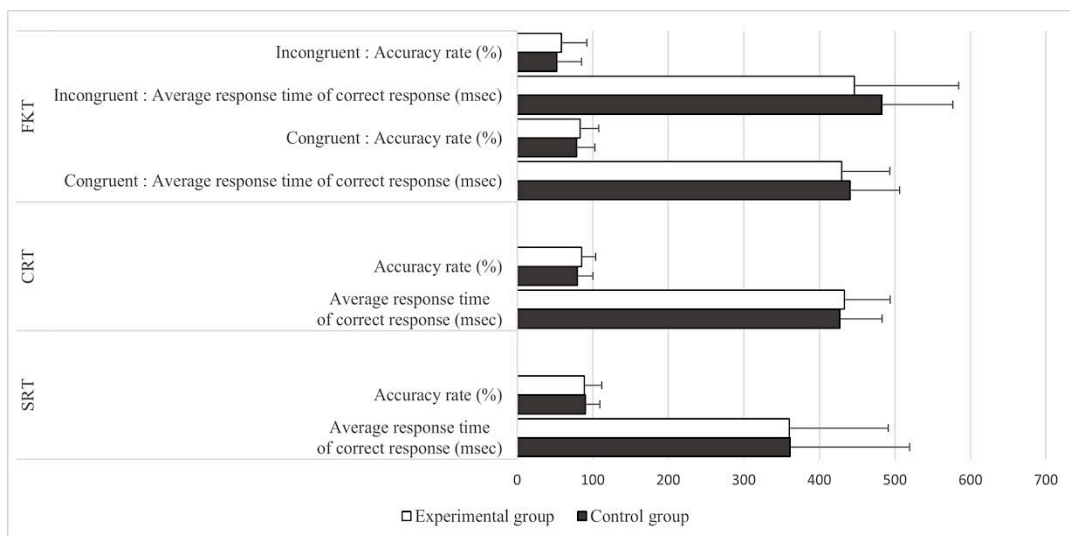


Fig. 4. In the post-test: SRT, CRT, and FKT were no differences between the control and experimental groups, which were analyzed by the Mann-Whitney U test

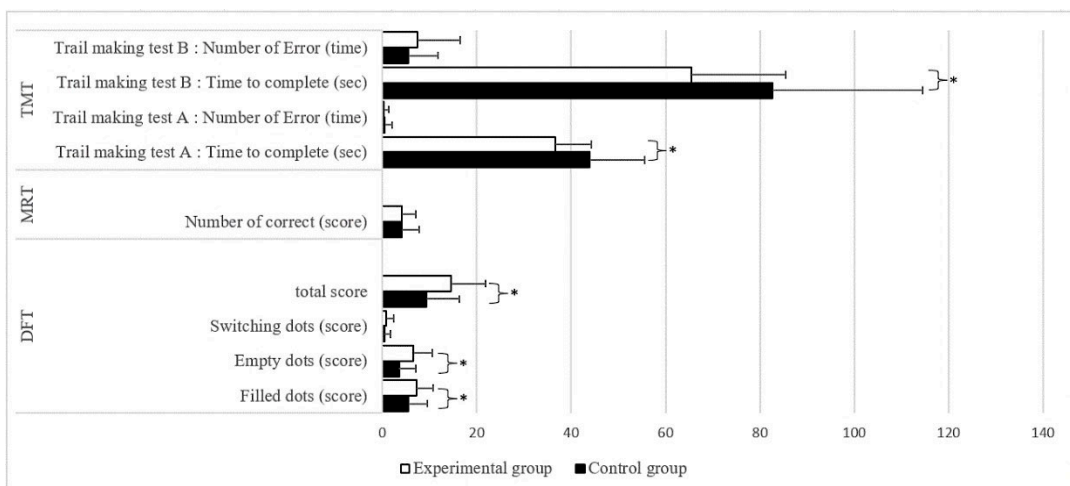


Fig. 5. In the post-test: TMT (Trail making tests B and A: Time to complete), and DFT (Filled dots and empty dots) were differences between the control and experimental groups, which were analyzed by the Mann-Whitney U test ($p < 0.05$)

Sports skills achievement test in physical education courses (Handball sports)

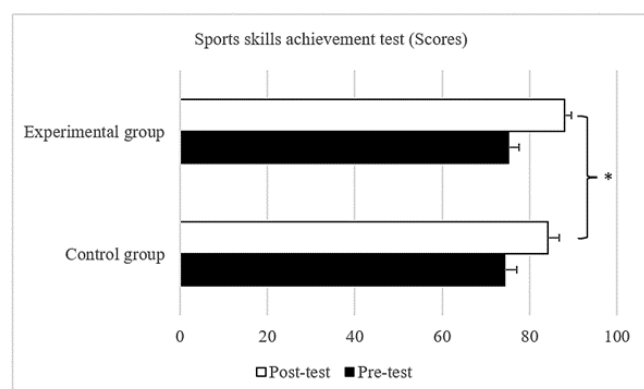


Figure 6. In the post-test: Sports skills achievement test was differences between the control and experimental groups, which were analyzed by the Mann-Whitney U test ($p < 0.05$)

Discussion

The experimental group had Trail making test (TMT) test shown in attention, executive functions, cognitive flexibility, and working memory (Delis et al., 2001; Swanson, 2005; Dwojaczny et al., 2021), which took less time to test than the control group. In addition, the design fluency test (DFT), Which was shown in cognitive performance related to executive function and cognitive flexibility (Delis et al., 2001), including the sports skills achievement test in the experimental group, had more scores than the control group. Because of students who have been trained in high-intensity functional training programs can develop an aerobic system that increases blood to the brain (Querido & Sheel, 2007; Ogoh & Ainslie, 2009; Shenoy et al., 2021; Arfanda et al., 2022) along with the resistance caused by the body weight itself to achieve fast and fast movement which, resistance training can increase the cortisol hormone level (Tsai et al., 2014). In addition, training high-intensity functions increased Brain-derived neurotrophic factors (BDNF) that caused the development in cognitive performance in attention, executive functions, cognitive flexibility, and working memory (Yarrow et al., 2010). Furthermore, Strategy game play in handball consists in remembering movements and deviations, and in associating them to visual landmarks or to experienced events, and to draw a mental map of the environment that can help to improve cognitive flexibility and executive function (Di Tore, 2016; Kiss & Balogh, 2019)

Moreover, high-intensity functional training programs can increase Intrinsic motivation and improve muscle function and the cardiovascular system (Wilke et al., 2019; Menz et al., 2019). Therefore, the experimental group in the part of attention, executive functions, cognitive flexibility, and working memory more than the control group and was related to improve the achievement of sports skills in the experimental group.

Conclusions

The effect of high-intensity functional with strategy sports program training in physical education class for

1 day/week, 1 hour per week, a total of training for 8 weeks. It can develop cognitive performance in terms of attention, executive functions, cognitive flexibility, and working memory, which were part of success in sports skills for high school students.

Acknowledgment

This study was supported by a research grant from Thailand Science Research and Innovation (TSRI) and Buriram Rajabhat University. This research was approved by the RDI BRU. We would like to thank students and physical education teachers in Krasang Pittayakom School, Krasang Subdistrict, Krasang District, Buriram Province for their helpful in activity and assessments.

Conflict of interest

The author declares that there have no of interest.

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ВПЛИВ ВИСОКОІНТЕНСИВНИХ ФУНКЦІОНАЛЬНИХ ТРЕНУВАНЬ ЗІ СПОРТИВНИМ НАВЧАННЯМ СТРАТЕГІЇ НА КОГНІТИВНУ ДІЯЛЬНІСТЬ ДЛЯ УСПІХІВ УЧНІВ СЕРЕДНЬОЇ ШКОЛИ У ФІЗИЧНОМУ ВИХОВАННІ

Аморнтхіап Ванді^{1ABCD}, Бан Чабайрам^{1BD}, Сухарт Хомян^{1CD}

¹Університет Бурірам Раджабхат

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 2 табл., 6 рис., 29 джерел.

Мета дослідження. Метою цього дослідження є розширення когнітивної діяльності на успішність спортивних навичок у фізичному вихованні в провінції Бурірам (Таїланд).

Матеріали та методи. Вибірку з 80 осіб розподілили на 2 групи по 40 осіб у кожній. Контрольну групу навчали стандартної стратегії навчання гандболу. Експериментальну групу навчали стратегії навчання гандболу з високоінтенсивним функціональним тренуванням. Обидві групи навчалися по 1 годині на тиждень відповідно до звичайного навчального розкладу школи протягом 8 тижнів. Усіх учнів оцінювали за допомогою комп'ютеризованого набору когнітивних тестів і тесту досягнення спортивних навичок до та після експерименту. Аналіз даних дослідження проводили шляхом перевірки відмінностей між групами з використанням параметричних і непараметричних методів статистики.

Результати. Після 8 тижнів експерименту було проведено аналіз різниці між експериментальною групою та контрольною групою в експериментальних даних, який показав, що когнітивна діяльність в рамках уваги, здатності до цілеспрямованої діяльності, когнітивної гнучкості та короткочасної пам'яті займає менше часу в експериментальній групі, ніж у контрольній групі, включаючи аналіз балів за досягнення спортивних навичок у тесті, де експериментальна група мала більше балів, ніж контрольна група, що є статистично значущим результатом за рівня 0,05.

Висновки. Програма високоінтенсивних функціональних тренувань зі спортивним навчанням стратегії на уроках фізичного виховання може розвивати когнітивну діяльність у рамках уваги, здатності до цілеспрямованої діяльності, когнітивної гнучкості та короткочасної пам'яті в учнів середньої школи.

Ключові слова: когнітивна діяльність, досягнення, спортивна навичка, фізичне виховання.

Information about the authors:

Wandee, Amorntheap: amorntheap.wa@bru.ac.th; <https://orcid.org/0000-0003-1581-8457>; Faculty of Education, Buriram Rajabhat University, 439 Jira Road, Nai Mueang, Buriram, 31000, Thailand.

Chabairam, Ban: ban.cb@bru.ac.th; <https://orcid.org/0000-0002-5889-0363>; Faculty of Education, Buriram Rajabhat University, 439 Jira Road, Nai Mueang, Buriram, 31000, Thailand.

Homjan, Suchart: Suchart.hj@bru.ac.th; <https://orcid.org/0000-0001-8880-6436>; Faculty of Education, Buriram Rajabhat University, 439 Jira Road, Nai Mueang, Buriram, 31000, Thailand.

Cite this article as: Wandee, A., Chabairam, B., & Homjan, S. (2023). Effect of High Intensity Functional with Strategy Sports Training on Cognitive Performance for Physical Education Achievement in High School Students. *Physical Education Theory and Methodology*, 23(4), 560-566. <https://doi.org/10.17309/tmfv.2023.4.10>

Received: 29.04.2023. Accepted: 14.07.2023. Published: 30.08.2023

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ORIGINAL SCIENTIFIC ARTICLE

A CROSS-COUNTRY VALIDATION BETWEEN KOSOVO AND THE NETHERLANDS OF THE DUTCH PERCEPTUAL-MOTOR SKILLS ASSESSMENT FOR TALENT DETECTION IN TABLE TENNIS

Blerta Abazi^{1ABD}, Milaim Berisha^{2,3CD} and Irene Renate Faber^{4,5,6BD}

¹AAB College

²UBT College

³Children's Fitness Centre of Canada

⁴University of Oldenburg, Oldenburg

⁵Windesheim University of Applied Sciences

⁶International Table Tennis Federation

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Milaim Berisha, E-mail: dr.milaimberisha@gmail.com

Accepted for Publication: July 14, 2023

Published: August 30, 2023

DOI: [10.17309/tmf.v.2023.4.11](https://doi.org/10.17309/tmf.v.2023.4.11)

Abstract

Background. This study focused on the cross-country validation of the Dutch perceptual-motor skills assessment used for talent detection in table tennis which also could be the basis to create country-specific norm values in young children (aged 7 to 9).

Materials and methods. In total, data from 172 children from Kosovo and 219 children from the Netherlands were compared. The data consisted of the outcomes of seven items of the Dutch perceptual-motor skills assessment evaluating gross motor function (i.e., sprint and vertical jump) and ball control (i.e., throwing a ball, speed while dribbling, aiming at target, ball skills and eye-hand coordination). A multivariate GLM analysis revealed significant differences between the two countries with large effect sizes regarding both constructs. Preliminary normative values are presented per country.

Results. The results show that perceptual-motor skills can vary between children of the same age and sex between European countries. For that reason, it seems sensible to further investigate the necessity of establishing norm values per country and also the underlying mechanisms that might reveal why and how cross-country differences arise.

Conclusions. Moreover, it might make sense to study an international sample of recreational and high performance youth and adult players to create a benchmark for talent detection and talent identification in table tennis. This will likely gain more insight into what the key aspects are to participate in table tennis and what is necessary for the elite level.

Keywords: racquet sport, youth, motor skills, testing.

Introduction

Talent detection is about the discovery of potential athletes in a heterogeneous population that are currently not involved in a specific sport (Vaeyens, Lenoir, Williams, & Philippaerts, 2008). Talent detection can be helpful in stimulating sports activities in young kids to find a sport that fits them best (Pion, 2015). An optimal connection between

the child's strengths and personal preferences and the sport is likely to increase the chances of success. For this reason, it is important to have a good insight in the typical profile of a certain sport (Pion, Teunissen, ter Welle, Spruijtenburg, Faber & Lenoir, 2020). Since performance in many sports rely on a child's perceptuo-motor abilities, it seems sensible to develop a so-called 'sport perceptuo-motor profile' and include a perceptuo-motor assessment within the talent detection process. This is especially the case for technique-based sports, like table tennis (Faber, Pion, Munivvana, Faber & Nijhuis-Van der Sanden, 2018).

Table tennis is generally considered as an early start sport with a large impact of the technical skills level on performance (Faber, Damsma & Pion, 2020). This has two consequences. First, children aiming to participate and especially those who want to excel in this sport will benefit from an early exposure to table tennis specific activities (Faber, Zamoscinska, Teunissen & Pion, 2020). Second, a certain level of sport-related perceptuo-motor abilities (e.g. speed, agility, eye hand coordination and ball control) are important for the development of the difficult technical skills (Faber, Koopmann, Büsch & Schorer, 2021). These aspects have impact on the approaches for talent development and should be taken into account for talent detection in table tennis; it seems sensible to organize talent detection already at an early age-span (i.e. 7 - 8 and 9 years) and include an assessment specifically valid for table tennis.

The Netherlands Table Tennis Association developed a perceptuo-motor assessment that was evaluated as part of the talent detection process (Faber, Elferink-Gemser, Faber, Oosterveld & Nijhuis-Van der Sanden, 2016). This assessment included eight test items: sprint, vertical jump, agility, throwing a ball, speed while dribbling, aiming at target, balls skills, eye-hand coordination. A first evaluation revealed good prospects for its added value to talent detection in the Netherlands; a discriminant analysis showed that approximately 30% of the primary school children fit the perceptuo-motor profile of young table tennis players. Especially, the items assessing ball control seem to be of value (i.e., throwing a ball, speed while dribbling, aiming at target, balls skills, eye-hand coordination). Talent detection programs to support children to find a sport that fits their strengths and personal preferences could benefit from adding this assessment.

Although this first evaluation showed promising results in the Netherlands, it is recommended to investigate the assessment's cross-country validity. Such an evaluation will provide insight whether the results and conclusions are generalizable to young populations outside the Netherlands. Previous studies in perceptuo-motor skills assessments showed that generalizability of the results and conclusions to other populations are not always straightforward. For example, a cross-country validation of the Movement Assessment Battery for Children-2 revealed that reference norms based on normative samples from the UK needed to be adapted in order to use the assessment as a diagnostic tool in the Netherlands and Flanders (the Dutch-speaking part of Belgium) (Niemeijer, van Waelvelde, & Smits-Engelsman, 2015). Also, studies using the first edition of the Movement Assessment Battery for Children with norm tables based on American normative samples, showed that cultural differences in performance on the test items existed and that for use in non-American children, the norms needed small adjustments (Niemeijer, van Waelvelde, & Smits-Engelsman, 2015; Engel-Yeger, Rosenblum & Josman, 2010; Pienaar, 2004). Also other studies revealed cross-country or cross-cultural differences between populations of children regarding their motor skills (Valentini, Nobre & Gonçalves Duarte, 2022; Bardid et al., 2016; Veldman, Jones, Santos, Sousa-Sá, & Okely, 2018).

For this reason, this study focused on a cross-country validation of the Dutch perceptuo-motor skills assessment used for talent detection in table tennis which also could be

the basis to create country specific norm values (Berisha & Çilli, 2020; Berisha M. Ç., 2018) in girls and boys between 7 to 9 year-old living in Kosovo. Providing the cross-country validation intends to support talent detection in table tennis and determine the perceptuo-motor skill level of the children living in Kosovo (Berisha, M, 2021). Based on the results, children who show higher abilities may be oriented to table tennis, as children who show lack perceptuo-motor and physical activities will be suggested and oriented to the beneficial activities for health and active life.

Materials and methods

Study design

In line with the purpose of the present study, the cross-sectional design was used, where two independent groups were compared and analyzed, which aims to determine the differences between 7-8-9 years of children living in Kosovo and the Netherlands in perspective of gross motor skills and ball control tests of Table tennis players. The causal-comparative method, which aims to determine the reasons for an existing / naturally occurring situation or event, differences in these causes, and the contributing variables or the results of an effect, were used.

Sample

The study sample consists of 117 girls and 55 boys from Kosovo and 51 girls and 138 boys from the Netherlands (Table 1). The included children go to a regular primary school within their country. Both children participating ($\pm 90-95\%$) and not participating (5-10%) in a sport were included. The participants included in the study and their parents were informed by written form about the benefits and risks (even no risks were detected) of the study. The study was conducted according to the Helsinki Declaration which protects the privacy of the volunteers.

Table 1. Study sample

Age (years)	Girls (n)		Boys (n)	
	Kosovo	Netherlands	Kosovo	Netherlands
7	67	10	14	47
8	43	30	25	34
9	7	41	16	57
Total sample	117	81	55	138

Perceptuo-motor skills assessment

For this study, seven items of the perceptuo-motor skills assessment of the Netherlands Table Tennis Association were administered: sprint, vertical jump, throwing a ball, speed while dribbling, aiming at target, balls skills, eye-hand coordination (Faber, Elferink-Gemser, Faber, Oosterveld, & Nijhuis-Van der Sanden, 2016; Netherlands Table Tennis Association, 2011). Sprint and vertical jump are considered to assess the player's gross motor function and speed while dribbling, aiming at target, balls skills, throwing a ball and eye-hand coordination are considered to assess their skills concerning ball-control (Faber, Nijhuis-Van Der Sanden,

Elferink-Gemser, & Oosterveld, 2015). Each item includes an untrained task to diminish the effect of learning. Excluding authentic table tennis tasks was chosen to better estimate the potential for table tennis than the performance of specific sport skills themselves (Gagné, 2004; Morrow, Jackson, Disch, & Mood, 2011; Vaeyens, Lenoir, Williams & Philippaerts, 2008) The standardization of the test items is captured in protocols, which includes a detailed description of materials, set-up, assignment, demonstration, training phase, testing phase, and registering test scores (Faber, Elferink-Gemser, Faber, Oosterveld, & Nijhuis-Van der Sanden, 2016; Netherlands Table Tennis Association, 2011). A reproducibility study using a test-retest design showed acceptable intraclass correlation coefficients ranging from 0.79–0.88 ($P < 0.01$) with coefficients of variation between 3–6% (Faber, Nijhuis-Van Der Sanden, Elferink-Gemser & Oosterveld, 2015).

The Dutch primary school children were tested using the perceptuomotor skills assessment during 3 physical education lessons within a period of 3 weeks. The 7 test items were divided over the 3 testing sessions for feasibility reasons. The children performed a warm-up prior to testing. The assessors were sport trainers or physiotherapy students, who were well-trained to guarantee that the test protocols were used in a standardized way; they first familiarised themselves with the test protocol and instructions and then they were given feedback during a training session by an expert of the Netherlands Table Tennis Association.

The Kosovar children have also been tested in a similar way, during Physical Education classes, mainly in the morning hours over a period of 3 weeks. The assessors were trainers table tennis, physical education teachers, previously well-trained for the testing standards.

Gross motor function

Sprint (SP): this test included a pyramid-shaped circuit in which players need to gather and return five table tennis balls one by one as fast as possible from five different baskets starting at the basis of the pyramid-shaped circuit. Time was measured in seconds and the best of two attempts was used as the final score.

Vertical jump (VJ): players were instructed to stand next to a wall and jump and touch the wall with their fingertips as high as possible. The difference between jumping and standing height with one arm up along the wall was measured in centimetres. The best of three attempts was used as the final score.

Ball control

Throwing a ball (TB): the players threw a table tennis ball as far away as possible with their preferred hand. The distance from the starting point at the marked line to the point of the ball's first bounce was measured in meters. The best of three attempts was used as the final score.

Speed while dribbling (SD): used a zigzag circuit in which the players needed to move sideways as fast as possible while dribbling with a basketball using one hand. Players had one attempt in which time was measured in seconds.

Aiming at target (AT): players needed to hit around the target (Ø 60 cm) on the floor at 2.5-meter distance with a table tennis ball using a standard bat with their preferred hand. Forehand and backhand had to be used alternately

during the attempts. A hit in the target's center (Ø 0.20 m) or the outer ring yielded 6 and 4 points, respectively. The total score of ten attempts was registered as the final score.

Balls skills (BS): this test also required hitting a round target on the floor (Ø 75 cm), but now players needed to throw a table tennis ball with their preferred hand via a vertical table tennis table from two different positions (1 and 2-meter distance away from the target). Each player had a total of twenty attempts. A hit in the centre (Ø 0.335 m) or the outer ring of the target yielded 2 and 1 points, respectively. The total score of the twenty attempts was registered as the final score.

Eye-hand coordination' (EH): players were instructed to throw a ball at a vertical table tennis table at 1-meter distance using one hand and catch the ball correctly with the other hand as frequently as possible in 30 seconds. The number of correct catches was scored.

Statistical analysis

IBM SPSS Statistics 26 (IBM Corp., Armonk, New York, USA) was used for the statistical analysis. The normality of the data was determined by using skewness and kurtosis values. Multivariate General Linear Model (GLM) analyses were used to test whether differences existed between the children from Kosovo and the Netherlands regarding gross motor function and ball control while using sex and age as covariates. This analysis included univariate outcome concerning differences on test item level. Partial eta squared were calculated as effect sizes. An effect around 0.01 was considered small, around 0.06 moderate and around 0.14 or higher as large (Cohen, 1988). Alpha was set at 0.05 for significance for all analysis. Based on the test's normality the determination of preliminary normative values was made by using the descriptive, frequency, and percentile values divided into five equal portions (percentiles).

Results

Table 2 presents the descriptive results per test items for girls and boys per age and per country. The multivariate GLM analysis revealed significant differences between the countries for both gross motor function and ball control with large effect sizes (gross motor function $F = 40.205$, $p < 0.001$, $\eta^2 = 0.172$ and ball control $F = 33.037$, $p < 0.001$, $\eta^2 = 0.301$). Children from the Netherlands outperformed the children from Kosovo concerning gross motor function and this was the other way around for ball control. Also the univariate comparison reveal significant differences on all test items ($p < 0.05$) between the children from Kosovo and the Netherlands, except for the test item 'eye hand coordination' ($p = .219$). Moderate to large effects sizes were seen for the test items 'vertical jump' ($\eta^2 = 0.163$), 'speed while dribbling' ($\eta^2 = 0.130$), 'aiming at target' ($\eta^2 = 0.098$) and 'ball skills' ($\eta^2 = 0.126$). Table 3 presents preliminary percentile scores for children from Kosovo and the Netherlands that could serve as normative values.

Discussion

Based on the results of the current study, it can be concluded that perceptuo-motor skills vary between children from Kosovo and the Netherlands. For that reason, it seems

Table 3. Preliminary normative values, i.e., percentile scores, for the perceptuo-motor skills per sex and age group

Age	Country	Sex	PCTL	Gross motor			Ball control			
				SP (s)	VJ (cm)	SD (s)	AT (points)	BS (points)	TB (m)	EH (points)
7-year olds	Netherlands	Girls	20 th	35.0	18.4	36.7	4	3	6.0	0
			40 th	35.4	23.1	39.3	4	8	7.2	4
			60 th	37.6	26.2	43.4	8	10	8.1	1
		Boys	20 th	37.0	18.0	30.1	0	4	5.3	0
			40 th	39.0	22.5	33.9	4	9	6.3	0
			60 th	40.2	26.0	40.7	8	15	7.0	3
	Kosovo	Girls	20 th	36.0	14.6	32.1	8	12	6.3	2
			40 th	39.8	18.0	35.2	12	14	7.2	3
			60 th	41.9	19.0	38.1	16	16	8.3	4
		Boys	20 th	35.7	15.0	33.6	8	9	6.2	2
			40 th	38.8	18.0	36.3	12	11	6.8	3
			60 th	41.2	19.0	38.0	15	14	7.3	4
8-year olds	Netherlands	Girls	20 th	35.6	21.0	27.7	8	3	6.2	0
			40 th	36.2	24.0	31.7	6	10	7.0	2
			60 th	37.4	27.2	36.5	12	12	7.9	5
		Boys	20 th	33.0	21.5	23.9	0	6	6.7	1
			40 th	36.3	24.0	26.1	8	10	8.2	4
			60 th	37.4	27.0	31.1	16	15	9.8	9
	Kosovo	Girls	20 th	35.2	14.0	15.8	8	12	6.9	3
			40 th	37.5	18.0	22.6	12	16	7.4	3
			60 th	40.0	22.0	28.3	20	19	8.1	4
		Boys	20 th	35.9	15.0	18.5	8	12	6.2	2
			40 th	37.1	18.0	22.1	12	16	7.2	3
			60 th	39.7	21.2	27.0	21	18	7.8	5
9-year olds	Netherlands	Girls	20 th	32.9	25.4	22.5	4	9	7.0	1
			40 th	35.5	29.0	27.1	4	13	7.6	2
			60 th	37.4	31.0	32.4	11	15	8.8	10
		Boys	20 th	32.9	24.6	20.4	4	11	8.5	4
			40 th	35.1	27.0	23.4	12	15	9.2	9
			60 th	37.2	30.0	24.6	20	18	10.7	12
	Kosovo	Girls	20 th	37.1	13.2	15.8	7	13	6.6	3
			40 th	38.6	16.0	21.2	14	18	7.8	5
			60 th	39.9	21.6	28.2	19	20	9.0	5
		Boys	20 th	32.3	12.4	16.8	20	12	6.5	4
			40 th	35.1	16.0	18.7	23	14	7.5	7
			60 th	36.9	22.0	19.4	30	22	8.52	9

SP (s): Sprint, VJ (cm): Vertical Jump, SD (s): Speed While Dribbling, AT (points): Aiming at Target, BS (points): Ball Skills, TB (m): Throwing a Ball, EH: Eye hand coordination

mechanisms that might reveal why and how cross-country differences arise. Moreover, for talent detection in table tennis, it might also make sense to include an international sample of recreational and high-performance youth and adult players. This will likely gain more insight into what the key-aspects are to participate in table tennis and what is

necessary for the elite level. It must be emphasized that this research and the perceptuo-motor skills assessment is only intended to improve talent programmes to help children to find a sport that fits their strength and personal preferences and accommodates them at the specific level of their abilities. It is never intended to limit the freedom of choice in youth.

Trainers and coaches should also be conscious of the possible risks of early specialization and selection at such a young age (e.g., injuries, mental exhaustion and dropouts).

Conflict of interest

The researcher declares that there is no conflict of interest in this research.

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МІЖДЕРЖАВНА ПЕРЕВІРКА МІЖ КОСОВО ТА НІДЕРЛАНДАМИ НІДЕРЛАНДСЬКОЇ ОЦІНКИ ПЕРЦЕПТИВНО-МОТОРНИХ НАВИЧОК ДЛЯ ВИЯВЛЕННЯ ТАЛАНТІВ У НАСТІЛЬНОМУ ТЕНІСІ

Блерта Абазі^{1ABD}, Мілаїм Беріша^{2,3CD}, Ірен Ренат Фабер^{4,5,6BD}

¹ААБ коледж

²УБТ – Вищий навчальний заклад

³Дитячий фітнес-центр Канади

⁴Ольденбурзький університет імені Карла фон Осецького

⁵Університет прикладних наук Віндесхайм

⁶Міжнародна федерація настільного тенісу

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 3 табл., 28 джерел.

Історія питання. Увагу в цьому дослідженні зосереджено на міждержавній перевірці нідерландської оцінки перцептивно-моторних навичок, яку використовують для виявлення талантів у настільному тенісі та яка також могла б стати основою для створення специфічних для країни нормативних значень для маленьких дітей (віком від 7 до 9 років).

Матеріали та методи. Загалом порівнювали дані 172 дітей із Косова та 219 дітей із Нідерландів. Дані склалися з результатів семи пунктів нідерландської оцінки перцептивно-моторних навичок, які оцінювали загальну моторику (тобто спринт і стрибок угору) і контроль м'яча (тобто кидок м'яча, швидкість під час ведення, прицілювання в ціль, навички володіння м'ячем і координацію очей і рук). Багатовимірний аналіз узагальненої лінійної моделі виявив статистично значущі відмінності між двома країнами з великими розмірами впливу щодо обох конструктів. Попередні нормативні значення представлені для кожної країни.

Результати. Результати показують, що перцептивно-моторні навички можуть відрізнятися в різних дітей одного віку та статі в різних країнах Європи. Із цієї причини видається доцільним продовжити дослідження необхідності встановлення нормативних значень для кожної країни, а також основних механізмів, які можуть виявити, чому та як виникають відмінності між країнами.

Висновки. Крім того, можливо, було б доцільно вивчити міжнародну вибірку молодих і дорослих гравців любительського та високопрофесійного класу, щоб створити еталон для виявлення та визначення талантів у настільному тенісі. Імовірно, це дасть змогу краще зрозуміти, які ключові аспекти передбачені для участі в настільному тенісі та що необхідно для елітного рівня.

Ключові слова: ракетковий спорт, молодь, моторні навички, тестування.

Information about the authors:

Abazi, Blerta: blerta1.abazi@universitetaab.com; <https://orcid.org/0000-0002-5588-2552>; Faculty of Physical Education and Sports, AAB College, Elez Berisha, 56, Industrial Zone, Pristina, 10000, Kosovo.

Berisha, Milaim: milaim.berisha@ubt-uni.net; <https://orcid.org/0000-0002-0353-7247>; Sports and Movement Sciences Faculty, UBT - Higher Education Institution, Lagjja Kalabria, 10000 Prishtine, Kosovo; Children's Fitness Centre of Canada, Toronto, Canada.

Faber, Irene Renate: irene.faber@uol.de; <https://orcid.org/0000-0002-4994-0453>; Institute of Sport Science, University of Oldenburg, Ammerlander Heerstrasse 114-118, 26129 Oldenburg, Germany; Germany Research Centre Human Movement and Education, Windesheim University of Applied Sciences, Zwolle, The Netherlands; International Table Tennis Federation, Lausanne, Switzerland.

Cite this article as: Abazi, B., Berisha, M., & Faber, I.R. (2023). A Cross-Country Validation Between Kosovo and the Netherlands of the Dutch Perceptual-Motor Skills Assessment for Talent Detection in Table Tennis. *Physical Education Theory and Methodology*, 23(4), 567-573. <https://doi.org/10.17309/tmf.2023.4.11>

Received: 18.05.2023. Accepted: 14.07.2023. Published: 30.08.2023

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ORIGINAL SCIENTIFIC ARTICLE

WATER GYMNASTICS AS A THERAPEUTIC METHOD TO IMPROVE MOTOR PLANNING IN CHILDREN WITH INTELLECTUAL DISABILITY

Diyana Georgieva^{1ABCDE} and Veselina Ivanova^{1ABCE}

¹Trakia University

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Diyana Georgieva, E-mail: paskaldi1929@abv.bg

Accepted for Publication: July 14, 2023

Published: August 30, 2023

DOI: 10.17309/tmfv.2023.4.12

Abstract

Study purpose. This paper is devoted to an experimental study aimed to identify the effects of water gymnastics as a therapeutic method for improving motor planning in children with intellectual disability studying in general and special education institutions.

Materials and methods. Twenty-three children (13 boys and 10 girls) aged from 6 to 11 years ($\bar{x} = 8.61$) participated in the study. Three neuropsychological tests were used to study motor function: Sequential alternation of fist-palm-side, Graphic test "Fence", and Fist-palm. Data were collected before and after participation in an 11-month therapy course conducted in a water environment. Descriptive analysis and One-way analysis of variance (ANOVA) were applied to process the empirical material. Cohen's η was used to interpret the effect size attributed to the therapeutic intervention.

Results. Programming, regulation, and control, as the main components of motor planning, showed improvement after the children participated in the organized sessions, as evidenced by the large or larger than typical effect size $\eta = [0.37:0.45+]$ recorded and the nonsignificant differences between groups differentiated by level of intellectual disability, age, and gender at the control measurement stage ($p > 0.05$).

Conclusions. The results lead to the generalization that at the final stage of the study, all three factors (level of intellectual disability, age and gender) had no significant influence on the development of motor planning, confirming the effects of water gymnastics as a technology for its improvement.

Keywords: motor planning, praxis, water gymnastics, children with intellectual disability.

Introduction

In the conditions of dynamic changes in various spheres of the social space, issues related to the education and preparation of the adolescent generation for autonomous life are gaining actualization. This implies a special approach to children who have problems in psychophysical development. In the spirit of the concept of individualization developed by Zh. Kozina and colleagues (Kozina et al., 2015), providing full support to these children is correlated with identifying the disorder, determining its nature and structure, and selecting relevant methodologies for therapeutic support (Tsvetkova-Arsova, 2004; Terzieva, 2020). Among the population of children with developmental disabilities, children with mental retardation (MR) account for the most significant

proportion, explained by the relatively wide variety of factors that can cause this condition. The problem of ID has been revised and discussed from all possible positions. Discussions continue in the face of dynamically changing social and academic opinions and views (Verzhikhovska, 2011; Chris et al., 2006). The interest in ID is provoked by the fact that the number of individuals with this type of dysontogeny is not decreasing, as evidenced by international statistics that in almost every country, intellectual disabilities occur among about 1% of the general population (APA, 2004). ID, as a disorder with a complex structure, causes secondary deviations in motor planning, which are reduced to a limited ability to perform or repeat coordinated movements aimed at achieving a specific result through a combination of muscular actions.

The ability to execute sequential complexes of movements and perform purposeful actions according to a pre-developed plan is a descriptive model of the concept of praxis. The

concept of A. R. Luria (2002) about motor planning is manifested by the fact that for the realization of each motor action, it is necessary to perform a series of individual movements corresponding to its general construction. The author calls such an idea an ideational sketch. Essentially, a plan of the action unfolds in individual motor acts – kinetic melodies. The enactment of the action is determined by transferring its idea to the executive (motor) area. Thus, the structure of the praxis as a higher mental function includes three domains – ideational, communicative and executive. The planar arrangement of movements encompasses several domains that form the types of praxis: dynamic, postural, oral, spatial, and constructive. Dynamic praxis is related to the dynamic organization of actions, sequence, and smooth switching from one element to another. Deficits in the motor planning component have an impact on graphic and oral communication, academic functioning and motor behavior of the child with intellectual disabilities (Macdonald et al., 2018).

An alternative solution to improve the motor function is the application of modern and progressive types of physical activity (Horvat & Franklin, 2001; Pitetti et al., 2001). In recent years, there has been a growing interest in physical therapy for individuals with intellectual disability performed in water environments, which has intensified research in this area (Stan, 2012; De Vierville, 2004). Among the various physical activities, water gymnastics deserves special attention, the resources of which can serve to improve the mechanisms of complex motor programs in children with intellectual disabilities. Water gymnastics is a set of exercises that take place in an aquatic space. Incorporating the water substance is particularly useful because of the slight resistance of water when performing the respective exercise, which generally affects the stability and strength of the musculature (Karaneshv, 1991) and because of safety in terms of positioning a person in the aquatic space regardless of the intensity and amplitude of the movements involved in the respective physical complex. Movements in water are also influenced by its hydrostatic pressure, temperature and chemical composition. According to the therapeutic goals set, the last two factors are subject to variations (Fragala-Pinkham, 2009). As a therapeutic method, aquatic gymnastics finds application in the intervention concepts of Bulgarian specialists, but there is still a fragmentation in the distribution of publications related to the research issue.

The lack of sufficient research motivated the choice to undertake a study whose aim was to identify the therapeutic effects of aquatic gymnastics on improving motor planning in children with intellectual disability. The central research thesis is in line with identifying a difference in the level of development of complex motor programs in children with intellectual disability before and after their participation in therapeutic aquatic gymnastics sessions. The object of the study is the motor planning (dynamic praxis) of children with ID taught in general and special education structures.

Materials and methods

Participants

The sample was selected by a convenience sampling method. It was formed from 23 Bulgarian children with

intellectual disability aged from 6 to 11 years ($\bar{x} = 8.61$). According to the report, the diagnostic picture of ID included mild ($N = 7$, $F70.0$) and moderate level ($N=16$, $F71.0$). By gender, 13 were boys, and 10 were girls. The children in the study population are educated in the general and special education structures located in the city of Stara Zagora, Republic of Bulgaria.

Study organization

The study was conducted from 2018 to 2019 and covers 3 phases:

(1) Development and implementation of a diagnostic battery designed to identify the level of motor planning development, selection of a relevant strategy to improve motor planning in children with intellectual disability.

(2) The application of the resources of water gymnastics as a therapeutic physical activity to improve motor planning. Prior to initiating the therapy sessions, the children's medical records were reviewed to eliminate potential risk factors. The actual intervention procedure then began. The children attended a public indoor swimming pool of appropriate height (feet always touching the ground) and temperature (28°C) twice a week for 11 months. An aquatics instructor worked with them to supervise and encourage their physical activity. Physical exercise in an aquatic environment had an average duration of 40 minutes. The sessions were differentiated into several time slots during which certain movement complexes for the upper and lower limbs were performed. Prior to entering the pool, 10-13 minutes were regulated for conducting a light dry workout to gradually increase the body's performance and achieve functional readiness for the upcoming activity in the aquatic environment. The next 25 minutes were utilized in the water: 15 minutes – of arm exercises (movements of the wrist in the figure of eight – with fingers together and with fingers apart and at different speeds; movements with the whole arm without and with flexion at the elbow joint – along a straight and curved path); 5-7 minutes – leg exercises (balancing, kicking; cycling) and 5 minutes – relaxation in the form of relaxation movements (walking in different directions – forward, backward, sideways). Specific equipment was used to perform some of the exercises: inflatable swimming rings, rubber dumbbells for water gymnastics, water gymnastics poles, elongated rubber equipment.

(3) Diagnostic reassessment of complex motor programs.

An adapted version of the battery of tests developed by A. P. Luria (2002), is used as a tool to assess motor planning development in children with ID. Diagnostic testing was performed in the Dynamic praxis category. The assessment of the dynamic organization of the motor act includes 3 neuropsychological probes: Sequential alternation of fist – palm – side, Graphic probe "Fence", Reciprocal coordination probe of the hands (fist – palm). In addition, the fourth Grade Scale was used, including quantitative and qualitative indicators:

Level 0 – independent and correct performance of the task without help from the experimenter;

Level 1 – performance of the task in which a number of minor errors are noted which are corrected by the child without the involvement of the examiner;

Level 2 – the realization of the sample takes place after stimulus support;

Table 1. Comparative results from the implementation of the three probes in the initial and final stage of the experiment

Statistical procedure	Sequential alternation of fist – palm – side		Graphic probe “Fence”		Reciprocal coordination	
Descriptive Statistics	Initial stage	Final stage	Initial stage	Final stage	Initial stage	Final stage
Mean	2.61	0.70	2.57	0.65	2.61	0.39
Median	3.00	1.00	3.00	1.00	3.00	0.00
Mode	3	1	3	1	3	0
Std. Deviation	0.499	0.470	0.590	0.573	0.499	0.499

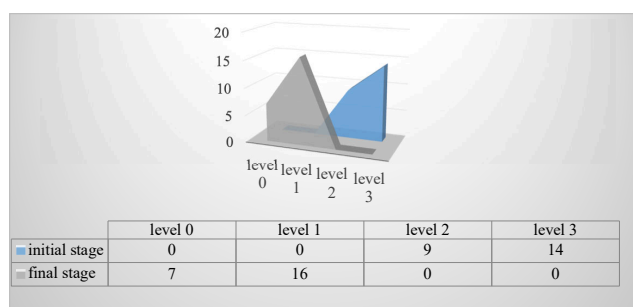
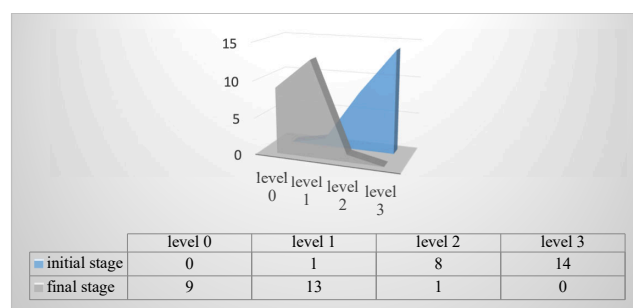
Level 3 – inability to perform the task. The increase in quantitative indicators is inversely proportional to the correct execution of the samples.

Statistical analysis

Tracking the dynamics of motor planning development in the studied areals was accomplished by fixing the initially obtained data for each child in a separate protocol. SPSS 16.0 statistical package was used for data processing. Descriptive analysis and One-way analysis of variance (ANOVA) were applied. The interpretation of effect size used the coefficient η , which was calculated using the formula: $\eta = (\bar{x} - A)/s$, where: A is a constant or the “gold standard”, $\bar{x}$ is the arithmetic mean, and s is the sample standard deviation.

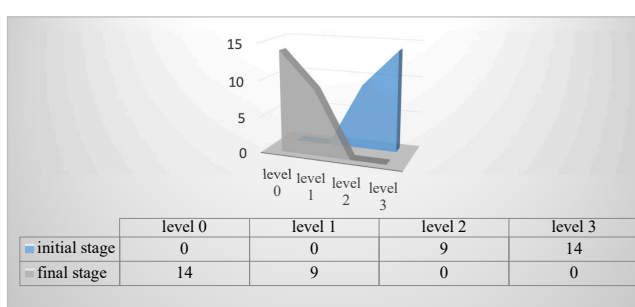
Results

First, descriptive statistics of the dependent variables were calculated. Then, the distribution of results for the 23 valid cases is presented separately for each of the three probes for the entire sample: (1) Sequential alternation of fist – palm – side, (2) Graphic probe “Fence”, (3) Reciprocal coordination test fist – palm (Table 1).

**Fig. 1.** Probe Sequential alternation of fist – palm – side for initial and final stage**Fig. 2.** Graphic probe “Fence” for initial and final stage

For the three samples implemented in the initial and final stages of the study, it can be summarized that the mean, median and mode values are in a position of complete symmetric distribution. The latter is evidence of an appropriately formed sample and the “purity” of the experiment in the applied research tests. When comparing the values, the inequalities $m_1 > m_2$; $Me_1 > Me_2$; $Mo_1 > Mo_2$ are obtained. A pronounced tendency to improve motor planning performance was found throughout the study insofar as a smaller value is indicative of better performance. Among the variables examined, the individual value of the first sample deviated the most from its mean ($SD = 0.499$ at the initial stage and 0.470 at the final stage). This SD suggests some degree of variability in the respondents’ ability to organize movements serially. In other words, the study participants differed from each other the most in their performance in this probe.

Figures 1-3 reflect the frequency distribution of data across the three probes at the study’s start and end time points. With respect to the first probe (Fig. 1), the data obtained in the course of the control experiment offer a quite different picture concerning the achievement of the children studied compared to the initial stage. It is noteworthy that almost 70% or more than half of the children (16) performed

**Fig. 3.** Reciprocal coordination for initial and final stage

independently. In spite of the inaccuracies, their actions were characterized by confidence and good self-control.

A similar trend was observed in the performance of the graphic test (Fig. 2). Error-free performance on the graphic model was observed in 39.1% of the cases, followed by the remaining 56.5% of the children who worked at a rate consistent with norms. They made no more than 1 interruption and were able to overcome the errors made completely independently.

Regarding reciprocal fluency (Fig. 3), in the final phase of the experiment, a positive dynamic in the ability to switch movements smoothly and synchronously was found in a dominant percentage of children (60.9%).

The zero quantitative indicator testifies to the progress made in this component of motor planning. With some fluctuation, motor program stability was found in the other 9 children (score 1). The visual analysis confirmed the absence of cases that gravitated around scores 2 and 3.

The next step was to use ANOVA to compare the arithmetic means for the samples and trace the relationships between the means of the population by comparing the variance components of the analysed variables. The variables that formed the groups (independent variables) in the present study were: level of ID, age, and gender. Their influence on the outcomes realized at the two points on the time continuum identified the effect size as interpreted by Cohen (Cohen, 1988).

In terms of the components studied, Fist – Palm – Side Alternation ($F = 3.631$, $p = 0.071$), Graphic test ($F = 1.574$, $p = 0.223$) and Reciprocal Coordination ($F = 0.439$, $p = 0.515$), the difference between the two groups of children (mild and moderate level of ID) was not statically significant ($p > 0.05$) at the final measurement. This allows claiming that

the factor level of ID does not influence the results found in the final stage of the experiment (Table 2). The effect size can be interpreted as large or more significant than the typical $\eta = [0.37:0.45+]$.

The majority of the children mastered the smooth (continuous) automated performance, with no difficulties switching from one program to another.

In the context of age variation between 6 and 11 years, results from the first ($F=2.181$, $p=.105$), second ($F = 0.969$, $p = 0.464$) and third samples ($F = 1.218$, $p = 0.343$) showed a difference that was also not statistically significant ($p > 0.05$), with effect sizes as large or larger than the typical effect size $\eta = [0.37:0.45+]$. The age factor was clearly not a source of differences in the development of motor planning skills that children demonstrated following active participation in regulated activities conducted in an aquatic space (Table 3). The results indicate that the mean shows a marked tendency towards reducing inaccuracies in the performance of complex motor complexes. After 11 months, almost all children, regardless of age group, had made clear

Table 2. Representative data from the analysis of variance on the factor Level of intellectual disability

Dependent variables		Sum of Squares	df	Mean Square	F	Sig.
Sequential alternation of fist – palm – side IS	Between Groups	3.728	1	3.728	44.739	0.000
	Within Groups	1.750	21	0.083		
Sequential alternation of fist – palm – side FS	Between Groups	0.718	1	0.718	3.631	0.071
	Within Groups	4.152	21	0.198		
Graphic probe IS	Between Groups	5.045	1	5.045	40.637	0.000
	Within Groups	2.607	21	0.124		
Graphic probe FS	Between Groups	0.503	1	0.503	1.574	0.223
	Within Groups	6.714	21	0.320		
Reciprocal coordination IS	Between Groups	0.326	1	0.326	1.331	0.262
	Within Groups	5.152	21	0.245		
Reciprocal coordination FS	Between Groups	0.112	1	0.112	0.439	0.515
	Within Groups	5.366	21	0.256		

Table 3. Representative data from the analysis of variance on the factor Age

Dependent variables		Sum of Squares	df	Mean Square	F	Sig.
Sequential alternation of fist – palm – side IS	Between Groups	1.112	5	0.222	0.866	0.524
	Within Groups	4.367	17	0.257		
Sequential alternation of fist – palm – side FS	Between Groups	1.903	5	0.381	2.181	0.105
	Within Groups	2.967	17	0.175		
Graphic probe IS	Between Groups	1.619	5	0.324	0.912	0.496
	Within Groups	6.033	17	0.355		
Graphic probe FS	Between Groups	1.601	5	0.320	0.969	0.464
	Within Groups	5.617	17	0.330		
Reciprocal coordination IS	Between Groups	0.845	5	0.169	0.620	0.686
	Within Groups	4.633	17	0.273		
Reciprocal coordination FS	Between Groups	1.445	5	0.289	1.218	0.343
	Within Groups	4.033	17	0.237		

Table 4. Representative data from the analysis of variance on the factor Gender

Dependent variables		Sum of Squares	df	Mean Square	F	Sig.
Sequential alternation of fist – palm – side IS	Between Groups	6.561	1	6.561	43.344	0.000
	Within Groups	3.179	21	0.151		
Sequential alternation of fist – palm – side FS	Between Groups	0.476	1	0.476	2.905	0.103
	Within Groups	3.438	21	0.164		
Graphic probe IS	Between Groups	9.326	1	9.326	31.837	0.000
	Within Groups	6.152	21	0.293		
Graphic probe FS	Between Groups	0.685	1	0.685	2.501	0.129
	Within Groups	5.750	21	0.274		
Reciprocal coordination IS	Between Groups	0.449	1	0.449	2.720	0.114
	Within Groups	3.464	21	0.165		
Reciprocal coordination FS	Between Groups	0.304	1	0.304	2.130	0.159
	Within Groups	3.000	21	0.143		

progress performing the diagnostic probes in a correct way without support from the experimenter.

The performance of the diagnostic test Fist-Palm-Side Alternation ($F = 2.905$, $p = 0.103$), Graphic test ($F = 2.501$, $p = 0.129$) and Reciprocal Coordination test ($F = 2.130$, $p = 0.159$) after the children's regular and beneficial attendance at the therapy sessions leads definitively to the conclusion that the results concerning the variables are not statistically significantly different between the two genders ($p > 0.05$), with effect sizes $\eta = [0.37:0.45+]$ found to be large or larger than typical (Table 4).

Hence, the factor gender did not influence any of the examined indicators at the experimental study's final stage (after 11 months). Despite typological gender differences, girls and boys were clearly equally motivated to put sufficient diligence and effort into the therapeutic activities organized and implemented in the non-traditional conditions of the aquatic environment.

Discussion

The aim of this study was to investigate the impact of water gymnastics as a therapeutic method to improve motor planning in children with ID. The research block for programming and control of movements and actions contained three neuropsychological tests: 3 positions test Fist – Edge – Palm, Graphic test, Reciprocal coordination test. The data obtained were processed immediately after the tests were administered, both in the initial and final stages, for reasons of a purely psychological nature. The numerous nuances in the children's behavior and the peculiarities of test administration, not recorded in the individual protocols, are still stored in the researcher's memory (Krajenbrink et al., 2020). Furthermore, the overall impression of the child allows for a more reasoned choice of one of the solutions in case of hesitation when the task performance falls in the border zone between two assessments. Therefore, when interpreting the results, it was important to consider how the data from the three probes corresponded. In the American neuropsychological school, this type of consistency is

referred to as convergence analysis (Baron, 2004), in which an overall vision of the child's motor behavior is built up and strong and weak 'factors' can be identified as well as their interaction.

The 3 positions test Firs – Edge – Palm identifies children's ability to learn the motor program by visual pattern and switch from one movement to another. Compared to the initial stage, after participation in the therapeutic sessions of water gymnastics, the realization of the diagnostic sample showed positive dynamics. A transition from a slow, element-by-element or intermittent complex of movements to the smooth execution of the motor program was registered. According to Forster (Forster et al., 2003), errors provoked by the placement of the three elements in different coordinate planes were reduced to single manifestations in which children showed independence in their correction. The regulated exercises in aqua space also normalized muscle tone, excluding the fragmented manifestations of increased or decreased tone.

The test of Reciprocal coordination was focused on investigating the robustness of consistency mechanisms in the organization of movements and the interaction of the two hemispheres. Similar to the first test, the practice of physical activities in the 11-month period determined changes manifested by automated execution of the motor program followed by isolated refusals at the beginning; normalized pace and improved muscle tone for the realization of movements. More successful task performance was a positive consequence of the specially structured aqua therapeutic program, in which part of the exercises included a complex related to the simultaneous change of hand posture: fist and palm in vertical position. Compared to the fist-palm-side sample, spatial errors were less pronounced due to the fact that in the reciprocal coordination test, both elements of the motor program (fist and palm) were located in the same coordinate plane (Domellöf & Säfström, 2020).

The Graphomotor sequences (i.e., repetitive sequences) test provided information for mastering the motor program in terms of a graphically presented pattern, smooth switching to the individual program elements, and automation of the

motor series. After the repeated test application, the motor program performance fluctuated between the absence of errors and their rapid correction following the specialist's instructions. The results are associated with the gradual improvement of the repertoire of motor schemes (Asenova, 2018). There were no dropouts from the program. The position of the graphic elements varied from their correct placement in the field to their repositioning on the top or bottom line without significant deviations. There was a trend towards a reduction in muscle tone changes.

Against the background that this is a pilot study, the need to conduct repeated experiments with a larger number of participants, a longer duration of the intervention program and a higher frequency of sessions in order to highlight more clearly the possibilities of multiplying the effects of the therapeutic method applied is evident.

Conclusions

The analysis of the data obtained before the therapeutic course of aquatic gymnastics showed statistically significant differences between the participants in the subgroups. In addition, qualitative characteristics differentiating dynamic praxis status were identified in children with varying level of ID, calendar age, and gender.

The developed and tested 11-month cycle of sessions, which is a complex implemented in water environment motor activities to improve motor planning in children with intellectual disability, proved to have a high coefficient of effectiveness. The effectiveness of aquatic gymnastics as a therapeutic method was established at the control stage of the study. Positive dynamics were noted in the majority of children in relation to all probes. Programming, regulation and control showed an improvement after the children participated in the organized sessions, as evidenced by the large or larger than typical effect size recorded and the insignificant differences between subgroups at the final measurement stage.

The greatest success was recorded in the performance of the reciprocal coordination probe. At the same time, the most serious difficulties manifested themselves in the test of alternating fist – palm – hand. The main reason for the contrasts in the performance of the samples was found in the placement of the elements of the two programs in the same or in different coordinate planes, which formed different degrees of complexity.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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ВОДНА ГІМНАСТИКА ЯК ТЕРАПЕВТИЧНИЙ МЕТОД ДЛЯ ПОКРАЩЕННЯ МОТОРНОГО ПЛАНУВАННЯ В ДІТЕЙ ІЗ ПОРУШЕННЯМ ІНТЕЛЕКТУАЛЬНОГО РОЗВИТКУ

Діяна Георгієва^{1ABCDE}, Веселіна Іванова^{1ABCE}

¹Тракійський університет

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 4 табл., 3 рис., 20 джерел.

Мета дослідження. Ця стаття присвячена експериментальному дослідженню, метою якого було виявлення впливу водної гімнастики як терапевтичного методу покращення моторного планування в дітей із порушенням інтелектуального розвитку, які навчаються в закладах загальної та спеціальної освіти.

Матеріали та методи. У дослідженні взяли участь 23 дитини (13 хлопчиків і 10 дівчаток) віком від 6 до 11 років ($\bar{x} = 8,61$). Для вивчення рухової функції використовували 3 нейропсихологічні тести: Послідовне чергування кулак-долоня-бік, Графічний тест «Паркан», Кулак-долоня. Дані збирали до та після участі в 11-місячному курсі терапії, який проводили у водному середовищі. Для обробки емпіричного матеріалу застосовували описовий аналіз та однофакторний дисперсійний аналіз (ANOVA). Для інтерпретації розміру ефекту, приписуваного терапевтичному втручання, використовували показник η Коена.

Результати. Програмування, регулювання та контроль, як основні компоненти моторного планування, показали покращення після того, як діти взяли участь в організованих заняттях, про що свідчать зареєстрований великий або більший за звичайний розмір ефекту $\eta = [0,37; 0,45+]$ та статистично незначущі відмінності між групами, диференційованими за рівнем порушення інтелектуального розвитку, віком та статтю, на етапі контрольного вимірювання ($p > 0,05$).

Висновки. Результати дозволяють дійти загального висновку, що на завершальному етапі дослідження всі три фактори (рівень порушення інтелектуального розвитку, вік і стать) не мали істотного впливу на розвиток моторного планування, підтверджуючи вплив водної гімнастики як технології для його покращення.

Ключові слова: моторне планування, практика, водна гімнастика, діти з порушенням інтелектуального розвитку.

Information about the authors:

Georgieva, Diyana: paskaldi1929@abv.bg; <https://orcid.org/0000-0001-5324-930X>; Faculty of Education, Trakia University, 6015 Studentski Grad, Stara Zagora, Bulgaria.

Ivanova, Veselina: v_g_chipeva@abv.bg; <https://orcid.org/0000-0002-0464-0967>; Faculty of Education, Trakia University, 6015 Studentski Grad, Stara Zagora, Bulgaria.

Cite this article as: Georgieva, D., & Ivanova, V. (2023). Water Gymnastics as a Therapeutic Method to Improve Motor Planning in Children with Intellectual Disability. *Physical Education Theory and Methodology*, 23(4), 574-580.
<https://doi.org/10.17309/tmf.2023.4.12>

Received: 22.05.2023. Accepted: 14.07.2023. Published: 30.08.2023

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ORIGINAL SCIENTIFIC ARTICLE

COMPREHENSIVE ASSESSMENT OF THE PREPAREDNESS OF HIGHLY QUALIFIED FIELD HOCKEY PLAYERS AT THE STAGE OF DIRECT PREPARATION FOR THE MAIN COMPETITIONS

Viktor Kostiukevych^{1ABCD E}, Nataliia Lazarenko^{1ACDE}, Vadym Adamchuk^{1BCDE},
Natalia Shchepotina^{1BCDE}, Tetiana Vozniuk^{1BCDE}, Oksana Shynkaruk^{2BCDE},
Inna Asauliuk^{1BCDE}, Stanislav Konnov^{1BCDE} and Serhii Voitenko^{1BCDE}

¹Vinnitsia Mykhailo Kotsiubynskyi State Pedagogical University

²National University of Ukraine on Physical Education and Sport

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Viktor Kostiukevych, E-mail: kostykevich.vik@gmail.com

Accepted for Publication: July 14, 2023

Published: August 30, 2023

DOI: 10.17309/tmfv.2023.4.13

Abstract

The purpose of the study was to experimentally substantiate the methodological approach to the development of a comprehensive assessment of the preparedness of highly qualified field hockey players at the stage of direct preparation for the main competitions.

Materials and methods. Highly qualified players, members of the national field hockey team of Ukraine (n=21) participated in the study. The average age of the players was ($\bar{x} \pm S$) 24.9 ± 5.76 years, their sports qualification was masters of sports of Ukraine. The study was conducted over the first and second competitive periods of the two-cycle planning of the training process of highly qualified field hockey players of the 2020-2021 sports season. During the first competitive period, a methodical approach to comprehensive assessment of the preparedness of highly qualified field hockey players was developed. Within the second competition period, which included the stage of direct preparation for the main competitions indicators of a comprehensive assessment of readiness of the players were determined. In order to develop a comprehensive assessment of fitness, tests and criteria were used to assess the level of physical, functional fitness, physical fitness in relation to technique and competitive activity of hockey players.

Results. A methodical approach has been developed for the comprehensive assessment of the preparedness of highly qualified field hockey players according to the following algorithm: determination of criteria for the manifestation of physical and functional preparedness, physical preparedness in relation to technique, competitive activity; development of a 10-point rating scale; establishment of a comprehensive assessment of players' readiness during the stage of direct preparation for the main competitions.

Conclusions. The structure of the stage of direct preparation for the main competitions consisted of a basic and a special preparatory mesocycles. The volume of direct motor activity was 38 hours, in particular, the ratio of means: general preparatory exercises – 55.4%, special preparatory exercises – 19.5%, lead exercises – 10.9%, competitive exercises – 15.2%; ratio of training loads: aerobic – 56.5%, aerobic-anaerobic – 32.7%, anaerobic-lactate – 7.6%, anaerobic-glycolytic – 3.2%. A statistically probable positive change ($p < 0.01$) in the indicators of the comprehensive assessment of players' preparedness during the stage of direct preparation for the main competitions was established.

Keywords: highly qualified field hockey players, stage of direct preparation for the main competitions, comprehensive assessment of the preparedness, ten-point scale.

Introduction

The trends in the development of sports of higher achievements at the current stage are characterized by the

rational application of training influences on the level of preparedness of athletes depending on the stage of the training macrocycle (Bondarchuk, 2005; Bompà, Buzzichelli, 2018; Platonov, 2020). One of the most important structural formations of the training process of athletes in the annual training cycle is the stage of direct preparation for the main competitions (Platonov, 2018; Kostiukevich, Konnov, 2022;

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Adamchuk et al., 2023). The problem of training athletes at this stage lies both in the structure and content of the training process, and the diagnosis of their level of preparation (Shamardin, 2012; Tyshchenko et al., 2019; Russell et al., 2022). That is, at the stage of direct preparation for the main competitions, it is necessary to optimally use the means of training work and loads of various orientations in order to bring athletes to a high level of readiness to participate in competitions. The analysis of such readiness should be carried out on the basis of a comprehensive assessment that reflects the manifestation of physical, functional, technical-tactical and competitive preparedness of athletes (Mitova, 2020; Oliinyk et al., 2021; Bezmylov et al., 2022).

The problem of comprehensive evaluation of the preparedness of athletes in team game sports has been the subject of scientific research by many specialists. In particular, in the work of Tyshchenko et al. (2019) proposed a system for monitoring the effectiveness of training and competitive activities of highly qualified handball teams. A comprehensive assessment of indicators of physical, functional and competitive fitness of qualified volleyball players as a criterion for the effectiveness of building a training process is presented in the work of Kostiukevych et al. (2019). In the studies of Tyshchenko et al. (2018) and Doroshenko et al. (2020) substantiated the factor structure of physical and functional fitness of basketball players, as well as the competitive activity of highly qualified basketball players as a comprehensive assessment of technical and tactical skills. Mitova (2020) proposed the technology of implementing a system of complex control in team game sports in the process of long-term training. With the help of a comprehensive assessment of indicators of physical, functional, competitive readiness of qualified football players in the study of Shchepotina et al. (2021) the effectiveness of training process management based on programming has been experimentally justified.

As for field hockey, the study of Perepelytsia et al. (2019, 2021) was aimed at determining the indicators of tactical preparedness of field hockey players as well as improving tactical preparation within the annual training cycle. Indicators of physical and functional fitness of highly qualified field hockey players as criteria for adaptation to training loads were considered in the work of Kostiukevych, Shchepotina, Shynkaruk et al. (2020). Konnov (2021) characterized the indicators of the integral assessment of the technical and tactical activity of a highly qualified team in field hockey. Kostiukevych et al. (2021) examined the factor structure of special abilities of highly qualified athletes in field hockey which included morpho-functional indicators, indicators of physical, technical-tactical and competitive readiness of players.

Therefore, the analysis of literary sources allows us to state that the problem of comprehensive assessment of athletes' preparedness at the stage of direct preparation for competitions is relevant. At the same time, for such an Olympic sport as field hockey, a separate study on the specified problem is needed, the results of which are highlighted in this article.

The hypothesis of the study: it was assumed that the determination of the indicators of the complex preparedness of highly qualified field hockey players will allow to optimize the managerial influences on the determination and

maintenance of the second phase of the sports uniform at the stage of direct preparation for the main competitions of the sports season.

The purpose of the study was to experimentally substantiate the methodological approach to the development of a comprehensive assessment of the preparedness of highly qualified field hockey players at the stage of direct preparation for the main competitions.

Materials and methods

Participants

Highly qualified players, members of the national field hockey team of Ukraine (n=21) participated in the study. The average age of the players was ($\bar{x} \pm S$) 24.9 ± 5.76 years, their sports qualification was masters of sports of Ukraine. The study was approved by the ethics committee of Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, and all procedures were in accordance with the Declaration of Helsinki. Informative consent to participate in the experiment was obtained from the study participants.

Study organization

The study was conducted over the first and second competitive periods of the two-cycle planning of the training process of highly qualified field hockey players of the 2020-2021 sports season. During the first competitive period, a methodical approach to comprehensive assessment of the preparedness of highly qualified field hockey players was developed. Within the second competition period, which included the stage of direct preparation for the main competitions (the European Field Hockey Championship "Championship II", which took place from 14 August to 21 August 2021 in Gniezno, Poland), indicators of a comprehensive assessment of readiness of the players were determined. In order to develop a comprehensive assessment of fitness, tests and criteria were used to assess the level of physical, functional fitness, physical fitness in relation to technique and competitive activity of hockey players (Table 1).

In the process of pedagogical observation, we timed the training work (recording the nature and duration of the exercises) with the simultaneous registration of the heart rate (HR) using a Polar RS800CX heart rate monitor. The analysis of the initial data made it possible to determine the volume and ratio of means (general training, special training, underwater, competitive), loads of various orientations (aerobic, mixed aerobic-anaerobic, anaerobic lactate, anaerobic glycolytic orientation).

Pedagogical testing was used to determine physical and functional fitness, physical fitness in relation to technology. To assess the starting speed, a 30 m run from a high start was used. Speed and strength abilities were determined by standing long jump. Cooper's test (continuous running for 12 minutes) was used to determine the general endurance of hockey players. To assess the speed endurance of hockey players, the 180 m shuttle run test is informative.

Based on the results of the shuttle run of 180 m, the integral adaptation index (IAI) was determined, which characterized the level of adaptation of the hockey players'

Table 1. Tests and criteria for comprehensive assessment of preparedness of the highly qualified field hockey players

Areas of preparedness		Tests and criteria					
Physical preparedness	Running 30 m from a high start, s	Long jump from a place, m	Shuttle run 180 m, s		Cooper's test, m		
Functional preparedness	MOCabs, l×min ⁻¹	MOCrel, ml×min ⁻¹ ×kg ⁻¹	IAI, relative units		ORI, relative units		
Physical preparedness interconnected with technique	Running 14.6 m with kicking the ball, s	Driving the ball – going around the posts – hitting the goal, s	Driving-passing the ball into the goal, s		Throwing the ball with a stick at a distance	A series of shots on goal, s	
Preparedness for competition	IC	MC	AC	EC	ECMA	CC	IE

Notes: MOCabs – absolute indicator of maximum oxygen consumption; MOCrel – relative indicator of maximum oxygen consumption; IAI – integral adaptation index; ORI – operational recovery index; IC – intensity coefficient; MC – mobility coefficient; AC – aggressiveness coefficient; EC – efficiency coefficient; ECMA – efficiency coefficient of martial arts; CC – creativity coefficient; IE – integral evaluation

body to anaerobic glycolytic loads. The lower the IAI indicator, the better the training of the hockey player:

$$IAI = t(f_1 + f_2 + f_3), (1)$$

where: t is the time of the 180 m shuttle run test;

f_1, f_2, f_3 – heart rate for 10 seconds at the end of the first, second and third minutes of recovery.

The operative recovery index (ORI) was determined by the formula (Kostiukevych, Shchepotina, Shynkaruk et al, 2020):

$$ORI = 100 - \frac{fr \cdot 100}{f_{sr}}, (2)$$

where: fr is heart rate at the end of the first minute of recovery in 10 s (from 50 to 60 s);

f_{sr} is heart rate immediately after the shuttle run 180 m test (in 10 s).

Absolute and relative indicators of maximum oxygen consumption (MOC_{abs} and MOC_{rel}) were determined on the basis of the run-based variant of the PWC₁₇₀ test (PWC_{170(V)}).

The level of physical fitness in relation to the technique of highly qualified hockey players was determined using the following tests:

1. Running 14.63 m with kicking the ball in order to assess starting speed in relation to special agility. Performance conditions: a hockey player from a high start at maximum speed runs a distance of 14.63 m and knocks out the ball, which is on the contact platform, with a blow of the stick. The result is evaluated by the duration of the entire exercise: from the start of the run to hitting the ball with the stick. The best result from two attempts is evaluated. Pause between attempts makes up 2-3 minutes.

2. Driving the ball – going around the posts – hitting the goal – evaluation of speed technique (Fig. 1). Performance conditions: the hockey player starts dribbling the ball, which is located at a distance of 45.7 m from the goal line, leads it to the post, which is located 21 m from the start, using at least 5 touches with the stick, then circles 5 posts that are behind 2 m from each other in a straight line, enter the kick circle (no more than 2 m beyond the circle line) and kick at the goal. The result is evaluated by the duration of the entire exercise – from the start of dribbling until the ball touches the back wall of the goal. The best result from two attempts was evaluated. Pause between attempts makes up 2-3 minutes.

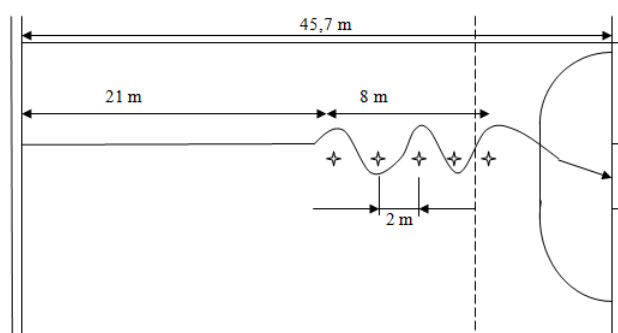
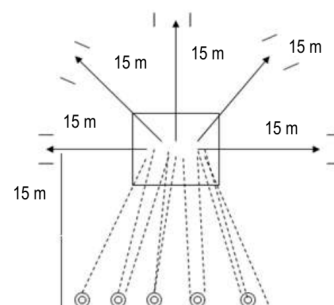


Fig. 1. Scheme of performance of the test “Dribbling the ball – going around the posts – hitting the goal”

3. Dribbling the ball – passing the ball to the goal (performed in the form of a shuttle run – 5 times) – in order to evaluate speed technique in relation to special endurance (Fig. 2). Performance conditions: 5 balls are placed on the starting line, a square (2×2 m) is drawn 15 m from the starting line, 5 goals are placed parallel to the left, right, and front sides of the square, as well as diagonally opposite its left and right corners at a distance of 15 m, each with a width of 1 m. The hockey player starts dribbling the ball using at least 3-x touches with the stick, enters it into the square, performs a targeted pass into the goal, which is located on the left, returns to the start, performs similar actions with the next ball, executes a pass to the gate, which is located opposite the left square, and so on. The result is evaluated by the duration of the entire exercise – from the start of dribbling the first ball until the hockey player crosses the starting line after the fifth pass of the ball.

Fig. 2. Scheme of execution of the “Dribbling – passing the ball into the goal” test



4. Throwing a ball with a stick at a distance – to assess technical preparation and special strength. Performance conditions: a hockey player throws the ball with a stick in a corridor 10 m wide. The result is evaluated by the best of three attempts.

5. A series of shots at the goal: in order to assess special speed-power endurance (Fig. 3). Performance conditions: 31 balls are placed in a straight line at a distance of 11 m from the goal (the distance between the balls is 20 cm). The central ball is in the center of the goal, and there are 15 more balls to the left and right of it. The hockey player starts the exercise from the left side and hits the balls with maximum force at the goal, which is protected by the goalkeeper. The result is evaluated by the duration of the entire exercise: from the beginning of the kick to the first ball and touching the goalkeeper or crossing the goal line of the 31st ball.

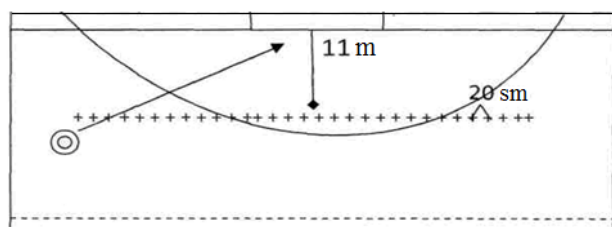


Fig. 3. Scheme of performance of the test – a series of shots at the goal

Control of competitive activity was carried out on the basis of assessment of technical and tactical activity (TTA) of players, taking into account coordination complexity. There were developed 6 specific indicators of competitive activity (coefficients of intensity, mobility, aggressiveness, efficiency, single combat efficiency, creativity) and integral assessment, which were described in detail in previous studies (Kostiukevych et al., 2018; Shchepotina et al., 2021).

1. The intensity coefficient (IC):

$$IC = \frac{\sum_{i=1}^n TTA}{t}, \quad (6)$$

where: $\sum_{i=1}^n TTA$ – total amount of technical and tactical actions of player in a match;

t – pure time played by a player in the match.

2. The mobility coefficient (MC):

$$MC = \frac{\sum_{i=1}^n TTA(2nd\ MCC + 3rd\ MCC)}{t} \times 2, \quad (7)$$

where: $\sum_{i=1}^n TTA(2nd\ MCC + 3rd\ MCC)$ – total amount of technical and tactical actions of player in the match in the second and third modes of coordination complexity;

2 – indicator of coordination complexity.

3. The aggressiveness coefficient (AC):

$$AC = \frac{\sum_{i=1}^n TTA(3rd\ MCC)}{t} \times 3, \quad (8)$$

where: $\sum_{i=1}^n TTA(3rd\ MCC)$ – total amount of technical and tactical actions of player in the match in the third mode of coordination complexity;

3 – indicator of coordination complexity.

4. The efficiency coefficient (EC):

$$EC = \frac{\sum_{i=1}^n preciseTTA}{\sum_{i=1}^n allTTA}, \quad (9)$$

where: $\sum_{i=1}^n preciseTTA$ – total amount of precise technical and tactical actions of player in the match;

$\sum_{i=1}^n allTTA$ – total amount of all technical and tactical actions of player in the match.

5. The single combat efficiency coefficient (SCEC):

$$SCEC = \frac{\sum_{i=1}^n preciseTTA(stops, holds, tacklings, dummies, performed in 3rd\ MCC)}{\sum_{i=1}^n allTTA(stops, holds, tacklings, dummies, performed in 3rd\ MCC)}, \quad (10)$$

where: $\sum_{i=1}^n preciseTTA(stops, holds, tacklings, dummies, performed in 3rd\ MCC)$ – total amount of precise technical and tactical actions of player in the match in the third mode of coordination complexity;

$\sum_{i=1}^n allTTA(stops, holds, tacklings, dummies, performed in 3rd\ MCC)$ – total amount of all technical and tactical actions of player in the match in the third mode of coordination complexity/

6. The creativity coefficient (CC):

$$CC = \frac{\sum_{i=1}^n preciseTTA(DP \times 1 + SP \times 2 + GP \times 5 + GK \times 5 + G \times 10)}{t}, \quad (11)$$

where: DP – developing passes; SP – sharpening passes; GP – goal passes; GK – goal kicks; G – goals.

7. The integral assessment (IA):

$$IA = IC + MC + AC + EC + SCEC + CC \quad (12).$$

Statistical analysis

In the mathematical processing of the research results, descriptive statistics were used, which involved the determination of the arithmetic mean ($\bar{x}$) and the mean square deviation (S). The statistical significance of the difference between indicators was determined using the Student's t -test for paired two samples, which was calculated as the ratio of the arithmetic mean of differences ($\bar{x}_d$) to the standard error of the arithmetic mean of differences (S_d). The hypothesis of a normal distribution of the research results was pre-tested according to the Shapiro-Wilk test (W). During statistical processing, the level of significance $p = 0.05$, $p = 0.01$ was accepted. Mathematical processing of the research results was carried out using the "Data Analysis" package of the MS Office Excel computer program, as well as using the Statistica 10.0 program (Albert et al., 2017; Byshevets et al., 2019; Kostiukevych, Lazarenko, Vozniuk et al., 2020).

Results

Experimental substantiation of the expediency of using training influences at the stage of direct preparation for the main competitions was carried out on the basis of a comprehensive assessment of the players' preparedness. In our study, the outlined stage consisted of basic and special preparatory mesocycles (Fig. 4).

Training influences on the preparedness of athletes were carried out through the use of loads of different orientations. The total amount of training loads at the stage of direct preparation for the main competitions amounted to 2260 minutes (~ 38 hours), of which 1274 minutes (56.5%) were aerobic loads, 736 minutes (32.7%) were mixed (aerobic-anaerobic) loads, 172 min (7.6%) anaerobic-lactate loads and 72 min (3.2%) anaerobic-glycolytic loads.

A comprehensive assessment of the preparedness of highly qualified field hockey players at the stage of direct

Stage of direct preparation for the main competitions						
Mesocycles	Basic			Special preparation		
Microcycles	4-day tightening	4-day shock	3-day recovery	4-day shock	3-day recovery	4-day introductory microcycle

Fig. 4. The structure of the stage of direct training of highly qualified field hockey players for the main competitions of the sports season

preparation for the main competitions was determined on the basis of a 10-point scale, which was developed on the basis of the algorithm:

The 1st step is to determine the main characteristics of the sample (arithmetic mean, mean square deviation) for each criterion of physical, functional fitness, physical fitness in relation to technique, integral assessment of competitive activity.

The 2nd step – based on the “3S rule”, according to which the interval from $\bar{x}+3S$ to $\bar{x}-3S$ contains 99.73% of all values

of the studied quantity (Byshevets et al., 2019), the interscore interval (ISI) was determined:

$$ISI = \frac{(\bar{x}+3S) - (\bar{x}-3S)}{9} (13)$$

The 3rd step is the definition of a 10-point scale of complex preparedness of highly qualified field hockey players: the value of the 1st point corresponded to the indicator – 3S; nine times the ISI value was added (or subtracted) to (from) this value (Table 2).

A comparative analysis of indicators of physical, functional fitness, physical fitness in relation to technique and competitive activity of highly qualified field hockey players before and at the end of the stage of direct preparation for the main competitions (Table 3) allows us to state that the training effects at this stage were effective. In particular, there were statistically significant changes in the indicators of the complex assessment of physical (8.0 %; $p<0.01$), functional (6.7%; $p<0.01$) preparedness, physical preparedness in relation to technology (1, 6%; $p<0.01$). Also, the statistical probability of increasing the indicators of the comprehensive assessment of players was observed by the value of the integrated assessment of competitive activity (6.1 %; $p<0.01$).

Table 2. Ten-point scale for evaluating the values of indicators of special abilities of highly qualified field hockey players (field players)

Indicator	Points									
	1	2	3	4	5	6	7	8	9	10
1 30 m run from a high start, s	4.59	4.51	4.43	4.35	4.27	4.19	4.11	4.03	3.95	3.87
2 Long jump from a place, m	1.98	2.11	2.24	2.37	2.50	2.63	2.76	2.89	3.02	3.15
3 180 m shuttle run, s	40.63	39.98	39.33	38.68	38.03	37.38	36.73	36.08	35.43	34.78
4 Cooper's test, m	2905.7	2904.5	3023.3	3082.1	3140.9	3199.7	3258.5	3317.3	3376.1	3434.9
5 MOCabs, l·min ⁻¹	3.30	3.45	3.60	3.75	3.90	4.05	4.20	4.35	4.50	4.65
6 MOCrel, ml·min ⁻¹ ·kg ⁻¹	40.91	43.73	46.55	49.37	52.19	55.01	57.83	60.65	63.47	66.29
7 IAI, relative units	2502.2	2579.1	2656.0	2732.2	2808.4	2884.6	2960.8	3037.0	3113.2	3189.4
8 ORI, relative units	16.03	17.09	18.15	19.21	20.27	21.33	22.39	23.45	24.51	25.57
9 Running 14.63 m with the kicking of the ball, s	2.95	2.90	2.85	2.80	2.75	2.70	2.65	2.60	2.55	2.50
10 Dribbling-going around the posts- hitting the goal, s	9.30	8.09	7.88	7.67	7.46	7.25	7.04	6.83	6.62	6.41
11 Dribbling - passing the ball into the goal, s	41.66	40.89	40.12	39.35	38.58	37.81	37.04	36.38	35.01	34.84
12 Hitting a ball with a stick at a distance, m	28.58	30.88	33.18	35.48	37.78	40.08	42.38	44.68	46.98	49.28
13 A series of shots on goal, s	32.78	31.81	30.84	29.87	28.90	27.93	26.96	25.99	25.02	24.05
14 Intensity coefficient, points	0.27	0.42	0.57	0.72	0.87	1.02	1.17	1.32	1.47	1.62
15 Mobility coefficient, points	0.59	0.86	1.13	1.40	1.67	1.94	2.21	2.48	2.75	3.02
16 Aggressiveness coefficient, points	0.19	0.44	0.69	1.13	1.57	2.01	2.26	2.51	2.76	3.01
17 Efficiency coefficient, points	0.51	0.56	0.61	0.66	0.71	0.76	0.81	0.86	0.91	0.96
18 Efficiency coefficient of single combats, points	0.15	0.24	0.33	0.42	0.51	0.60	0.69	0.78	0.87	0.96
19 Creativity coefficient, points	0.90	0.18	0.27	0.36	0.45	0.54	0.63	0.72	0.81	0.90
20 Integral assessment, points	2.18	2.94	3.70	4.46	5.22	5.98	6.74	7.50	8.26	9.02
21 Comprehensive evaluation, points	49.0	63.11	77.2	91.3	105.4	119.5	133.6	147.7	161.8	175.9

Notes: MOCabs – absolute indicator of maximum oxygen consumption; MOCrel – relative indicator of maximum oxygen consumption; IAI – integral adaptation index; ORI – operational recovery index

Table 3. Indicators of a comprehensive assessment of the preparedness of highly qualified field hockey players (n=21) during the stage of direct preparation for the main competitions

Types of preparedness	Comprehensive evaluation, points								
	SDP		Changes ($\Delta \bar{x}$)		Statistical indicators				
	Initial average values ($\bar{x}_1$)	Final average values ($\bar{x}_2$)	In points	%	d	σ	Sd	tp	p
Physical preparedness	24.0	26.1	2.1	8.0	2.4	2.37	0.51	4.71	<0.01
Functional preparedness	22.3	23.9	1.6	6.7	2.4	1.34	0.29	8.27	<0.01
Physical fitness in relation to technology	31.2	31.7	0.5	1.6	1.1	2.21	0.26	4.23	<0.01
Integrated assessment of competitive activity	35.1	37.4	2.3	6.1	0.7	0.71	0.16	4.38	<0.01

Notes: SDP – the stage of direct preparation for the main competitions; d – the arithmetic mean of the differences; σ – mean square deviation of the differences; Sd – standard error of the arithmetic mean of the differences; tp – estimated value of Student's t-test; p – level of significance

The indicators of the comprehensive assessment reflect the general level of preparedness of athletes and can serve as indicative models for the readiness of athletes for the main competitions of the sports season (Fig. 5).

Statistically probable changes that occurred in indicators of physical, functional fitness, physical fitness in relation to technique and competitive activity allow us to draw a conclusion about the rational construction of the training process of highly qualified hockey players at the stage of direct preparation for the main competitions.

Discussion

The training process of athletes at the stage of direct preparation for the main competitions of the sports season is determined by the training exercises on the basis of which the second phase (maintenance phase) of the sports uniform is formed. Sports form is the state of an athlete characterized by the best readiness for competitive activity. Sports form represents the harmonious development of all aspects of an athlete's preparedness (Bondarchuk, 2005; Bompá, Buzzichelli, 2018; Platonov, 2020). Based on this, in order to determine the state of sportsmen's sports form, a comprehensive assessment of their preparedness is necessary. In our study, a comprehensive assessment of the preparedness of highly qualified field hockey players at the stage of direct preparation for the main competitions was carried out on the basis of the following algorithm:

- determined tests for assessing the readiness of athletes, which to the greatest extent characterize the peculiarities of sports activity in field hockey;
- an integrated assessment of competitive activity in this sport was developed;
- a 10-point scale of comprehensive assessment of preparedness and competitive activity of highly qualified field hockey players was developed;
- a comparative analysis of the comprehensive preparedness of the players during the stage of direct preparation for the main competitions was carried out.

Our study is a continuation of solving the problem of comprehensive assessment in team game sports (Tyshchenko

et al., 2018; Doroshenko et al., 2020; Mitova, 2020, etc.). The proposed methodological approach of comprehensive assessment of the preparedness of highly qualified field hockey players significantly complements the results of previous studies in the context of the development and use of unified measurement units – points, which significantly simplifies the comparison of the obtained results, the comparison of different aspects of the athletes' preparedness. In our study, it was assumed, on the one hand, to develop a methodical approach to determine the comprehensive preparedness of highly qualified field hockey players, and on the other hand, to establish model indicators that reflected the level of their sports form. Thus, the presented models of preparedness can be used as a guide in the process of annual training and sports selection at the stages of multi-year improvement of field hockey players.

The integral assessment of competitive activity substantiated in previous studies (Kostiukevych et al., 2021; Shchepotina et al., 2021) was also reflected in field hockey. This emphasizes the important practical significance of the presented results, since the integral assessment acts as an objective and informative criterion of the competitive activity of hockey players, taking into account the quantitative and qualitative side of technical-tactical activity, the coordination complexity of technical-tactical actions, their tactical significance, the role of players, etc. Thus, the presented results complement the existing body of research on the assessment of competitive performance in team game sports (White, MacFarlane, 2015; Solovey et al., 2020; Oliynyk et al., 2021).

The knowledge accumulated regarding the structure of the stage of direct preparation for the main competitions of the season gained further development (Platonov, 2018). In addition, indicators of volumes and ratios of training equipment, loads of different orientations of highly qualified field hockey players represent a contribution to the existing scientific work on the content of the stage of direct preparation for competitions in team sports (Kostiukevych et al., 2019; Tyshchenko et al., 2019; Shchepotina et al., 2021).

The use of the results of this study will allow to optimize managerial influences in the training process of highly

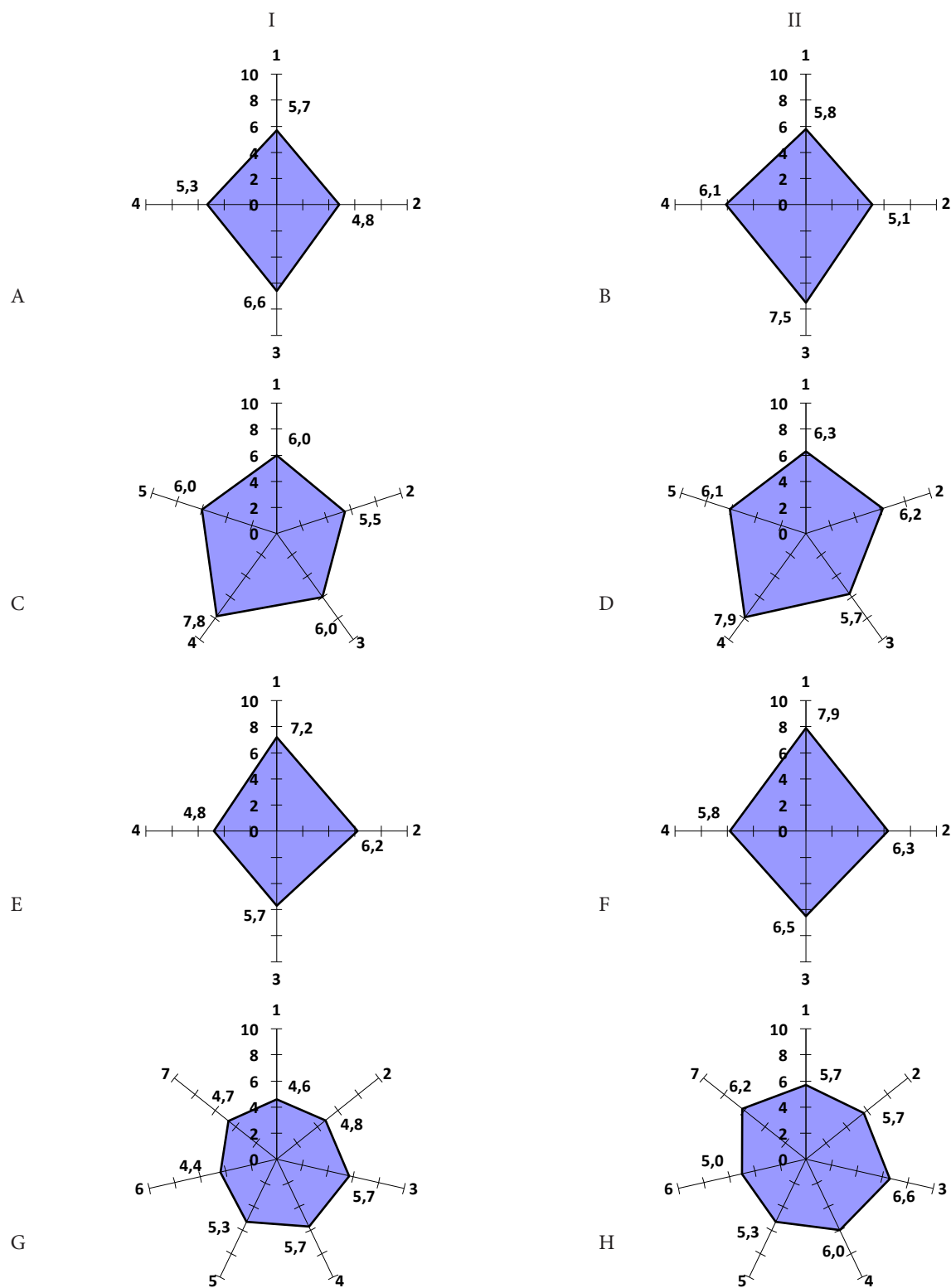


Fig. 5. Graphical models of a complex assessment of the preparedness of highly qualified field hockey players (n = 21) at the beginning (I) and at the end (II) of the stage of direct preparation for the main competitions: A, B – physical fitness: 1 – running 30 m from a high start; 2 – long jump from a standing position; 3 – shuttle run 180 m; 4 – Cooper's test; C, D – physical fitness in relation to technique: 1 – running 14.63 m with hitting the ball; 2 – dribbling the ball – going around the posts – hitting the goal; 3 – dribbling the ball – passing the ball into the goal; 4 – throwing the ball with a stick at a distance; 5 – a series of shots at the goal; E, F – functional readiness: 1 – absolute indicator of maximum oxygen consumption; 2 – relative indicator of maximum oxygen consumption; 3 – integral adaptation index; 4 – operational recovery index; G, H – competitive activity: 1 – intensity factor; 2 – mobility coefficient; 3 – coefficient of aggressiveness; 4 – efficiency ratio; 5 – efficiency coefficient of martial arts; 6 – creativity coefficient; 7 – integral assessment

qualified athletes, first of all, at the stage of direct preparation for the main competitions, where the main tasks of the sports season are solved.

Conclusions

A comprehensive assessment of athletes' preparedness reflects the optimal state of their readiness for effective participation in competitive activities, primarily for participation in major competitions. The scientific and methodical approach to the development of a complex assessment of the preparedness of highly qualified field hockey players involved an algorithm: definition of criteria for assessing the manifestation of various aspects of players' preparedness; development of a 10-point scale of values for each of the criteria (determination of the arithmetic mean ($\bar{x}$), mean square deviation (S), interscore interval according to the "3S rule"); assessment of test results; establishing model indicators of athletes' readiness for the main competitions of the sports season.

A statistically probable increase in the preparedness of highly qualified field hockey players during the stage of direct preparation for the main competitions was established at the significance level of $p < 0.01$ according to the indicators of physical (8.0%), functional (6.7%), physical preparedness in relationships connection with technology (1.6%), integrated assessment of competitive activity (6.1%). On the basis of these data, we can state the optimal construction of the players' training process at this stage.

The perspective of further research will be determined by determining the dynamics of a comprehensive assessment of the preparedness of highly qualified field hockey players during the annual macrocycle.

Acknowledgements

The research was carried out within the framework of the plan of the research work of the Department of Theory and Methodology of Sports of Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University for 2016-2020 "Theoretical and Methodological Foundations of Programming and Modeling of the Training Process of Sportsmen of Different Qualifications" (state registration number 0116U005299) and for 2021-2025 "Organizational and methodological principles of programming the training process of gratified and highly gratified athletes" (state registration number 0121U109550).

Conflict of interests

The authors state that there is no conflict of interests.

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КОМПЛЕКСНА ОЦІНКА ПІДГОТОВЛЕНOSTI ВИСОКОКВАЛІФІКОВАНИХ ХОКЕЇСТІВ НА ТРАВІ НА ЕТАПІ БЕЗПОСЕРЕДНЬОЇ ПІДГОТОВКИ ДО ГОЛОВНИХ ЗМАГАНЬ

Віктор Костюкевич^{1ABCDE}, Наталія Лазаренко^{1ACDE}, Вадим Адамчук^{1BCDE},
Наталія Щепотіна^{1BCDE}, Тетяна Вознюк^{1BCDE}, Оксана Шинкарук^{2BCDE},
Інна Асаулюк^{1BCDE}, Станіслав Коннов^{1BCDE}, Сергій Войтенко^{1BCDE}

¹Вінницький державний педагогічний університет імені Михайла Коцюбинського

²Національний університет фізичного виховання і спорту України

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 10 с., 3 табл., 5 рис., 26 джерел.

Мета дослідження – експериментально обґрунтувати методичний підхід щодо розробки комплексної оцінки підготовленості висококваліфікованих хокеїстів на траві на етапі безпосередньої підготовки до головних змагань.

Матеріал та методи. У дослідженні взяли участь висококваліфіковані гравці члени національної збірної команди України з хокею на траві (n=21). Середній вік гравців становив ($\pm$ S) 24,9 $\pm$ 5,76 років, спортивна кваліфікація – майстри спорту України. Дослідження проводилося упродовж першого та другого змагальних періодів двохциклового планування тренувального процесу висококваліфікованих хокеїстів на траві спортивного сезону 2020-2021 років. Упродовж першого

змагального періоду був розроблений методичний підхід до комплексної оцінки підготовленості висококваліфікованих хокеїстів на траві. В межах другого змагального періоду, до якого входив етап безпосередньої підготовки до головних змагань, було визначено показники комплексної оцінки підготовленості гравців. Для розробки комплексної оцінки підготовленості було використано тести та критерії для оцінки рівня фізичної, функціональної підготовленості, фізичної підготовленості у взаємозв'язку з технікою та змагальної діяльності хокеїстів.

Результати. Розроблено методичний підхід щодо комплексної оцінки підготовленості спортсменів високої кваліфікації в хокеї на траві за таким алгоритмом: визначення критеріїв прояву фізичної, функціональної підготовленості, фізичної підготовленості у взаємозв'язку з технікою, змагальної діяльності; розробка 10-бальної шкали оцінок; встановлення комплексної оцінки підготовленості гравців упродовж етапу безпосередньої підготовки до головних змагань.

Висновки. Структуру етапу безпосередньої підготовки до головних змагань склали базовий і спеціально-підготовчий мезоцикли. Обсяг безпосередньої рухової діяльності становив 38 год, зокрема, співвідношення засобів: загально-підготовчих вправ – 55,4 %, спеціально-підготовчих вправ – 19,5 %, підвідних вправ – 10,9 %, змагальних вправ – 15,2 %; співвідношення тренувальних навантажень: аеробних – 56,5 %, аеробно-анаеробних – 32,7 %, анаеробно-алактатних – 7,6 %, анаеробно-гліколітичних – 3,2 %. Встановлено статистично-вірогідну позитивну зміну ($p < 0,01$) показників комплексної оцінки підготовленості гравців упродовж етапу безпосередньої підготовки до головних змагань.

Ключові слова: висококваліфіковані хокеїсти на траві, етап безпосередньої підготовки до головних змагань, комплексна оцінка підготовленості, 10-бальна шкала.

Information about the authors:

Kostiukevych, Viktor: kostykevich.vik@gmail.com; <https://orcid.org/0000-0002-6215-764X>; Department of Theory and Methodology of Sports, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Ostrozkogo St, 32, Vinnytsia, 21001, Ukraine.

Lazarenko, Nataliia: lazarenkoni@gmail.com; <https://orcid.org/0000-0002-3556-8849>; Department of Primary Education, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Ostrozkogo St, 32, Vinnytsia, 21001, Ukraine

Adamchuk, Vadym: vadim-adamchuk@ukr.net; <https://orcid.org/0000-0002-5009-7221>; Department of Theory and Methodology of Sports, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Ostrozkogo St, 32, Vinnytsia, 21001, Ukraine.

Shchepotina, Natalia: shchepa@mbx.vn.ua; <https://orcid.org/0000-0002-9507-3944>; Department of Theory and Methodology of Physical Education, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Ostrozkogo St, 32, Vinnytsia, 21001, Ukraine.

Vozniuk, Tetiana: TV_Vinnitsa@ukr.net; <https://orcid.org/0000-0002-5951-7333>; Department of Theory and Methodology of Sports, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Ostrozkogo St, 32, Vinnytsia, 21001, Ukraine

Shynkaruk, Oksana: shi-oksana@ukr.net; <https://orcid.org/0000-0002-1164-9054>; Department of Innovative and Information Technologies in Physical Education and Sport, National University of Ukraine on Physical Education and Sport, Fizkultury St, 1, Kyiv, 03680, Ukraine.

Asauliuk, Inna: innaasauliuk@gmail.com; <https://orcid.org/0000-0001-8119-2726>; Department of Theory and Methodology of Physical Education, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Ostrozkogo St, 32, Vinnytsia, 21001, Ukraine.

Konnov, Stanislav: konnovstas12345@gmail.com; <https://orcid.org/0000-0002-2166-1735>; Department of Theory and Methodology of Sports, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Ostrozkogo St, 32, Vinnytsia, 21001, Ukraine.

Voitenko, Serhii: voytenkosm@ukr.net; <https://orcid.org/0000-0003-0025-1064>; Department of Theory and Methodology of Sports, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Ostrozkogo St, 32, Vinnytsia, 21001, Ukraine.

Cite this article as: Kostiukevych, V., Lazarenko, N., Adamchuk, V., Shchepotina, N., Vozniuk, T., Shynkaruk, O., Asauliuk, I., Konnov, S., & Voitenko, S. (2023). Comprehensive Assessment of the Preparedness of Highly Qualified Field Hockey Players at the Stage of Direct Preparation for the Main Competitions. *Physical Education Theory and Methodology*, 23(4), 581-590. <https://doi.org/10.17309/tmfv.2023.4.13>

Received: 22.05.2023. Accepted: 14.07.2023. Published: 30.08.2023

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DIFFERENCES BETWEEN U21 AND U23 SEMI-PROFESSIONAL SOCCER PLAYERS IN PERFECTIONISM AND PASSION

Ricardo Martín-Moya^{1ABCD}, Adelaida Irene Ogallar-Blanco^{1ABCD}, Eduardo García-Mármol^{1ABCD}, Antonio Liñán-González^{1ABCD} and Francisco Tomás González-Fernández^{1ABCD}

¹University of Granada

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Antonio Liñán-González, E-mail: antoniolg@ugr.es

Accepted for Publication: July 25, 2023

Published: August 30, 2023

DOI: 10.17309/tmfv.2023.4.14

Abstract

Study purpose. The aim of this study is to analyse differences in perfectionism and passion and how these variables interact and might be expected to affect performance in U21 and U23 soccer players.

Materials and methods. A total of 60 healthy semi-professional soccer players (age: 21.57±1.95 years; height: 179.76±5.79 cm) participated in the study. The participants were divided into two equal groups, one with those players younger than 21 years old and the other including players aged 21–23. This study was descriptive with a cross-sectional design and used the Frost Multidimensional Perfectionism Scale (FMPS) and Passion Scale questionnaires.

Results. A paired-samples t-test was used for defining differences as a repeated measures analysis (U21 Group and U23 Group). Additionally, a t-test with data from the FMPS revealed significant differences in perfectionism global score, concern over mistakes, parental expectations, parental criticism, doubts about actions and organization. The participants were shown to be a heterogeneous group in both perfectionism and passion, with moderate perfectionistic characteristics, except for the personal standards subscale, in which the opposite trend was found. According to the outcomes obtained, the U21 group shows significant values in terms of the level of perfectionism.

Conclusions. This research has highlighted the importance of addressing maladaptive perfectionism in interventions and support programs for athletes. Strategies such as promoting a growth mindset, encouraging self-compassion, and fostering a supportive and mastery-oriented environment have been suggested to help athletes manage perfectionistic tendencies and enhance their well-being and performance.

Keywords: adaptive perfectionism, maladaptive perfectionism, harmonious passion, soccer players, U23.

Introduction

Semi-professional soccer teams must, at least, have a minimum of six players under-23 years-old (U23) of a total of 22 players. Joining these teams allows U23 players to train and play alongside professional players, improving their skills and increasing their visibility within the club. Therefore, Examining the psychological differences between U23 players (players under 23 years old) and older players can indeed provide valuable insights for guiding and developing strategies for players on their path to the elite level. The differences between younger and older soccer players have been studied in various fields, but mostly focusing on physical and physiological demands (Peña-González

et al., 2020), however, less attention has been placed on psychological variables (Huertas et al., 2019). Older players often have more life experience and may demonstrate greater emotional maturity and control compared to U23 players (Alesi et al., 2019; Champ et al., 2020). They may handle high-pressure situations better, maintain focus during matches, and cope with setbacks more effectively (Price et al., 2020). U23 players may benefit from guidance and support in developing emotional resilience and managing the pressures of elite soccer.

Perfectionism is indeed a personality trait characterized by striving for perfection and setting excessively high standards for oneself and others (Drigas et al., 2020). Individuals with perfectionistic tendencies often have an intense desire to avoid mistakes, seek flawless performance, and hold themselves to unattainable ideals (Fleming et al., 2022). According to Frost et al. (1990), perfectionism is considered a multidimensional construct, consisting of three

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dimensions: a) self-Oriented Perfectionism: this dimension reflects an individual's tendency to set high personal standards, have a strong internal drive for perfection, and exhibit self-critical tendencies. Those with high levels of self-oriented perfectionism may constantly strive to meet their own lofty expectations, leading to self-imposed pressure and a fear of failure, b) Other-Oriented Perfectionism: This dimension pertains to the expectations and demands individuals place on others to be perfect. People with high levels of other-oriented perfectionism tend to have strict standards for those around them and can be critical of others' performances. They may have difficulty delegating tasks or trusting others to meet their expectations and c) Socially Prescribed Perfectionism: This dimension reflects the perception that individuals hold excessively high expectations for oneself, based on the belief that others expect perfection. Those with high levels of socially prescribed perfectionism feel intense pressure to meet societal or social standards, fearing negative evaluations or judgments from others (Frost et al., 1993). Related to perfectionism are ambition and motivation, U23 players are often highly motivated and ambitious, seeking to establish themselves in the professional game. They may possess a strong drive to succeed and prove themselves (Lin & Muenks, 2022). Understanding and harnessing this motivation can help in setting appropriate goals and providing targeted support and guidance. It is important to note that Frost's model of perfectionism is widely recognized and has been influential in understanding the multidimensional nature of this construct. However, there have been subsequent developments and refinements to the understanding of perfectionism, including other models that propose additional dimensions or variations of the construct (Sederlund et al., 2020; Seong et al., 2021).

The work of (Flett & Hewitt, 2014) have indeed made significant contributions to the understanding of perfectionism in the context of sport and exercise. Their work has inspired numerous studies that have explored the correlates, causes, and effects of perfectionism in sport. Flett and Hewitt (2005), developed the Multidimensional Perfectionism Scale (MPS), that measures self-oriented perfectionism, other-oriented perfectionism, and socially prescribed perfectionism, aligning with Frost's multidimensional model. They found that athletes with high levels of perfectionism, particularly self-oriented and socially prescribed perfectionism, are more prone to experience negative psychological outcomes such as anxiety, depression, burnout, and disordered eating (Freire et al., 2022; Olmedilla et al., 2022), while adaptive perfectionism can be associated with positive outcomes such as high achievement motivation and dedication (Flett & Hewitt, 2014).

Perfectionism, as a predisposition to set high standards for oneself, might subordinate to certain emotional or motivational variables, such as the experience of passion in sports. Passion, in the vast majority of cases, is defined as a strong, stable, long-lasting feeling that captures a person, possesses him and manifests itself in the orientation of all individual aspirations in one direction. It represents a deep enthusiasm, dedication, and enjoyment for the sport (Vallerand, 2016). In this regard, the Dualistic Model of Passion (DMP) (Vallerand, 2010, 2016) suggests that individuals engage in activities to fulfill psychological needs, such as competence, relatedness, and autonomy. The DMP

focuses specifically on the concept of passion and how it relates to the pursuit of activities.

According to the DMP (Vallerand, 2010), there are two types of passion: a) Harmonious Passion: refers to a strong internal desire and inclination to engage in an activity because it is personally valued and aligned with one's identity and b) Obsessive Passion: on the other hand, is characterized by an uncontrollable and compulsive urge to engage in an activity. The DMP suggests that the key difference between harmonious and obsessive passion lies in the internalization process. Harmonious passion is developed through autonomous internalization, where individuals freely choose to engage in the activity because they find it enjoyable and personally meaningful. In contrast, obsessive passion arises from controlled internalization, where individuals engage in the activity due to external pressures or contingencies, such as social expectations or rewards. In the sports context, obsessive passion can be associated with maladaptive outcomes such as stress and burnout, injury proneness, worry and anxiety and moral disengagement (Vallerand, 2015), while harmonious passion is linked to adaptive outcomes as enjoyment and flow, self-esteem, psychological well-being, persistence and longevity and autonomy (Clohessy et al., 2021; Konter et al., 2020; St-Cyr et al., 2023).

The interrelation between perfectionism and passion has received increasing attention in recent research across various fields, including sports psychology, education, and work settings. Understanding the interplay between these constructs can provide valuable insights into how they influence each other and their combined impact on outcomes (Jordana et al., 2022). Research suggests that perfectionism can influence the development and nature of passion (Smith et al., 2020). Specifically, self-oriented perfectionism may enhance the formation of harmonious passion when individuals perceive their achievements as personally fulfilling and congruent with their identity (Woods et al., 2022). However, socially prescribed perfectionism, with its focus on meeting others' expectations, may undermine the development of harmonious passion and lead to obsessive passion (St-Cyr et al., 2023). Passion can also influence perfectionism. Harmonious passion is associated with adaptive perfectionism, where individuals set high standards for themselves based on intrinsic motivation and personal values. In contrast, obsessive passion may be associated with maladaptive perfectionism, where individuals set unattainable standards and experience excessive self-criticism and fear of failure (Flett & Hewitt, 2014).

Chamorro et al. (2019) found that young talented Spanish football players who developed their sporting careers in a highly competitive environment and maintained commitment to other areas of life (e.g. academic or personal) were more adaptive in terms of autonomous motivation, harmonious passion and perceived satisfaction. The psychological characteristics indicate a basic psychological need compared to a player who is solely focused on becoming a professional player (Pedraza-Ramirez et al., 2020). Following De Oliveira et al. (2015), indicate that in professional soccer players who have professional contracts, adaptive perfectionism inclinations have a positive impact on intrinsic motivation and are considered a significant personality trait in the development of autonomous behavior. Conversely, in amateur athletes that lack professional

training, the propensity for perfectionism was found to be an intervening factor in the development of extrinsic motivation behaviors, this demonstrated that for athletes during their early career in sports, concerns regarding errors, doubts in action and parental criticism increase the athlete's-controlled behavior.

In general, although it has been found that perfectionism and passion are interrelated and they both can influence performance in a diversity of contexts, including sports, research on how these variables interact and might expect affect performance in team sports, such as soccer, is still scarce. Furthermore, it is relevant to analyze the levels of perfectionism and passion between U21 and U23 semi-professional soccer players.

Materials and Methods

Participants

A total of 60 healthy semi-professional soccer players (21.57 ± 1.95 years; height: 179.76 ± 5.79 cm.) from the Andalusian region, which has a population ranging from 8,472,407 inhabitants according to the Spanish Government National Institute of Statistics (Instituto Nacional de Estadística, INE, 2023) <http://www.ine.es/>; accessed on March 21, 2023) participated in this study. This group was divided into two equal subgroups according to the age of the participants, one with players younger than 21 years (19.8 ± 0.76 years) and the other including players aged 23 years or younger (23.37 ± 0.82 years). The rationale for using 21 and 23-year-old as the division criterion was due the fact that semi-professional teams can have a maximum of 22 players, of which at least 6 must be occupied by sub-23s. In addition, two years of personal maturation can make a difference in terms of the future expectations of each player.

Inclusion criteria for participant groups in this study were: (i) a background of ≥ 10 years of periodized training and federated competition, (ii) not have or have suffered a serious injury or chronic pain in the past two seasons and no existence of neuropsychological impairment that could affect the response of questionnaires, (iii) existence of medical problems, (iv) federated soccer players in the third division RFEF in 2022-2023 season, (v) complete and sign the consent form and (vi) respond all questionnaires.

Design and procedures

Experimental Approach to the Problem

The present study was descriptive with a cross-sectional design and was conducted between February and March of 2023. Semi-professional soccer players usually trained at least four times a week in various clubs of same category (90 min $\approx$ per session) and played one match a week. The training sessions included a warm-up, main part, and cooldown.

All soccer players were informed of the main purpose of the study and completed and signed an informed consent form before completing the questionnaire. The athletes were treated according to the guidelines of the American Psychological Association, which ensured the anonymity of the participants' responses. Furthermore, the study was conducted in accordance with the ethical principles of the

Helsinki Declaration on Human Research and was approved by the local university scientific committee (code: 2021/64).

Measures

The following measures were used:

(A) Perfectionism: The Spanish version of the Frost Multidimensional Perfectionism Scale (FMPS) (Frost et al., 1990); Spanish version by Carrasco et al. (2009), was used to measure dimensions of perfectionism. The questionnaire includes 35 items that create the 6 subscales of perfectionism proposed by (Frost et al., 1990), with 9 items measuring the dimension Concern Over Mistakes (CM, e.g. If I fail at work/school, I am a failure as a person), 7 items measuring Personal Standards (PS), 5 items to assess Parental Expectations (PE), 4 items assessing Parental Criticism (PC, e.g. As a child, I was punished for doing things less than perfectly), 4 items for Doubts About Actions (DAA) and 6 items assessing Organization (ORG). All items were answered on a 5-point Likert-type scale from 1=hardly ever to 5=always.

(B) Passion was assessed using the Spanish version of the Passion Scale (Chamarro et al., 2015; Marsh et al., 2013). Consisting of two six-point subscales, the scale measures obsession and harmonious passion for an activity. It also included five additional individual criteria to determine if participants' engagement with the event met enthusiasm. They are: time (time spent on the activity), liking (favorite for the activity), value (degree to which the activity is appreciated), passion (activity perceived as passion), and identity (activity perceived as passion). part of one's identity), although the latter was not included in previous editions. Each question was scored using a 5-point Likert scale (1=strongly disagree; 5=strongly agree). A higher score reflects a higher level of passion. Alpha scores of 0.79 for Obsessive Passion and 0.84 for Harmonious Passion reflect the high internal consistency of the two subscales.

Procedure

Evaluation protocols were available online (Google Forms®, Google LTD., USA). Participants were asked to take measurements with their mobile phones. They received information about the study, their rights as participants and questions such as the confidentiality of their answers and their proprietary scientific use. They can only access the survey with their consent. Participants were neither compensated nor given feedback. Data were collected between February and March 2022.

Statistical Analysis

Descriptive statistics were calculated for each variable. Before any parametric statistical analysis were performed, the assumption of normality and homoscedasticity were tested with the Kolmogorov-Smirnov and Levene's tests, respectively. A paired sample t-test was used for determining differences as a repeated measures analysis (U23 Group and >23 Group). Cohen's d was the effect size indicator. To interpret the magnitude of the effect size, we adopted the following criteria: $d \leq 0.20$, small; $d \leq 0.50$, medium; and $d \leq 0.80$, large. Pearson's correlation coefficient r was used to examine the relationship between each one of the six

subdimensions of perfectionism and the two components of passion. To interpret the magnitude of these correlations, the following criteria was adopted: Trivial: ≤ 0.10 ; small: 0.10 to 0.29; moderate: 0.30 to 0.49; large: 0.50 to 0.69; very large: 0.70 to 0.89; almost perfect: ≥ 0.90 . Multiple regression analysis was used to model the prediction of passion from the remaining variables. In this regression analysis, all variables were examined separately. Data were analyzed using Statistica software (version 13.3; Statsoft, Inc., USA).

Normality and homoscedasticity assumptions were tested using the Kolmogorov-Smirnov and Levene's tests, respectively, before performing parametric statistical analyses. Differences were determined using a paired-sample t-test as a repeated measures analysis (U23 subgroup and >21 subgroup). Cohen's *d* is an indicator of effect size (Cohen, 1992). To account for the magnitude of effect sizes, we used the following criteria: $d \leq 0.20$, small; $d \leq 0.50$, medium; and $d \leq 0.80$, large. Pearson's correlation coefficient *r* was used to study the relationship among each of the six subdimensions of perfectionism and the two variables of passion. To account for the magnitude of these correlations, the following criteria were employed: insignificant: ≤ 0.10 ; small: 0.10 to 0.29; moderate: 0.30 to 0.49; large: 0.50 to 0.69; very large: 0.70 to 0.89; near-perfect: ≥ 0.90 . Passion prediction was modeled from the remaining variables using multiple regression analysis. The alpha outcomes were .79 for obsessive passion and .84 for harmonious passion, which show high internal consistency for both subscales. Appropriate psychometric characteristics have been reported for this scale.

Results

A paired sample t-test was used for defining differences as a repeated measures analysis (U21 Group and U23 Group). Additionally, a t-test with data from the FMPS revealed significant differences in perfectionism global score $p=0.001$, concern over mistakes $p=0.03$, parental expectations $p=0.01$, parental criticism $p=0.001$, doubts about actions $p=0.05$ and organization $p=0.02$. However, the dataset did not reveal significant differences between personal standards $p=0.44$. On the other hand, a t-test with data from the Passion Scale did not revealed significant differences in any of the variables from the questionnaire. See table 1, for more information.

If the results are observed in Figure 1 of the FMPS questionnaire, it is shown that the U21 group has higher values regarding the perfectionism scale in relation to the U23 group.

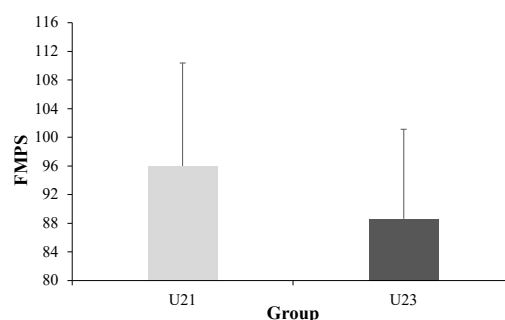


Fig. 1. Outcomes from FMPS and differences between both groups

Table 1. Descriptive statistics variable for each variable

	Total group (n=60)	U21 soccer players (n=30)	U23 soccer players (n=30)	
Variable (possible scores range)	Mean±SD [min-max]	Mean±SD [min-max]	Mean±SD [min-max]	t-test, Cohen's d
Frost Multidimensional Perfectionism Scale				
Perfectionism (35–135)	90.81±16.81 [48–142]	96.00±14.37 [63–122]	88.20±12.49 [62–111]	0.001**, 0.70
Concern over mistakes (9–45)	21.59±5.51 [9–35]	24.73±4.51 [16–35]	22.93±4.11 [17–35]	0.03*, 0.43
Personal standards (7–35)	25.10±3.85 [12–30]	25.03±3.86 [17–30]	22.86±4.26 [11–30]	0.44, 0.17
Parental expectations (5–25)	17.68±6.20 [9–37]	19.11±7.05 [9–37]	16.16±4.85 [9–34]	0.01*, 0.48
Parental criticism (4–20)	10.75±4.01 [5–21]	11.98±4.20 [5–21]	9.39±3.34 [5–16]	0.001**, 0.68
Doubts about actions (4–20)	6.45±2.71 [4–15]	6.93±3.04 [4–15]	5.89±2.20 [4–12]	0.05*, 0.39
Organization (6–30)	9.23±3.11 [4–19]	10.00±3.29 [4–19]	8.48±2.73 [4–16]	0.02*, 0.50
Passion Scale				
Harmonious passion (6–30)	35.01±4.92 [12–42]	39.76±4.80 [19–42]	34.39±6.07 [9–42]	0.92, 0.07
Obsessive passion (6–30)	21.76±7.46 [6–40]	22.82±7.70 [7–38]	20.34±7.26 [6–40]	0.15, 0.33
Time (1–7)	4.46±1.67 [1–7]	4.42±1.76 [1–7]	4.39±1.61 [1–7]	0.96, 0.01
Liking (1–7)	6.56±0.71 [4–7]	6.62±0.65 [5–7]	6.50±0.76 [4–7]	0.41, 0.16
Value (1–7)	6.15±1.08 [2–7]	6.18±0.96 [4–7]	6.05±1.21 [2–7]	0.64, 0.12
Passion (1–7)	6.15±1.15 [2–7]	6.29±0.98 [3–7]	6.00±1.28 [2–7]	0.1, 0.25
Identity (1–7)	5.85±1.18 [2–7]	5.98±1.05 [3–7]	5.71±1.29 [2–7]	0.22, 0.23

* Denotes significance at $p < 0.05$. and ** denotes significance at $p < 0.01$

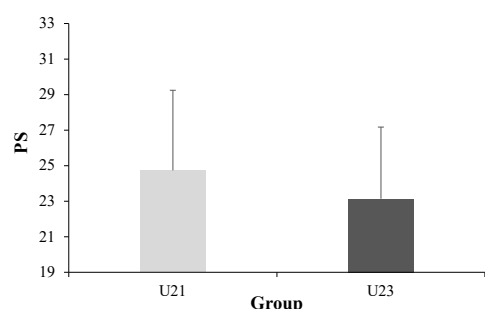


Fig. 2. Outcomes from Personal Standards dimension (FMPS) and differences between both groups

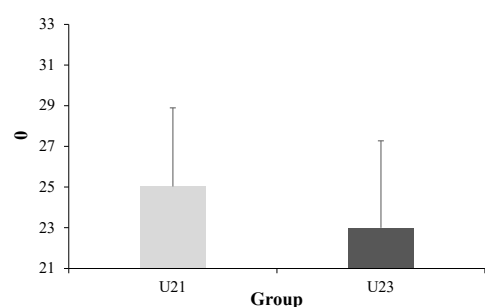


Fig. 3. Outcomes from Organization dimension (FMPS) and differences between both groups

As well as, in the results obtained in several of the dimensions, serving as an example the dimension of Personal Standards (Figure 2) and Organization (Figure 3), where the values of the U21 participants show a greater relevance compared to the U23 players.

Discussion

The aim of this study was to analyze possible differences in perfectionism and passion between U23 and U21 semi-professional soccer players, along with to analyze the relationship between some dimensions in these groups.

The participants were shown to be a heterogeneous group in both perfectionism and passion, with moderate perfectionistic characteristics, excepting for the personal standards subscale, in which the opposite trend is found. According to the outcomes obtained, the U21 group shows significant values in terms of the level of perfectionism. This may be due, following (Bourke, 2003), U21 soccer players are generally in the early stages of their professional careers with the greatest need to do each of their sports interventions perfectly, while U23 soccer players have more experience and may be or next to their prime of their careers having a somewhat less uncertain future. The developmental stage can influence the pressures, expectations, and mindset related to perfectionism (Dunn et al., 2020; Fleming et al., 2023).

In relation to the scale on concern over mistakes in its positive dimension of adaptive perfectionism, it is again the U21 soccer players who show significant values in this variable. Results that would be in agreement with those obtained by (Livazović & Kuzmanović, 2022), in which it can be explained why U23 soccer players have had more time to develop coping strategies and resilience to deal with the challenges of the sport. They may have learned

from past experiences, both successes, and failures, which can shape their perspective on perfectionism (Gotwals & Tamminen, 2022). U21 players, on the other hand, may still be in the process of developing effective coping mechanisms (Junnarkar et al., 2021; MacIntyre et al., 2019).

Regarding the differences between U21 and older players, the t-test and Cohen's d, show some interesting results, as they show that U21 players are exposed to parental criticism, concern about mistakes and parental expectations, all negative sub-dimensions of perfectionism (maladaptive perfectionism). As mentioned earlier, concern about mistakes involves the fear of making mistakes and the possible negative consequences of those mistakes, while parental criticism refers to the parent's belief that they are perfect (Bonavolontà et al., 2021). This attribution seems logical, as U21 players are at a more critical stage of development in their personal and sporting lives than older players (Chamorro et al., 2019). In this line, parental control over the players appears to a greater extent in U21 participants. Being natural that the maturational level of these players is lower and their parents are more aware of their development and more involved in decision-making regarding older players (Kramers et al., 2022; Wachsmuth et al., 2023).

In this regard, the desire to fulfill family expectations may be augmented by the perception that a successful performance at this point will lead to professional success (Szalánczi et al., 2020). This would easily lead to a mentality of always improving and a sense of urgency to achieve greatness, both of these are associated with the perfectionism and passion scores. Conversely, older players may have a different perspective, as they fulfill their personal expectations, enjoy the sport, or maintain their current level, instead of concentrating on becoming professionals (Smith et al., 2020). Additionally, the capacity for harmonious passion to influence positive aspects of perfectionism (personal standards and the organization) is consistent, as both parties enjoy the activity and are intrinsically motivated by it (Konter et al., 2020). Harmonious passion is driven by activity satisfaction rather than reward or external pressure (Lopes & Vallerand, 2020) and is associated with improved wellbeing, positive affect, and reduced anxiety and depression (Vallerand & Verner-Filion, 2020).

On the other hand, significant results are shown in the values related to the positive variables of perfectionism, doubts about actions and organization. Young soccer players may experience doubts about their actions, decisions, and performances on the field (Vestberg et al., 2020). They may question whether they made the right pass, took the correct shot, or made the best decision in a game situation. These doubts can stem from a desire to perform well and meet their own high standards (Vestberg et al., 2020). Excessive doubts about actions can lead to hesitation, overthinking, and a lack of confidence on the field. It may hinder decision-making and prevent players from playing instinctively and freely (Soylu, 2021; Webb et al., 2020). It is important to help young players develop coping strategies to manage doubts about their actions. Teaching them to focus on the process rather than the outcome, encouraging self-reflection and learning from mistakes, and fostering a supportive and positive environment can help them navigate these doubts more effectively (De Muynck et al., 2021). Those players

who prioritize organization may have a strong attention to detail in their training routines, ensuring they have all their equipment in place, and meticulously planning and preparing for games (Álvarez et al., 2019). While being organized can have its benefits, it is essential to strike a balance. Excessive focus on organization can lead to rigidity, anxiety, and a fear of deviating from their planned routines. It can also create additional pressure and stress if they perceive any disruption to their organized approach as a threat to their performance (Panza et al., 2020).

Maladaptive perfectionism is characterized by setting unrealistic goals and a minimum of tolerance for failure, while adaptive perfectionism is able to establish high standards that are also malleable, disregarding small imperfections while still achieving a sense of fulfillment and satisfaction when the standards are achieved (Malivoire et al., 2019). Following these theoretical approaches, there was no association between the maladaptive aspects of perfectionism and obsessive passion, nor between the adaptive aspects of perfectionism and harmonious passion. This is not common and congruent with previous studies (Schellenberg et al., 2023; Vallerand & Verner-Filion, 2020).

Conclusions

This study highlighted the importance of addressing maladaptive perfectionism in interventions and support programs for young athletes (U21 and U23). Strategies such as promoting a growth mindset, encouraging self-compassion, and fostering a supportive and mastery-oriented environment have been suggested to help athletes manage perfectionistic tendencies and enhance their well-being and performance. In particular, the recognition of differences between age groups (U21 and U23) can contribute to a more effective selection of interventions and strategies to solve the specific problems of athletes at different stages of development. Overall, these findings have a tendency to provide the basis for the creation of psychological programs that can enhance the health and performance of soccer players. This research has contributed to a greater understanding of the perils of perfectionism and has shaped interventions and support strategies in the sporting domain.

Awareness of the value of recognizing this behavioral pattern in players could help to prevent or mitigate the development of maladaptive perfectionistic patterns. This would also facilitate the detection of players who have already experienced adverse effects of perfectionism, so training sessions can be reduced and more effective ways to implement prevention strategies can be employed (e.g., promoting a healthier relationship with sports and competition during training). Additionally, when patterns of passion that are harmonious are detected, coaches, parents, health psychologists and educators should be aware of the potential associations with adaptive perfectionism, this will help to promote dedication and a healthy commitment to soccer, which will facilitate the enjoyment and motivation of players.

Conflict of Interest

The researchers affirm that there were no financial or commercial ties that might be seen as creating a conflict of interest during the research's conduct.

Funding

This work is funded by Iundenia, Centro de Formación de Técnicos Deportivos (CIF B-18905760. Código de Centro 18013708), and was also supported by the startup Football Connection (FOOC) (NO. 4.073.379). No other specific sources of funding were used to assist in the preparation of this article.

Acknowledgments

We thank the semi-professional soccer players and the team managers for their collaboration with and participation in the study.

Data Availability Statement

The corresponding author will freely make the raw data used to support this article's conclusions available.

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ВІДМІННОСТІ У ПЕРФЕКЦІОНІЗМІ ТА ЗАХОПЛЕННІ МІЖ НАПІВПРОФЕСІЙНИМИ ФУТБОЛІСТАМИ ВІКОМ ДО 21 ТА ДО 23 РОКІВ

Рікардо Мартін-Моя^{1ABCD}, Аделаїда Ірен Огаллар-Бланко^{1ABCD},
Едуардо Гарсія-Мармол^{1ABCD}, Антоніо Ліньян-Гонсалес^{1ABCD},
Франсіско Томас Гонсалес-Фернандес^{1ABCD}

¹Гранадський університет

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 9 с., 1 табл., 3 рис., 53 джерела.

Мета дослідження. Мета цього дослідження полягає в тому, щоб проаналізувати відмінності в перфекціонізмі та захопленні, а також те, як ці змінні взаємодіють і можуть впливати на результативність у футболістів віком до 21 та до 23 років.

Матеріали та методи. Загалом у дослідженні взяли участь 60 здорових напівпрофесійних футболістів (вік: $21,57 \pm 1,95$ року; зріст: $179,76 \pm 5,79$ см). Учасників розподілили на дві рівні групи: одну з гравцями молодше 21 року, а другу з гравцями віком 21–23 роки. Це дослідження було описовим із перехресним планом дослідження, і в ньому використовували опитувальники «Багатовимірна шкала перфекціонізму Фроста» (FMPS) та «Шкала захоплення».

Результати. Для визначення відмінностей використовували t-критерій Стьюдента для парних вибірок як аналіз повторних вимірювань (група віком до 21 року та група віком до 23 років). Крім того, завдяки застосуванню t-критерію Стьюдента з даними опитувальника FMPS були виявлені статистично значущі відмінності в загальній оцінці рівня перфекціонізму, стурбованості щодо помилок, батьківських очікувань, батьківській критиці, сумнівах щодо дій та організації. Було показано, що учасники являють собою гетерогенну групу як за перфекціонізмом, так і за захопленням, із помірними перфекціоністськими характеристиками, за винятком підшкали особистих стандартів, у якій спостерігається протилежна тенденція. Відповідно до отриманих результатів, група віком до 21 року демонструє значні величини рівня перфекціонізму.

Висновки. Це дослідження підкреслило важливість усунення неадаптивного перфекціонізму у втручаннях і програмах підтримки для спортсменів. Були запропоновані такі стратегії, як сприяння психології зростання, заохочення співчуття до себе та сприяння розвитку сприятливого й орієнтованого на майстерність середовища, щоб допомогти спортсменам керувати перфекціоністськими тенденціями та покращувати своє самопочуття та результативність.

Ключові слова: адаптивний перфекціонізм, неадаптивний перфекціонізм, гармонійне захоплення, футболісти, віком до 23 років.

Information about the authors:

Martín-Moya, Ricardo: rmartinm@ugr.es; <https://orcid.org/0000-0002-9840-3515>; Department of Personality, Evaluation and Psychological Treatment, Faculty of Psychology, University of Granada, Ctra. Alfonso XIII, 52005, Melilla, Spain.

Ogallar-Blanco, Adelaida Irene: adelaidaogallar@ugr.es; <https://orcid.org/0000-0001-6186-3035>; Department of Physical Education and Sports, Faculty of Sport Sciences, University of Granada, Ctra. Alfonso XIII, 52005, Melilla, Spain.

García-Mármol, Eduardo: eduardogarcia@ugr.es; <https://orcid.org/0000-0002-8126-7211>; Department of Personality, Evaluation and Psychological Treatment, Faculty of Psychology, University of Granada, Ctra. Alfonso XIII, 52005, Melilla, Spain.

Liñán-González, Antonio: antoniolg@ugr.es; <https://orcid.org/0000-0002-1268-8098>; Nursing Department, Faculty of Health Sciences, University of Granada, Ctra. Alfonso XIII, 52005, Melilla, Spain.

González-Fernandez, Francisco Tomás: ftgonzalez@ugr.es; <https://orcid.org/0000-0002-1480-7521>; Department of Physical Education and Sport, Faculty of Education and Sport Sciences, University of Granada, Ctra. Alfonso XIII, 52005, Melilla, Spain.

Cite this article as: Martín-Moya, R., Ogallar-Blanco, A.I., García-Mármol, E., Liñán-González, A., & González-Fernández, F.T. (2023). Differences Between U21 and U23 Semi-Professional Soccer Players in Perfectionism and Passion. *Physical Education Theory and Methodology*, 23(4), 591-599. <https://doi.org/10.17309/tmfv.2023.4.14>

Received: 27.06.2023. Accepted: 25.07.2023. Published: 30.08.2023

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ORIGINAL SCIENTIFIC ARTICLE

THE SEVENTH AND EIGHTH GRADE PRIMARY SCHOOL STUDENTS' PHYSICAL FITNESS AND RESULTS ON THE GYMNASTICS POLYGON

Dejan Milenković^{1ABCD}

¹University Union – Nikola Tesla

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Dejan Milenković, E-mail: dejan.milenkovic2309@gmail.com

Accepted for Publication: August 14, 2023

Published: August 30, 2023

DOI: [10.17309/tmfv.2023.4.15](https://doi.org/10.17309/tmfv.2023.4.15)

Abstract

The purpose of the study was to determine the connection between physical fitness and the results on the gymnastics polygon in the seventh and eighth grade elementary school students. Additionally, it was necessary to determine the differences in the observed variables in relation to the grade, separately for each gender.

Materials and methods. A total of 128 students from three elementary schools (64 male and 64 female students), 13 and 14 years old, participated in the testing. Five physical fitness tests were used (modified agility "T" test (MAT), Illinois agility run test, 10×5 shuttle run test, standing balance test and 2-minute step in place test), and a specially designed gymnastics polygon was used to assess the level of adoption of technical elements from artistic gymnastics.

Results. A statistically significant correlation was recorded between all observed parameters with different levels, from moderate to strong correlations, both in relation to the grade, as well as in relation to the gender of the students. It was also determined that in boys, there are differences in only one test (MAT) in favor of the eighth graders, while in girls, there was a difference in three tests (MAT; 10x5 shuttle test; 2-minute step in place test) in favor of the eighth graders.

Conclusions. So it can be concluded that there is a strong mutual connection between physical fitness and sports-specific skills, which are presented in this paper by means of the technical elements of artistic gymnastics.

Keywords: physical development, artistic gymnastics, physical education, male and female students.

Introduction

Sports activities form the basis of the physical education program. Physical education classes that include such activities affect the development of morphofunctional (Prontenko et al., 2020) and physical fitness (Ward et al., 2017). Sports content in the physical education program, in addition to improving physical fitness, also contributes to the development of fundamental motor and sport-specific skills and tactical knowledge (Milenković, 2022; Hastie, Martinez de Ojeda & Calderon, 2011; Wallhead & O'Sullivan, 2005), which makes physical education classes a spot where it is possible to master and improve a large number of such skills and knowledge in order to improve motor status of the students (Milenković, 2021). Sports-specific skills are trained and perfected through various sports activities in the form of team and individual sports. One of the sports activities is artistic gymnastics.

In artistic gymnastics, various technical elements are performed on different devices on which the exercisers master their body mass. Successful performance of these routines requires a high level of physical fitness (Kolimechkov, Petrov & Alexandrova, 2021). Due to its structure, physical requirements and physiological profile, artistic gymnastics belongs to the group of coordination-difficult aesthetic-technical disciplines (Boraczyński, Boraczyński, Boraczyńska & Michels, 2013). Artistic gymnastics, as a basic sport, is one of the most important contents of the physical education program in elementary school (Pajek, Čuk, Kovač & Jakše, 2010). Within this activity, which can be practiced from an early age, children are introduced to basic elements such as jumping, hanging, rotating, crawling, rolling, etc. Artistic gymnastics has had a central position in the physical education program for years and manages to keep it as one of the basic sports. It improves body management during the development of locomotor, non-locomotor and manipulative skills, promotes the development of coordination, flexibility, agility, muscle strength, endurance and bone strength, thus improving the body's health bulletin and a physically active

lifestyle (Werner, Williams & Hall, 2012, 5). The aims in the study of artistic gymnastics in the physical education program range from the contribution that gymnastics can make to the achievement of psychomotor competence at younger ages, through the use of this skill to understand the relationship between the structure and function of the body in the middle years of schooling, to the appreciation of not only the complex nature of movement in general, but also the context of artistic gymnastics in its widest sense in older school-aged children (Mauldon, 2014, 17).

Effective practice of sports content in physical education can also be performed through polygons, which represent a unique exercise with multiple tasks in order to perform motor activities without a break, with faster or slower continuous movement from one task to another (Rašidagić, Manić & Mahmutović, 2016). Polygons are very useful in the creative aspect of the organization of classes through very interesting and dynamic exercises/tasks that are at the same time very useful for the development of physical fitness and the improvement of sports education (Milenković, 2021). Polygons give results in the development of motor skills (Marinković, Pavlović, Korovljev, Dimitrić & Bogdanovski, 2016) and functional capacity (Bekić, Alić, Atiković & Emić, 2017). They can be used at different ages, such as high school (Milenković & Stanojević, 2013), older grades of elementary school (Milenković, 2022), but also to improve the motor skills of children in younger grades of elementary school (Pavlović, Marinković & Marković, 2018). Polygons are very effective in physical education with an important physical and mental impact on children (Popa, Contiu & Bădău, 2019).

Given the importance of the elements of physical development that are the subject of this paper, this research aims to determine the connection between physical fitness and the results on the gymnastics polygon in the seventh and eighth grade elementary school students. It is assumed that there is a statistically significant relationship between these elements of motor status, both in boys and girls. Additionally, the differences in the observed variables in relation to the grade should be determined, separately for each gender. The importance of this research is to identify which indicators of children's physical fitness have the greatest influence on the performance of gymnastic elements in the physical education program for elementary school students, in order to more effectively direct work towards their further development.

Materials and methods

Participants

128 students from three elementary schools, aged 13 to 14, participated in the testing, which was conducted at the beginning of the 2022-23 school year. The criteria for the inclusion of students in the testing included regular attendance of the physical education program. The sample was further divided into the 7th grade (32 male and 32 female) and the 8th grade (32 male and 32 female) students.

The consent for student testing was obtained from the school authorities, the children's parents, as well as the children themselves. The research was organized in accordance with the recommendations for clinical research given by the World Health Organization within the Helsinki Declaration (WHO, 2013) and approved by the Ethics

Committee of the Faculty of Sports, University Union – Nikola Tesla in Belgrade (code: 172/22).

Measuring instruments

Physical Fitness

To test physical fitness, a battery of five diagnostic tests was used (Wood, 2008), which previous research has found to be reliable and valid for assessing physical fitness: Modified agility «T» test – MAT (Sassi, et al., 2009); Illinois agility run test (Hachana et al., 2014; Kutlu, Yapici & Yilmaz, 2017); 10×5 Shuttle Test (Boddington, Lambert, St Clair Gibson & Noakes, 2001); Standing Balance Test (Geldhof et al., 2006); 2-Minute Step in Place Test (Haas, Sweeney, Pierre, Plusch & Whiteson, 2017)

Artistic Gymnastics Polygon

To assess the level of adoption of technical elements of artistic gymnastics, a specially designed polygon composed of those elements of artistic gymnastics that are studied in the older grades of elementary school (7th and 8th grades) was used.

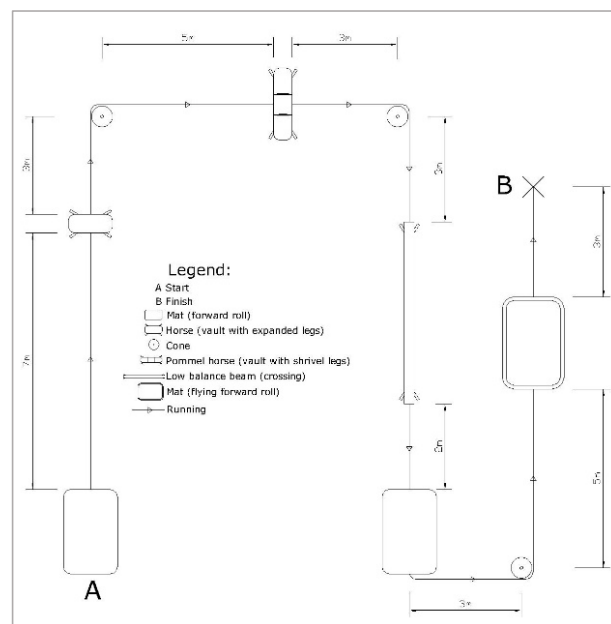


Fig. 1. Artistic Gymnastics Polygon

Description of the gymnastics polygon. Execution of the polygon starts from point A with a forward roll on the first mat. Afterwards a vault with expanded legs is performed over a horse, then the first cone is circled, followed by a vault with shrivel legs over a pommel horse. After going around the second cone, you cross over the low balance beam and perform another roll forward on the second mat. By going around the third cone, you get into a position for performing a flying forward roll on the third mat. The polygon and time measurement ends by running past point B. Either male or female student is obliged to fully complete the task before moving on to the next one (e.g. if he/she falls from a low balance beam he/she must climb to the same place from which he/she fell and continue moving along the balance beam).

Statistical analysis

Additionally to descriptive parameters (Mean±St.Dev), a correlation analysis was used to determine the relationship between physical fitness and the results at the gymnastics polygon (Pearson product-moment correlation coefficient). Pearson's correlation coefficient can be interpreted as an effect size and indicates the strength of the relationship between the two variables. According to Cohen (1988), a correlation coefficient of 0.10 or more is considered a weak or small correlation, 0.30 or more represents a moderate correlation, and 0.50 or more represents a strong or large correlation. The T test for independent samples was also used to determine differences in relation to the students' grade, separately for boys and girls. Statistical significance was established at the $p \leq 0.05$ level.

Results

The following chapter presents the research results (Tables 1 and 2), as well as their interpretation and analysis. Table 1 contains descriptive data of all variables of this research, presented in both total and by the gender. The

variables are the result obtained on the gymnastics polygon and the tests of physical fitness. (Modified agility "T" test, Illinois Agility Run Test, 10×5 Shuttle Test, Standing Balance Test and 2-Minute Step in Place Test).

If the difference between the grades is being analyzed, statistically more significant differences can be found in girls, than in boys. In the gymnastics polygon (AGP) and agility tests (MAT, ILL and 10×5), better results are represented by lower values. In the balance test (SBT) and endurance test (2-min), higher values are better results.

The eighth grade boys are significantly better than the seventh grade boys only on the MAT test ($t = 2.10$, $p = 0.040$). The eighth grade girls perform significantly better than the seventh grade girls on the MAT test ($t = 6.18$, $p < 0.001$), 10×5 Shuttle Test ($t = 2.50$, $p = 0.015$) and 2-Minute Step in Place Test ($t = -2.24$, $p = 0.028$).

The correlation between physical fitness and the results on the gymnastics polygon (AGP) can be found in Table 2. Statistical significance was recorded in all correlations for both boys and girls in both grades.

In the seventh grade, boys in most cases recorded strong correlations between physical fitness and the results

Table 1. Descriptives of 7th and 8th grade students (Mean±St.Dev.) and differences between the grades

	7 th grade		8 th grade	
	Boys (32)	Girls (32)	Boys (32)	Girls (32)
Height	167.31±7.62	161.78±6.31	173.34±7.19	165.47±4.16
Weight	54.53±9.78	47.56±4.6	59.59±9.24	55.13±5.62
BMI	19.42±2.7	18.15±1.09	19.75±2.22	20.14±2
MAT	8.29±1.25	9.32±0.96	7.7±0.98*	7.81±0.99*
ILL	20.55±2.34	23.13±2.29	19.46±2.46	22.41±2.23
10×5	14.93±1.26	16.46±1.5	15.56±2.74	15.58±1.32*
SBT	20.11±10.19	18.16±7.44	17.16±7.9	18.59±6.67
2-min	129.69±8.14	121.41±4.88	126.84±7.23	124.06±4.58*
AGP	21.65±1.77	23.20±3.02	21.31±1.80	22.48±2.23

Legend: * – significance of differences between 7th and 8th grade students $p \leq 0.05$; BMI – body mass index; MAT – modified agility T test; ILL – illinois agility run test; 10×5 – 10×5 shuttle test; SBT – standing balance test; 2-min – 2-minute step in place test; AGP – artistic gymnastics polygon.

Table 2. Pearson's correlation between physical fitness and the results on the gymnastics polygon

		Artistic Gymnastics Polygon (AGP)			
		7 th grade boys	7 th grade girls	8 th grade boys	8 th grade girls
MAT	Pearson	0.729	0.484	0.477	0.662
	Sig. (2-tailed)	<0.001*	0.005*	0.006*	<0.001*
ILL	Pearson	0.525	0.561	0.399	0.423
	Sig. (2-tailed)	0.002*	0.001*	0.024*	0.016*
10×5	Pearson	0.445	0.363	0.357	0.388
	Sig. (2-tailed)	0.011*	0.041*	0.045*	0.028*
SBT	Pearson	-0.582	-0.379	-0.607	-0.436
	Sig. (2-tailed)	<0.001*	0.033*	<0.001*	0.013*
2-min	Pearson	-0.384	-0.395	-0.414	-0.367
	Sig. (2-tailed)	0.030*	0.025*	0.019*	0.039*

on the gymnastics polygon (above .50): MAT ($r = 0.729$), ILL ($r = 0.525$) and SBT ($r = -0.582$), while in girls there are noticeably more moderate correlations (from 0.30 to 0.50): MAT ($r = 0.484$), 10×5 ($r = 0.363$), SBT ($r = -0.379$) and 2-min ($r = -0.395$).

When analyzing the eighth grade, most of the correlations in both boys and girls are at a moderate level, except for the SBT test in boys ($r = -0.607$) and MAT in girls ($r = 0.662$) where a strong correlation was recorded.

Discussion

This research was carried out with the aim of identifying the connection between physical fitness and the results on the gymnastics polygon in male and female students of the seventh and eighth grade of elementary schools. A statistically significant correlation was recorded between all observed parameters with different levels, from moderate to strong correlations, both in relation to the grade and in relation to the gender of the students. Differences in physical fitness and the results on the gymnastics polygon between the seventh and eighth grade students were also examined, separately for each gender. It was found that in boys there were differences in only one test (MAT $p = 0.040$) in favor of the eighth graders, while in girls there was a difference in three tests (MAT $p < 0.001$; 10×5 Shuttle Test $p = 0.015$; 2-Minute Step in Place Test $p = 0.028$) in favor of the eighth grade girls.

Artistic gymnastics is an essential part of physical education curricula all over the world, especially in the first years of schooling (Kovač, Sember & Pajek, 2020), but also in later school ages. Trajković, Madić, Sporiš, Aleksić-Veljković and Živčić-Marković (2016) point to the connection between the results in artistic gymnastics and the physical fitness of students and they believe that participation in gymnastics must be recommended as a positive basic activity for school-aged children from early childhood until adulthood, confirming that the teaching of gymnastics within the physical education program affects the increase in the physical fitness of students and therefore indicates a positive connection between the observed parameters. Annual school gymnastics training in combination with physical education improves the level of physical fitness in terms of speed, agility, flexibility, endurance and balance and thus promotes the development of physical fitness of young people (Granacher & Borde, 2017). Firmansyah, Rumini & Priyono (2022) share the same viewpoint and indicate that gymnastic exercises can affect the improvement of agility, coordination, balance and speed, as well as the overall motor development of both male and female students. Sukmawati, Septaliza, Fikri & Kesumawati (2022) also confirm the effectiveness of artistic gymnastics in improving physical fitness.

It is considered (Kirk, 2005) that due to the improvement of physical fitness and motor skills, students should be included in various sports activities, such as gymnastics, which contributes to higher quality physical education teaching, as well as greater physical activity of children in everyday life (Raudsepp & Päll, 2006; Logan, Webster, Getchell, Pfeiffer & Robinson, 2015; Jaakkola, Yli-Piipari, Huotari, Watt & Liukkonen, 2016). The researches clearly show the existence of positive transfer between different

motor and sport-specific skills (O'keeffe, Harrison & Smyth, 2007; Kokstejn & Musalek, 2019), which, on the other hand, significantly depend on the development of physical fitness (Hulteen, Morgan, Barnett, Stodden & Lubans, 2018; Ivashchenko, Berezhna & Cieślicka, 2020; Shevchenko, Khudoli & Potop, 2020).

The connection between the results in artistic gymnastics and physical fitness is also noted in elementary school children who practice gymnastics, because the results in the tests covering the area of speed (4x10m shuttle run test, 20m shuttle run test), explosive strength (standing long jump) and aerobic endurance tests (20m multistage fitness test) indicate a positive influence of the gymnastics program on the physical fitness and health status of the students (Kolimechikov, Petrov & Alexandrova, 2021). Similar results were obtained by Kiuchukov et al. (2019) who confirm that artistic gymnastics improves the components of physical fitness and has a positive effect on the physical development of children. In their research, both male and female gymnasts had better physical fitness in most parameters after the implementation of Alpha-Fit battery compared to their peers who do not go in for gymnastics.

The differences that exist between the children in the seventh and eighth grade (somewhat larger and more significant for girls in favor of the eighth grade) can be explained by attending a physical education program for a year longer with many teaching contents that can affect the better physical status and technical knowledge of the students. In this regard, the program contributed to a partial advantage in the physical preparedness and motor experience of the eighth-grade students when performing certain tests of physical fitness.

Conclusion

Within the physical education program, for the optimal physical development of children and the youth, diversity is needed; diversity which is reflected in the training, practice and improvement of various fundamental motor skills and sport-specific skills that arise from the former. On the other hand, the practice on the development of physical fitness that have a cause-and-effect relationship, both with fundamental motor skills and with sports-specific skills, also has its place in the program. All these components of physical development mutually influence each other and jointly contribute to the successful mastering of the elements of sports education as one of the thematic areas to which the contents of the physical education program are directed.

The aim of this research was to identify the connection between physical fitness and the results on the gymnastics polygon in the seventh and eighth grade elementary school students. Additionally, it was necessary to examine the differences in physical fitness and the results on the gymnastics polygon between the seventh and eighth grade students, separately for each gender. A significant correlation between the variables of physical fitness and the results on the gymnastic polygon is recorded in both boys and girls. In that regard, a strong mutual connection between physical fitness and sport-specific skills, which are presented in this paper through the technical elements of artistic gymnastics, is confirmed. The differences that exist in favor of male and female students of the eighth grade can also be explained by

the fact that older children were included in and treated with the contents of the physical education program for a longer period of time, which affected better technical training and physical preparation.

Attention should also be drawn to the use of the polygon as one of the organizational forms of work in physical education, which has proven to be an effective way of training, as confirmed by the aforementioned research. The application of the polygon provides great opportunities for the implementation of the content of the physical education program, both in an organizational and creative sense. Due to its interesting form of work, which is fun for students, the polygon seems very refreshing in the teaching process.

It can be said that the implementation of this research had certain limitations related to the relatively small sample of respondents that covered three schools. The inclusion of wider population and a larger number of respondents would have resulted in much more accurate and reliable results. Furthermore, in order to get a better insight, a larger number of physical performance parameters can be included. In any case, the research provides certain information that indicates the tendency of physical development of students and can serve for some new research that will include a much wider population with a more representative sample.

Conflict of interest

The author did not receive support from any organization for the submitted work. The author has no relevant financial or non-financial interests to disclose.

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ФІЗИЧНА ПІДГОТОВЛЕНІСТЬ І РЕЗУЛЬТАТИ НА ГІМНАСТИЧНОМУ ПОЛІГОНІ УЧНІВ 7-8 КЛАСІВ ПОЧАТКОВОЇ ШКОЛИ

Деян Міленкович^{1ABCD}

¹Університет Уніон – Нікола Тесла

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 2 табл., 1 рис., 42 джерела.

Метою дослідження було встановлення зв'язку між фізичною підготовленістю та результатами на гімнастичному полігоні учнів 7-8 класів початкової школи. Крім того, необхідно було визначити відмінності в спостережуваних змінних залежно від класу, окремо для кожної статі.

Матеріали та методи. Загалом у тестуванні взяли участь 128 учнів трьох початкових шкіл (64 учні та 64 учениці) віком 13 та 14 років. Було використано п'ять тестів на фізичну підготовленість (модифікований Т-тест на спритність (MAT), Іллінойський тест на спритність, тест «човниковий біг 10х5», тест «збереження рівноваги стоячи» та тест «крок на місці протягом 2 хвилин»), а для оцінки рівня засвоєння технічних елементів спортивної гімнастики використовували спеціально спроектований гімнастичний полігон.

Результати. Була зареєстрована статистично значуща кореляція між усіма спостережуваними параметрами з різними рівнями, від помірної до сильної кореляції, як залежно від класу, так і залежно від статі школярів. Також встановлено, що у хлопців є відмінності лише в одному тесті (MAT) на користь восьмикласників, а у дівчат – у трьох тестах (MAT; тест «човниковий біг 10х5»; тест «крок на місці протягом 2 хвилин») на користь восьмикласниць.

Висновки. Отже, можна зробити висновок про наявність сильного взаємозв'язку між фізичною підготовленістю та специфічними спортивними навичками, які представлені в цій роботі у вигляді технічних елементів спортивної гімнастики.

Ключові слова: фізичний розвиток, спортивна гімнастика, фізичне виховання, учні та учениці.

Information about the authors:

Milenković, Dejan: dejan.milenkovic2309@gmail.com; <https://orcid.org/0000-0001-9341-0890>; Faculty of Sport, University Union – Nikola Tesla, Narodnih heroja 30/I 11070 Belgrade, Serbia.

Cite this article as: Milenković, D. (2023). The Seventh and Eighth Grade Primary School Students' Physical Fitness and Results on the Gymnastics Polygon. *Physical Education Theory and Methodology*, 23(4), 600-606. <https://doi.org/10.17309/tmfv.2023.4.15>

Received: 03.07.2023. Accepted: 14.08.2023. Published: 30.08.2023

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INCREASING THE RELIABILITY OF TEST CONTROL USING INFORMATION TECHNOLOGIES IN INCLUSIVE PHYSICAL EDUCATION

Oksana Blavt^{1ABCD}, Gennadii Iedynak^{2BCE}, Svitlana Pereverzieva^{3BC},
Viktor Holub^{4BC} and Svitlana Melnyk^{5BCE}

¹Lviv Polytechnic National University

²Kamianets-Podilskyi Ivan Ohienko National University

³Kyryvi Rih State Pedagogical University

⁴Taras Shevchenko Regional Humanitarian Pedagogical Academy in Kremenets

⁵Lutsk National Technical University

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Oksana Blavt, E-mail: oksanablavt@ukr.net

Accepted for Publication: August 14, 2023

Published: August 30, 2023

DOI: 10.17309/tmfv.2023.4.16

Abstract

The purpose of the study was to determine the reliability and validity of a method developed on the basis of information technologies to control the strength endurance of the core muscles of students with disabilities.

Materials and methods. 38 students with disabilities, aged 18-23, who entered the first year of study at the university, voluntarily participated in the study. The studied sample consisted of students with a simple form of disorder in the musculoskeletal system, who have the ability to move independently and perform motor actions. An information-search approach to data collection was used at the theoretical level, and pedagogical testing and methods of mathematical statistics were used at the empirical level.

Results. A method for assessing the strength endurance of the core muscles developed on the basis of information technologies is presented. To implement the method, a network of sensors formed by analog and digital sensors, wireless infrared communication devices, information from which enters the programmable logic controller and is fed to the personal computer, is used. The software has been developed that implements immediate processing and presentation of test control results in real-time. Correlation analysis was used to calculate the indicators of test reliability and validity of fixing the results of tests using the method presented in this paper and the traditional method.

Conclusions. Experimental verification of the presented method for controlling the development of the core muscles of students with disabilities has proven its practical effectiveness. In conclusion, the numerical values of reliability and validity obtained using the automated method of countering are within the range of "above average," in contrast to the measurements made by the traditional method of control using a test exercise: the calculation of test reliability and validity revealed a level of "below average." The set of obtained numerical characteristics of empirical data proved the advantage of using the latest information technologies in inclusive physical education as a factor of its effectiveness. Achieving positive results in ensuring the proper level of health, full physical and psychological rehabilitation of higher education students with disabilities is considered as a practical value of implementing inclusion in a higher education institution.

Keywords: students, physical education, testing, inclusion, control, information technologies.

Introduction

Problem statement. The change of modern accents in the interpretation of the concept of disability leads to the need to provide a comprehensive approach to creating

conditions that would contribute to the full implementation of their inclusion in the higher education system. A direct component of the effectiveness of the level of inclusiveness is the development of new technologies in the educational process of a higher school, which are considered indicators of their importance (Page, Anderson, & Charteris, 2021).

Achieving positive results in ensuring the proper level of health, full physical and psychological rehabilitation of higher education students with disabilities is considered

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as a practical value of implementing inclusion in a higher education institution (Goodwin, & Watkinson, 2000).

At the same time, full-fledged physical activity is often the first thing that a person with a disability loses as a result of a serious injury. Therefore, the function of ensuring both the physical and psychosocial development of students with disabilities is entrusted to inclusive physical education (PE) (Lidor, & Hutzler, 2019).

It was determined (Grenier, Patey, & Grenier-Burtis, 2022), that inclusive PE has significant potential for correcting and improving the motor skills of students with disabilities. Obtaining new scientific data on the formation of vital skills by means of PE will contribute to the further development of this field of knowledge, ensuring physical independence, reducing complications associated with health disorders, and enabling students with disabilities to successfully realize themselves in a regular academic environment.

We note that attention to the topic of disability has intensified today. Scientists agree (Blavt, 2022; Morley, Bailey, Tan, & Cooke, 2005; Tant, & Watelain, 2016), that PE is the most effective means of implementing inclusion in higher education.

At the same time, it has been proven (Qi, & Ha, 2012), that improving the health of students with disabilities during their studies is a necessary condition for overcoming inequality, gaining freedom and generally a new quality of life. It has been investigated (Koryahin, Blavt, Bakhmat, Guska, Ludovyk, Prozar, Bodnar, Kravets, & Bezgrebelnaya, 2019; Pocock, & Miyahara, 2018), that as an effective way to reduce the physical maladjustment of students with disabilities, their involvement in systematic PE classes is considered.

A distinctive feature of inclusive PE is its dynamism because there is a constant adaptation of this process to the individual characteristics of each student with a disability (Baglieri, Valle, Connor, & Gallagher, 2011; Keles, ten Braak, & Munthe, 2022). Instead, in certain scientific sources (Block, & Obrusnikova, 2007; Ruscitti, Thomas, & Bentley, 2017), inclusive PE is considered an individual program for the correction of physical development. According to sources (Gupta, 2021; Gogoi, 2019) an effective means of implementing this is the introduction of innovative technical developments, which are planned as a result of modernization to ensure the effectiveness of physical improvement. According to available research (Koryahin, Blavt, Vanivska, & Stadnyk, 2020; Varga, & Révész, 2023), the introduction of informative technologies (IT), which are a generator of progressive ideas and the optimal means of developing the innovative potential of inclusive PE.

It is believed (Rum et al., 2021) that the latest IT are non-invasive, portable and convenient ways of monitoring activities of persons with disabilities. One of the biggest challenges in using technological tools to assess the physical fitness outcomes of people with disabilities is that disability rarely affects two individuals in the same way, thus introducing greater intersubject variability relative to able-bodied individuals (Curran, & Frossard, 2012).

In addition, given that we are talking about persons with disabilities, IT can ensure objectivity and reliability of measurements given the degree of health impairment and related functional limitations (Cooper et al., 2018). So, considering the latter, let's single out a group of muscles – the

muscles of the cortex, which are multifunctional in providing a numerous list of functional operations (Nanjwan, & Dada, 2018). Considering that the muscles of the cortex are involved in almost all movements of the human body, the study of the level of their development in the PE process of students with disabilities is of particular importance.

Purpose of the research in determining the reliability and validity of a method developed on the basis of IT to control the strength endurance of core muscles of students with disabilities.

Materials and methods

Research methods

The research has a theoretical-empirical systematic character. Such a combined approach was used to achieve a higher degree of validity and reliability. The topic is new, so data is difficult to collect. Because of the above, an information-search approach to data collection was used at the theoretical level of the research.

At the empirical stage, a mixed (quantitative-qualitative) approach to data collection was used, based on the fact that they alone are not absolute in their form. The technical modeling method was used to develop the control tool. The data were obtained as a result of a pedagogical experiment and the use of mathematical statistics methods for processing and interpreting the obtained results. The results are presented in the form of numbers from an accurate measurement.

Quantitative research of a descriptive-experimental nature involved the collection of experimental data during testing, which was carried out according to the standard procedure for performing test exercises. The results were recorded using a stopwatch and the developed device. Quantitative data analysis involved calculations performed using statistical methods to objectively measure reality.

The test used in the study were quantitative and easy to reproduce and repeat. It is considered that the use of a large number of tests for students with disabilities may cause fatigue. We tried to avoid this to exclude the dependence of test results on physiological factors. Given that the studied sample consisted of students with disabilities, fatigue may cause tremors and violation of the standardization of the test task.

A standardized and easily repeatable test “Keeping the legs at an angle in the supine position” was used. Test procedure. The student takes a position lying on his back, his hands are held on his chest in a crossed position, and his head lies on the floor. Performing the test involves lifting both legs up and holding them at an angle of 60 degrees (vertically). The upper part of the body should be kept on the floor. The time of holding a certain pose is fixed (Magill, & Anderson, 2017).

The execution procedure involved the start of the test task according to the sound signal provided by the device, during which the execution of the movement was initiated. When the student finished the test task, the device notified with a sound signal.

The test was performed twice in a row, to obtain the results of repeated measurements for each student of the studied sample. The average value of repeated measurements was used in the analysis.

Study participants

38 students with disabilities, aged 18-23, who entered the 1-st year of study Lviv Polytechnic National University, Kamianets-Podilskyi Ivan Ohienko National University, Kryvyi Rih State Pedagogical University, Taras Shevchenko Regional Humanitarian Pedagogical Academy in Kremenets and Lutsk National Technical University, an equal number of girls and boys, voluntarily participated in the study.

We tried to achieve homogeneity of the studied sample, so students with uncomplicated forms of disorders in the musculoskeletal system were selected. Students with cognitive disabilities were not included in the study. The criteria for forming the study sample were as follows: absence of injuries, illnesses, or complications during the last month; the ability to independently complete the test task without external influence.

The study is characterized by certain limitations. First, the sample size is relatively small, and students with uncomplicated musculoskeletal disorders who do not need external support for movement were included. Secondly, there was a lack of information about other aspects of the disease, which can certainly affect the results of the test control.

The study was planned and carried out following the principles of bioethics set forth by the World Medical Association (WMA-2013) in the Helsinki Declaration "Ethical Principles of Medical Research Involving Humans" and UNESCO in the "General Declaration on Bioethics and Human Rights".

PE of students with disabilities involves ethical issues and lengthy procedures. After they agreed to participate, consent was obtained from their classmates and PE teachers. The limited number of participants in this study suggests obtaining information about group patterns rather than significant values.

Control of the studied parameters was carried out during studies at the university, during one calendar year, namely at the beginning of the study (october) and at the end of the study (may-june). The break between testing was 8 months. Participants performed two to three trials of each test.

Statistical analysis

Statistical analysis was used as a process of data collection and analysis to identify research patterns and trends, the results of which became the basis of the research conclusions. Statistical correlation calculation was used to calculate test reliability. Reliability and validity were measured using intraclass correlation coefficients, standard error of measurement, and coefficient of variation. The reliability of the test was considered high when the intraclass correlation coefficient was 0.79-0.95, the validity – 0.6-1.0. The coefficient of variation, as the standard deviation divided by the mean, was additionally calculated for each trial and all trials combined (Vincent, 2005). All statistical analyzes were performed using SPSS Version 21, and p-values < 0.05 were considered statistically significant.

Results

In order to carry out scientific research in a certain direction, let's specify the following. The normal functionality

of the core muscles (local and global) ensures the preservation of segmental stability of the spine and its protection, good posture, correct curvature of the back, balance, and the health of the spine in general. In addition, the muscles of the cortex are involved in ensuring the vital functions of the body (breathing, posture control, urination, etc.) (Nanjwan, & Dada, 2018).

This was the basis of the scientific search for the research of the level of development of the muscles of the cortex. On the other hand, the issue of strength endurance development goes beyond motor readiness as a factor correlating the level of somatic health, physical capacity and individual lifestyle (Doma, Deakin, Schumann, & Bentley, 2019).

In the practice of inclusive PE, a test exercise for lowering the legs from a lying position is used to control strength endurance. However, with this method of control, there is a certain dependence of the subjective assessment of perception by the specialist who carries out the control, in the standardization of compliance with all methodological requirements of the test exercises that are set visually. Namely, fixing the corner and maintaining a stable position of the body and legs in the corner position. The possibility of errors also occurs when recording the results of the test exercise with a stopwatch. All of the above, respectively, reduces the reliability of the test, and, therefore, the degree of reliability of the control results.

To eliminate all the listed factors, a method of controlling the strength endurance of the core muscles has been developed (fig. 1).

The method of assessing the strength endurance of the core muscles is carried out as follows. A network of sensors is placed on the student's body. The sensor network is formed by analog and digital sensors (Wojcik et al., 2020). In the sensor network, signals are registered and identified when the student performs the test exercise. Using a network of sensors in the method provided an opportunity to monitor the change of any measurement parameters of the performance of the test task in real-time.

The received signal is sent to the programmable logic controller by wireless infrared communication devices. The function of the programmable logic controller is to manage all the structural elements that are used to implement the method and process the information coming from the sensor network: combining the sensor network, processing the information received from the sensors, and passing it on

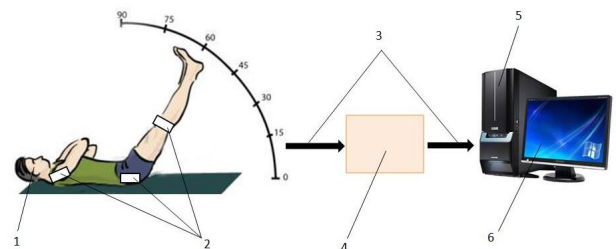


Fig. 1. Structural diagram of the method of assessing the strength endurance of the core muscles: 1 – student, 2 – sensor network, 3 – wireless infrared communication devices, 4 – programmable logic controller, 5 – personal computer (PC), 6 – liquid crystal display

Table 1. The results and reliability of control test the strength endurance of the core muscles (n = 38)

Statistical parameters	Test tasks and measurement results (s)							
	at the beginning of the experiment				at the end of the experiment			
	using the test exercises		using the developed method		using the test exercises		using the developed method	
	female	male	female	male	female	male	female	male
M	10.1	18.3	11.4	17.2	14.2	23.7	15.6	24.1
S	3.1	2.9	4.7	4.1	2.5	5.8	2.3	1.9
V (%)	46.2	47.1	45.1	43.3	38.2	37.2	28.2	27.6
r_{tt}								
reliability	0.601	0.690	0.921	0.881	0.655	0.642	0.902	0.858
validity	0.217	0.284	0.441	0.478	0.211	0.308	0.436	0.501

for processing on the PC. The programmable logic controller works in automatic mode and provides high measurement accuracy, long battery life, and the ability to seamlessly transfer information to a PC, thanks to which the high efficiency of control results and the informative presentation of results are achieved.

From the programmable logic controller, the signal is transmitted to the PC by wireless infrared communication devices. The signals of the student's performance of the exercise are recorded and visualized on a PC using the developed software. It is possible to save the results for the necessary period in the database and observe their dynamics.

The developed method was tested in the PE practice of students with disabilities (Tab. 1).

It should be noted that in the testing of students with disabilities, the use of a network of sensors is another advantage, as they allow to obtain synthesized information and exclude the influence of tremor variability during the performance of test tasks (Camomilla, Bergamini, Fantozzi, & Vannozzi, 2018). Which, accordingly, can affect the results of the retest.

This was reflected in the reliability and validity coefficients of the test results using the developed control method. At the end of the experimental study, the indicators of these parameters reached digital values > 0.75 , which proves the high level of reliability of the control results. Accordingly, with $r_{tt} = 0.60-0.69$, the values of which are obtained using the traditional measurement method, the use of the test for individual evaluations is questionable.

The validity of measuring the strength endurance of the core muscles using the developed method was acceptable using the traditional control method and reached values in the range from 0.35 to 0.56, which are "above average" and "acceptable", respectively. Therefore, the test results obtained in this way can be considered reliable.

Taking into account the fact that a qualitative analysis of the phenomenon is impossible without the use of variation indicators, the coefficient of variation $V(\%)$ was calculated. A decrease in the coefficient of variation (up to 28%) at the second stage of measurements indicates the achievement of homogeneity of the population, and the average is a typical and reliable characteristic of it. We assume that the PE process and the use of the developed tool became the factor that ensured the effectiveness of the PE process. Thus, the reserves were used to improve the physical endurance of the core muscles of the students of the studied sample.

Discussion

The urgency of considering the issue of the effectiveness of PE for students with disabilities takes on special importance in connection with the long-term hostilities on the territory of Ukraine, and, therefore, the permanent increase of persons with disabilities as a result of the war. The conducted scientific research is based on the fact that in Ukraine there is practically no experience in the practice of forming inclusive physical education in institutions of higher education, we believe that the development of this field of knowledge, as an inexpensive and effective means of health protection, should be one of the priority tasks of the modern educational policy of higher education. Our research expands scientific information on the importance of physical education in the process of eliminating health disorders of students with disabilities (Qi & Ha, 2012), using the basics of inclusive pedagogy (Alasim, 2021), innovative practices of pedagogical content (Baglieri & Bacon, 2020; Grenier, Patey, & Grenier-Burtis, 2022), physical therapy (Whitney, Moore, & Fry, 2017; Sawade, 2023). and integration of IT into this process (Mykytyuk, Blavt, Hnatchuk, Stechkevych, & Helzhynska, 2022).

The study is consistent with scientific data (Goodwin & Watkinson, 2000). regarding the need to focus efforts on the justification and creation of effective technologies of inclusive PE (Tant & Watelain, 2016), organized based on modern general scientific and special technologies of the theory (Pocock & Miyahara, 2018), methodology and practice of PE (Block, & Obrusnikova, 2007), using the latest achievements of IT (Blavt, Iedynak, Pityn, Hluhov, Guska, Stadnyk, Zaikin, & Karatnyk, 2022; Gogoi, 2019).

We tried to raise interest in the problem of effective use of IT network resources and provision of prompt access to information. According to the data (Curran & Frossard, 2012), the analysis of the PE process for people with disabilities is the most important in this process based on objective information.

An important aspect that limits the interpretation of results is the lack of standardization in control (Rum et al., 2021). In PE, control information obtained and analyzed with the help of IT is the prerogative of research and conclusions (Curran & Frossard, 2012; Klavina, 2011; Koryahin, Blavt, Vanivska, & Stadnyk, 2020). The practical significance of examining the development of core muscles in students with

disabilities is that these muscles provide fundamental movements that require targeted exposure because of impairment.

For the first time, a developed and practically tested latest technical method, created based on the latest IT, is presented to level the peculiarities and limitations that complicate the PE process of students with disabilities in a higher education institution. The obtained results are important for the modernization of PE content for students with disabilities in the direction of its individualization. Our research is consistent with the information (Ivashchenko, 2020; Chernenko et al., 2020), that continuous assessment, as a result of control, is the basis of understanding the development of motor skills during the period of PE.

Conclusions

The implementation of IT in inclusive physical education is considered an optimal means of developing the innovative potential of this process. To receive high-quality physical education that meets students with disabilities needs, which will ensure the improvement of their physical condition based on the improvement of impaired motility, implies the presence of permanent control, which is the basis of individual correction of classes.

The paper presents a method of controlling the strength endurance of the core muscles developed on the basis of the latest IT, which are proposed to be used in the physical education of students with disabilities. The expediency of researching the development of core muscles is due to their role and importance in ensuring the vital functions of the body and performing isometric or dynamic stabilization during movements. The proposed method ensures immediate acquisition of objective control data, without creating any restrictions for the implementation of motor tasks of students with disabilities. The integration of the latest IT in the test control of students with disabilities ensures the elimination of a number of problematic factors of the current control based on automatic monitoring of changes in the measurement parameters of the test task in real-time.

Experimental verification of the presented method of controlling the development of the core muscles of students with disabilities has proven its practical effectiveness. In conclusion, the numerical values of reliability and validity obtained using the automated method of control are within the range of "above average", in contrast to the measurements made by the traditional method of control using a test exercise: the calculation of test reliability and validity revealed a level of "below average" and "accepted".

The set of obtained numerical characteristics of empirical data proved the advantage of using the latest IT in inclusive physical education as a factor of its effectiveness. At the same time, determining the level of reliability and validity of the test used to control the strength endurance of the core muscles in the traditional way proved the low level of these indicators.

In general, the scientific potential of equipping the test process with the use of the latest IT ensures a high level of control and evaluation of the studied parameters for a limited period of physical education of students with disabilities.

Conflicts of interest

No conflicts of interest exist.

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ПІДВИЩЕННЯ НАЙДІЙНОСТІ ТЕСТОВОГО КОНТРОЛЮ ІНФОРМАЦІЙНИМИ ТЕХНОЛОГІЯМИ У ІНКЛЮЗИВНОМУ ФІЗИЧНОМУ ВИХОВАННІ

Оксана Блавт^{1ABCD}, Геннадій Єдинак^{2BCE}, Світлана Переверзева^{3BC},
Віктор Голуб^{4BC}, Світлана Мельник^{5BCE}

¹Національний університет «Львівська політехніка»

²Кам'янець-Подільський національний університет імені Івана Огієнка

³Криворізький державний педагогічний університет

⁴Кременецька обласна гуманітарно-педагогічна академія імені Тараса Шевченка

⁵Луцький національний технічний університет

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 7 с., 1 табл., 1 рис., 38 джерел.

Мета дослідження полягала у визначенні надійності та валідності розробленого засобу на основі інформаційних технологій для контролю силової витривалості м'язів кора здобувачів вищої освіти з інвалідністю.

Матеріал та методи. У дослідженні добровільно взяли участь 38 здобувачів вищої освіти з інвалідністю, віком 18-23 роки, які вступили на І-ший курс навчання університету. Досліджувану вибірку склали здобувачі вищої освіти із нескладною формою порушень в опорно-руховому апараті, які володіють навичкою самостійного пересування та здійснення рухових дій. Використано інформаційно-пошуковий підхід до збору даних на теоретичному рівні та педагогічне тестування й методи математичної статистики – на емпіричному.

Результати. Представлено на основі інформаційних технологій розроблений спосіб контролю силової витривалості м'язів кора. Для реалізації способу використано мережу сенсорів, сформованої аналоговими та цифровими сенсорами, бездротові пристрої інфрачервоного зв'язку, інформація з яких поступає на програмований логічний контролер та подається на персональний комп'ютер. Розроблено програмне забезпечення, яким реалізують негайну обробку та представлення результатів тестового контролю в режимі реального часу. Кореляційним аналізом здійснено обчислення показників тестової надійності та валідності фіксації результатів виконання тестів з використанням представленого у роботі способу та традиційним способом.

Висновки. Експериментальною перевіркою представленого способу контролю розвитку м'язів кора здобувачів вищої освіти з інвалідністю засвідчено його практичну ефективність. У підсумку, числові значення надійності та валідності, які отримано з використанням автоматизованого способу контролю знаходяться у межах «вище середнього», на відміну від вимірювань, здійснених традиційним способом контролю з використанням тестової вправи: обчислення тестової надійності та валідності виявило рівень «нижче середнього». Сукупністю отриманих числових характеристик емпіричних даних доведено перевагу використання новітніх інформаційних технологій у інклюзивному фізичному вихованні як чинника його ефективності. Досягнення позитивних результатів у забезпеченні належного рівня здоров'я, повної фізичної та психологічної реабілітації здобувачів вищої освіти з інвалідністю розглядаємо як практичну цінність реалізації інклюзії у закладі вищої освіти.

Ключові слова: здобувачів вищої освіти з інвалідністю, фізичне виховання, тестування, інклюзія, контроль, інформаційні технології.

Information about the authors:

Blavt, Oksana: oksanablavt@ukr.net; <https://orcid.org/0000-0001-5526-9339>; Department of Physical Education, Lviv Polytechnic National University, Bandera St, 12, Lviv, 79013, Ukraine.

Iedynak, Gennadii: yedinak.g.a@gmail.com; <https://orcid.org/0000-0002-6865-0099>; Department of Theory and Methods of Physical Education, Kamianets-Podilskyi Ivan Ohienko National University, Ohienko St, 62, Kamianets-Podilskyi, 32300, Ukraine.

Pereverzieva, Svitlana: pereva@gmail.com; <https://orcid.org/0000-0001-6107-4685>; Department of Physical Culture and Methods of Its Teaching Teacher, Kryvyi Rih State Pedagogical University, Gagarina Ave., 54, Kryvyi Rih, Dnipropetrovska Oblast, 50086, Ukraine.

Holub, Viktor: golub06va@ukr.net; <https://orcid.org/0000-0003-3123-7169>; Department of Theory and Methods of Physical Education, Taras Shevchenko Regional Humanitarian Pedagogical Academy in Kremenets, Litseina St, 1, Kremenets, Ternopil'ska oblast, 47003, Ukraine

Melnyk, Svitlana: ml.svitlana@ukr.net; <https://orcid.org/0000-0002-2663-0241>; Department of Physical Culture, Sports and Health, Lutsk National Technical University, Lvivska St, 75, Lutsk, 43018, Ukraine

Cite this article as: Blavt, O., Iedynak, G., Pereverzieva, S., Holub, V., & Melnyk, S. (2023). Increasing the Reliability of Test Control Using Information Technologies in Inclusive Physical Education. *Physical Education Theory and Methodology*, 23(4), 607-613. <https://doi.org/10.17309/tmf.2023.4.16>

Received: 03.07.2023. Accepted: 14.08.2023. Published: 30.08.2023

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ORIGINAL SCIENTIFIC ARTICLE

EDUCATION FOR SUSTAINABLE DEVELOPMENT: UNDERSTANDING BY PHYSICAL EDUCATION AND SPORTS SPECIALISTS

Halyna Tsyhura^{1ABCD} and Serhii Harkusha^{1AD}

¹T. H. Shevchenko National University "Chernihiv Colehium"

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Halyna Tsyhura, E-mail: zygura.g@ukr.net

Accepted for Publication: August 14, 2023

Published: August 30, 2023

DOI: 10.17309/tmfv.2023.4.17

Abstract

Study purpose. The purpose of the study was to investigate the need for physical education and sports specialists to acquire competencies for the organization of educational activities for sustainable development and their understanding of the involvement of the field of physical education and sports in the implementation of sustainable development goals.

Materials and methods. The study involved 106 specialists in physical education and sports from various regions of Ukraine (73 women and 33 men). The participants comprised representatives of general secondary education institutions (schools, lycées, gymnasiums) – 70.7% of the respondents (75 persons), representatives of higher education institutions (universities and academies) – 11.3% of the respondents (12 persons), representatives of sports institutions (youth sports schools and sports complexes) – 10.4% of the respondents (11 persons), representatives of vocational education institutions (schools, colleges) and out-of-school youth work centers – 7.5% of the respondents (8 persons). The respondents' work experience in the field of physical education and sports ranged from 1 to 45 years. The study used the methods of surveying, analysis and synthesis of information, and mathematical information processing.

Results. The survey revealed that most of the respondents are not sufficiently familiar with the issues of sustainable development. 51.89 % of the respondents indicate partial awareness of the concept and sustainable development goals, 5.66 % claim that they are not familiar with such information at all. The majority of the physical culture and sports specialists who participated in the experiment do not understand the essence and depth of Sustainable Development Goals and only link physical education and sports to such Sustainable Development Goals as good health and well-being (Goal 3), quality education (Goal 4), and gender equality (Goal 5).

Conclusions. It was found that only 3.8% of the respondents can find a correlation between the field of physical education and sports and the seventeen Sustainable Development Goals. 62.26% of the respondents indicate that they need to expand their knowledge and skills on sustainable development, 46.23% of the respondents want to deepen the knowledge and skills in the methodology of implementing education for sustainable development. Most of the surveyed physical education and sports specialists need advanced training to acquire the competencies necessary for the implementation of educational activities for sustainable development.

Keywords: sustainable development, education, physical education, sports, physical education instructor, trainer.

Introduction

Education for Sustainable Development (ESD) is an approach to organizing the educational process that aims to inform members of society about the main environmental, economic and social issues of sustainable development; promotes understanding of the essence of the factors that determine an unsustainable way of life; and develops critical,

non-standard and creative thinking to find the most effective solutions to global problems (UNECE Strategy, 2005).

The impetus for the introduction of ESD in Ukraine was the European integration processes (Uhoda, 2014). They led to several reforms. In particular, in the field of education, in 2017, a new version of the Law "On Education" was adopted, where the goal of education is defined as "... raising the educational level of citizens to ensure sustainable development of Ukraine and its European choice." In addition, in 2017, the physical culture curricula for general secondary education institutions were updated, which, as

part of the key competencies, included the formation of an active and responsible citizen who is ready to participate in solving environmental issues and is aware of the importance of sustainable development of society (Navchalna prohrama, 2017). This requires that physical culture teachers and sports coaches have both relevant knowledge of sustainable development issues and skills in organizing educational activities for sustainable development.

In 2018, the United Nations recognized sport as a factor in ensuring sustainable development along with education. As a result, states are encouraged to effectively use the power of sport to achieve sustainable development goals, and organizers of sporting events are encouraged to use a variety of initiatives to engage sport for sustainable development and peace (Sport as an enabler, 2018). This has contributed to the fact that athletes and the sports industry abroad have become active in achieving sustainable development goals and have accumulated significant experience (Tsyhura, 2022a). Physical culture and sports specialists working in the field of education are much less involved in the implementation of these goals. Recommendations on the possibilities of physical culture in the context of education for sustainable development appeared during the Decade of Education for Sustainable Development (Osborne & Batista, 2010; Lynch, 2016). A new wave of interest in this issue has been emerging since 2018, but researchers note that the educational aspects of sustainable development in the field of physical culture and sport is very little investigated (Baena-Morales et al., 2021; Lundvall & Fröberg, 2022).

In Ukraine, the sphere of physical culture and sports in general is not much involved in the implementation of Sustainable Development Goals (Imas et al, 2018; Natsionalnyi olimpiyskyi komitet Ukrainy, 2020). We have repeatedly emphasized the importance of preparing future physical culture and sports specialists for educational activities for sustainable development (Tsyhura, 2019; Tsyhura, Harkusha, 2020); defined the essence and structural components of the readiness of future physical culture and sports specialists for educational activities for sustainable development (Tsyhura, 2020) and the main organizational and pedagogical conditions that affect such training (Tsyhura, 2022b). In addition, in one of our previous studies, we found that students of the Faculty of Physical Culture are not sufficiently aware of the issues of sustainable development and need to acquire competencies to perform this educational activity (Tsyhura, 2021). We believe that qualified physical culture and sports specialists may also have a similar need.

Objective: to study the need of physical culture and sports specialists to acquire competencies for the organization of educational activities for sustainable development and their understanding of the involvement of the field of physical culture and sports in the implementation of sustainable development goals.

Materials and methods

Participants of the study

The voluntary online survey involved 106 persons in total: 73 women and 33 men – 68.9% and 31.1% of respondents, respectively. The survey participants came from all regions

of Ukraine. Among them, 75 persons (70.7%) represented general secondary education institutions (schools, lyceums, gymnasiums), 12 persons (11.3%) represented higher education institutions (universities and academies), 11 persons (10.4%) represented sports institutions (youth sports schools and sports complexes), and 8 persons (7.5%) represented vocational education institutions (schools, colleges) and out-of-school youth work centers. All respondents working in general secondary and vocational education institutions are physical culture teachers; representatives of higher education institutions teach disciplines such as Pedagogy, Recreational Physical Activity, Theory and Methods of Physical Culture, Professional Skills, Fitness Technologies, Personal Training, Athletics, Gymnastics, Basketball, Volleyball, Football, Tennis, and are trainers in the respective sports.

The experience of the survey participants in the field of physical culture and sports ranged from 1 to 45 years (Fig. 1). The majority of respondents were aged 30-45.

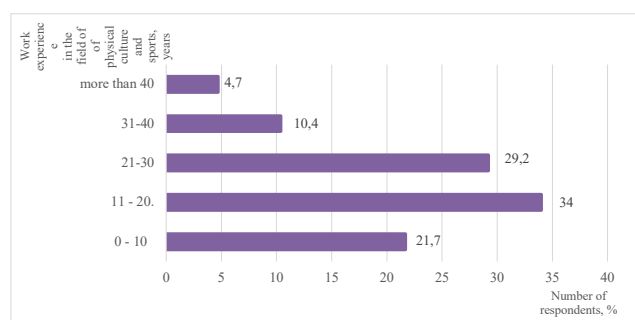


Fig. 1. The distribution of respondents by length of service in the field of physical culture and sports

Design of the study

The study was conducted in 2021-2022. The survey was designed using Google Form. The survey consisted of an introduction and two sections. In the Introduction, we explain the reason for the online survey.

The content of the introduction of the online survey: "Dear colleagues! According to the Law of Ukraine "On Education", the purpose of education is: "...raising the educational level of citizens to ensure sustainable development of Ukraine". Sustainable development is understood as a balance of economic growth with environmental protection and social well-being of society. Since 2017, the curricula for general secondary education institutions in Ukraine have been providing for the formation of a personality aimed at sustainable development of society, which is ensured by key competencies that are integrated in the relevant content areas. In this regard, you are invited to take part in a survey to identify the need for physical culture and sports specialists for assistance in organizing educational activities for sustainable development. The survey is anonymous. Please answer the questions that are offered to you."

The first block of the survey included open-ended questions and allowed us to collect social information about the place and length of service in the field of physical culture and sports, main disciplines/subjects of teaching, region of residence, and gender.

The second block of the survey contained a list of Sustainable Development Goals (Table 1) and open-, closed-, and semi-closed questions related to sustainable development and educational activities for sustainable development.

The survey was distributed in the form of Google Forms through social groups of educators on Facebook. The survey was addressed to physical culture and sports specialists – teachers of higher education institutions, teachers of general secondary education institutions, and coaches of various sports. Participants were informed about the purpose of the study and its voluntary nature and the anonymity, and confidentiality of the information provided.

Table 1. List of Sustainable Development Goals (SDGs)

List of Sustainable Development Goals
1. No poverty
2. Zero hunger
3. Good health and well-being
4. Quality education
5. Gender equality
6. Clean water and sanitation
7. Affordable and clean energy
8. Decent work and economic growth
9. Industry, Innovation and Infrastructure
10. Reduced inequality
11. Sustainable cities and communities
12. Responsible consumption and production
13. Climate action
14. Life below water
15. Life on land
16. Peace, justice and strong institutions
17. Partnership for the goals

Statistical analysis

The material was systematized and mathematically processed using Microsoft Excel 2010.

Results

We will present the results of the survey concerning the views of specialists of physical culture and sports on the problems of sustainable development and the implementation of educational activities for sustainable development.

To the question “How well do you know the concept of “sustainable development” and the goals of sustainable development?”, more than half of the respondents answered “I am partially familiar with this concept, I have heard something about the goals of sustainable development”. Slightly less than half of the respondents answered “I am well acquainted with this concept, I am well aware of the sustainable development goals” (Table 2). Among the participants of the online survey, there were also those who said: “I am not familiar with this concept and the sustainable development goals,” but there were very few of them.

Table 2. Results of answering the question: “How well are you familiar with the concept of “sustainable development” and the sustainable development goals?”

Proposed answers	Number of answers	
	Number of respondents	%
I am well acquainted with this concept, I am well aware of the sustainable development goals	45	42.45
I am partially familiar with this concept, I have heard something about the goals of sustainable development	55	51.89
I am not familiar with this concept and the sustainable development goals	6	5.66

The next question was a question of evaluation in which the survey participants were asked to rate themselves on a 10-point scale: “One of the tasks of education for sustainable development is to teach everyone to understand what is happening to the environment, economy and society and to find the best ways to solve problems in the interests of all members of society and nature today and in the long term. To what extent do you have sufficient knowledge and skills to perform educational activities for sustainable development?” As a result, the most of respondents rated themselves at 7 and 8 points, namely: 27 respondents (25.47%) and 28 respondents (26.41%), respectively (Fig. 2). Many participants of the survey rated themselves with the highest scores, namely: 17 respondents (16.04%) rated themselves with 9 points and 15 respondents (14.15%) with 10 points. A much smaller number of survey participants rated themselves with 6 points or less: 5 respondents (4.72%) rated themselves with 6 points, 8 respondents (7.55%) with 5 points, 1 respondent (0.94%) with 2 and 4 points, and 2 respondents (1.89%) with 1 and 3 points.

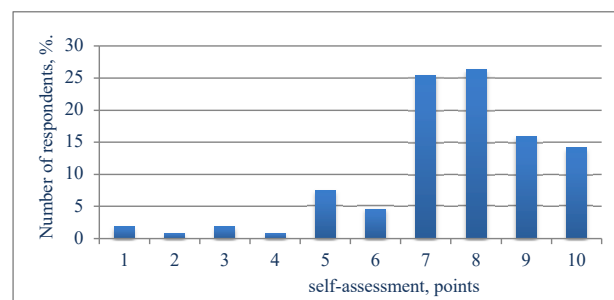


Fig. 2. Respondents' self-assessments of knowledge and skills in implementing educational activities for sustainable development

To the question “From what sources did you acquire knowledge and skills in organizing educational activities for sustainable development?”, most answers were “self-education via the Internet”, much less – “advanced training courses on education for sustainable development” (Table 3), and in the column “Other” one respondent indicated “Chandran Nair’s book “The State of Sustainable Development””, and one more respondent indicated “work experience, information from colleagues”; 6 respondents (5.66%) indicated that they did not receive such information at all.

Table 3. Results of answering the question: «From what sources did you acquire knowledge and skills in organizing educational activities for sustainable development?»

Proposed answers	Number of answers	
	Number of respondents	%
Self-education via the Internet	76	71.70
Advanced training courses on education for sustainable development	21	19.81
Other	9	8.49

Table 4. Results of answering the question: “How often do you use sustainable development knowledge in your professional activities?”

Proposed answers	Number of answers	
	Number of respondents	%
use often	41	38.68
use sometimes	57	53.77
do not use	8	7.55

To the question “How often do you use sustainable development knowledge in your professional activities?”, more than half of the participants of the online survey answered “use sometimes”, much less – a “use often”, and there were few answers “do not use” (Table 4).

Among the SDGs that physical culture and sports specialists discuss most often with students, Goals 3 and 4 (the full names of the SDGs are given in Table 1) were predictably identified by 91.51% and 76.42% of respondents, respectively (Fig. 3). A very high percentage of respondents also mentioned Goal 5 – 58.49%. About a third of the respondents say that among the Sustainable Development Goals that they discuss with their pupils and students are Goals 6, 16 and 17 – 37.74%, 34.91%, and 35.85%, respectively.

Much less specialists try to work with pupils and students on Goals 8, 10, and 11 – 27.36%, 20.75%, and 17.92%, respectively. And only 9.43 – 11.32% of specialists pay attention to such extremely important Sustainable Development Goals as 13, 14 and 15, which form the basis of sustainable development.

Results of answers to the question: “Which of Sustainable Development Goals are not related to physical culture

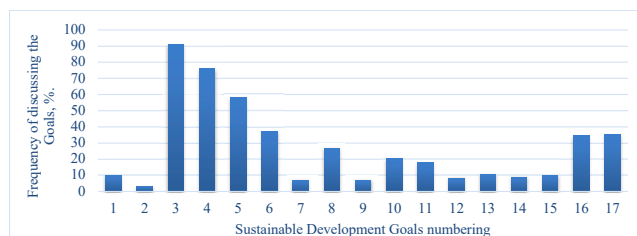


Fig. 3. Results of answers to the question: “Which of Sustainable Development Goals do you discuss most often with your students/pupils?”

and sport at all?” are shown in Fig. 4. Among the respondents, only 3.8% pointed to the correlation between all 17 Sustainable Development Goals and the field of physical culture and sport. The rest of the respondents do not see such a correlation. Almost half of the respondents indicated that, in their opinion, Goals 1, 2, and 14 are irrelevant to physical culture and sports specialists – 49.06%, 49.06% and 48.11% of respondents, respectively. A slightly less percentage of respondents showed the same attitude toward Goals 9, 13, and 15: 41.51%, 39.62%, and 41.51% of respondents, respectively. About a third of the online survey participants indicated that they did not see any common ground between physical culture and sport and Goals 7, 11 and 12, which is 33.96%, 33.02% and 36.79% of respondents, respectively. About 1/4 of the participants in the online survey did not find anything in common between physical culture and sports and Goals 6, 8, 10, 16 – 18.87%, 25.47%, 23.58% and 24.53% of respondents, respectively. About 1/10 of the respondents indicated that Goals 3, 4, and 17 are irrelevant to physical culture and sports specialists – 14.15%, 12.26%, and 11.32%, respectively. A similar view on Goal 5 indicated 5.66% of respondents.

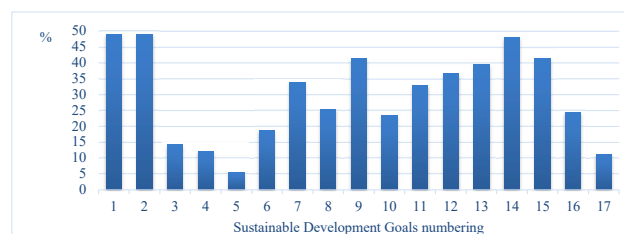


Fig. 4. Results of answers to the question: “Which of Sustainable Development Goals are not related to physical culture and sport at all?”

To the question “In what form do you conduct educational activities for sustainable development?”, half of the respondents indicated a physical culture lesson, ¼ of the participants – educational activities; very few participants noted group work involving sustainable development issues (Table 5). In the column “Other”, respondents indicated educational work for sustainable development during individual conversations and competitions or indicated that they did not conduct such work.

Table 5. Results of answering the question: “In what form do you conduct educational activities for sustainable development?”

Proposed answers	Number of answers	
	Number of respondents	%
I introduce sustainability issues during physical culture lessons/activities	54	50.94
I conduct educational activities with students on sustainable development issues	40	37.74
I conduct group work on sustainable development	5	4.72
Other	7	6.60

Table 6. Results of answering the question: “Do you think it necessary to improve your level of knowledge and skills for successful implementation of educational activities for sustainable development?”

Proposed answers	Number of answers	
	Number of respondents	%
Yes, I need to deepen my knowledge and skills on sustainable development issues	66	62.26
Yes, I need to deepen my knowledge and skills on the methods of implementing education for sustainable development	49	46.23
No, there is no need for this	1	0.94

Answering the question “Do you think it is necessary to improve your level of knowledge and skills for successful implementation of educational activities for sustainable development?”, almost 2/3 of the participants of the online survey indicated that they needed to expand their knowledge and skills on sustainable development (Table 6). Almost half of the participants indicated that they needed to deepen knowledge and skills in the methodology of implementing education for sustainable development, and only one respondent indicated that they did not have such a need.

To the question “Do you think it is necessary to introduce a separate discipline on sustainable development in the educational programs of training of physical culture and sports specialists to form relevant knowledge, skills and abilities on education for sustainable development?”, the respondents’ opinions were divided almost equally with a slight advantage in favor of the affirmative answer “Yes” (Table 7).

Table 7. Results of answering the question: “Do you think it is necessary to introduce a separate discipline on sustainable development in the educational programs for training specialists in physical culture and sports?”

Proposed answers	Number of answers	
	Number of respondents	%
Yes	56	52.83
No	50	47.17

The answers to the question “In which disciplines, in your opinion, is it possible to introduce separate modules to prepare future specialists in physical culture and sports for educational activities in the interests of sustainable development?” were interesting. In particular, the respondents mentioned the following disciplines as general training: Biology, Geography, Fundamentals of Life Safety, Valeology, Fundamentals of Health, Economics, Psychology; and professional training disciplines: Theory and Methods of Physical Culture, Theory of Sports, Physical Culture, Tourism, Organization and Management in Physical Culture, Legal Aspects of Physical Culture, General and Sports Pedagogy, Professional Skills. Some respondents pointed to the introduction of a separate course on Sustainable Development in Physical Culture and Sport.

Discussion

The study assumed that physical culture and sport specialists are not sufficiently aware of the issues of sustainable development and need to acquire appropriate competencies to perform educational activities for sustainable development. Our data complement the results of research by scientists who propose using physical culture and sports to promote the achievement of sustainable development goals. In particular, Osborne & Batista (2010) note that physical culture teachers in Brazil support education for sustainable development within their school subject and are convinced of the importance of working on issues of social equality, partnership, sanitation, waste management, and believe that the environment is a cross-cutting issue that should be addressed by all disciplines. Lynch (2016) shows the potential of physical culture and sport to contribute to Sustainable Development Goals 3, 4, and 17 through several projects. We support the arguments of Lundvall and Fröberg (2022), who believe that quality physical culture is not only about health through movement but also about providing knowledge about health and everything that affects it – society and the environment (natural and human-made). They propose to consider Goals 3, 4, 5, 10, 11, 12 in the field of physical culture. Baena-Morales et al. (2021) further expand the range of Goals that have links to physical culture (13 and 16 are added to the already mentioned Goals). And Salvo et al. (2021) point to the possibility of physical culture contributing to the achievement of fifteen Goals. We are convinced that all seventeen SDGs can be considered from the perspective of physical culture and sport, as we will argue below, but we believe that the question is no longer whether physical culture and sport can be a tool for achieving the SDGs, but how it can be realized.

According to our research, a significant number of physical culture and sports specialists (57.55% of respondents) are not sufficiently aware of the issues of sustainable development and the methodology of organizing educational activities for sustainable development within the professional activities of a physical culture and sports specialist. This can be explained by the lack of a clear state policy on these issues (Koreneva, 2018). Thus, no regulatory document or program that regulates the professional activity of a physical culture and sports specialist has tasks related to the goals of sustainable development (Analiz, 2017). Another reason for the lack of involvement of sports specialists in such activities is that most of them do not see the correlation between sports and the environment (Chernushenko, 1994). While this situation has already changed dramatically in leading European countries, in Ukraine, some physical culture and sports specialists still do not understand the essence and depth of the sustainable development goals.

According to the survey, only 3.8% of respondents pointed to the correlation between the field of physical culture and sports and 17 Sustainable Development Goals. For example, there are respondents who say that Goals 5 and 10 are not related to physical culture and sport. However, the issues of social equality and gender have been facing society for decades and are very relevant and discussed in the field of physical culture and sports (Kempe-Bergman et al., 2020; Eime et al., 2021; Nemček, 2022). Paralympic sport is also gaining ground and is a way to reduce social inequality

(Foster et al., 2019; Goh, 2020). Some respondents, who work in the education sector, noted that Goals 3, 4, and 17 do not apply to the field of physical culture and sport. It's outrageous because without partnership and cooperation, it is impossible to organize any sports or physical culture activities, and many leading scientists in the field are working on improving and maintaining health through physical culture (Kruceвич, 1999; Nosko et al., 2010; Harkusha, 2014). In addition, the terms "education", "health", and "physical culture" are logically related (Goncharova et al., 2020; Ivashchenko et al., 2021; Govindasamy et al., 2022). Some respondents also pointed out that there is no correlation between physical culture, sport and SDGs 6, 7, 8, 9; but the dependence of the health of every athlete, as well as of any person, on sanitation and water quality is undeniable (Donnelly et al., 2016; Tsyhura (Usmanova), 2018; Chamberlain et al., 2019); as well as the dependence of the sports industry on the state of the economy, energy resources and innovative technologies (Thomas & Grant 2014; Erdmann et al., 2022; Wilby et al., 2023).

Much of respondents see nothing in common between sport and SDGs 1, 2, 11, 12, 13, 14, 15 and 16. This is also surprising, as climate change is becoming an increasingly important issue for the proper organization of the Winter Olympics, with organizers increasingly reporting a lack of snow cover and high average temperatures (Wilby et al., 2023), which negatively affects both the chemical composition of the biosphere and its biodiversity in general, and the health of athletes (Çalik & Geri, 2022; Sustainability for All, 2022). Also, the sports industry uses a large amount of the planet's resources and requires appropriate infrastructure for its development. In addition, poverty and hunger are socioeconomic phenomena that professional sports are trying to combat in some countries, and poverty and persistent malnutrition are the reasons that encourage Brazilian children to practice football to get into professional sports and forget about hungry childhoods forever (Uehara et al., 2021).

The obtained results confirm that physical culture and sports specialists need advanced training in a variety of sustainable development issues to acquire the relevant competencies in order to perform quality educational activities in this area in accordance with the requirements of modern Ukrainian legislation on education.

Thus, the results obtained indicate the imperfection of the training of physical culture and sports specialists and their retraining during the advanced training courses, as they do not have enough competencies to perform educational activities for sustainable development.

Conclusions

It was found that most of the surveyed physical culture and sports specialists are not sufficiently familiar with the issues of sustainable development. 51.89 % of respondents indicate partial awareness of the concept and goals of sustainable development, 5.66 % of respondents claim that they are not familiar with such information at all.

It was found that the majority of physical culture and sports specialists who took part in the experiment did not understand the essence and depth of the Sustainable Development Goals – only 3.8% of respondents indicated the correlation between the field of physical culture and sports and

all 17 Sustainable Development Goals. The majority of respondents correlate the physical culture and sport only to the following Sustainable Development Goals as good health and well-being (Goal 3), quality education (Goal 4), and gender equality (Goal 5).

It was found that 62.26% of respondents need to enlarge their knowledge and skills on sustainable development, 46.23% of respondents want to deepen knowledge and skills in the methodology of implementing education for sustainable development, and most of the surveyed physical culture and sports specialists need advanced training to acquire the competencies necessary for the implementation of educational activities for sustainable development.

Conflict of interest

The authors have no conflicts of interest to declare.

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ОСВІТА ДЛЯ СТАЛОГО РОЗВИТКУ: РОЗУМІННЯ ФАХІВЦЯМИ ФІЗИЧНОЇ КУЛЬТУРИ І СПОРТУ

Галина Цигура^{1ABCD}, Сергій Гаркуша^{1AD}

¹Національний університет «Чернігівський колегіум» імені Т. Г. Шевченка

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 8 с., 7 табл., 4 рис., 40 джерел.

Мета: вивчити потребу фахівців фізичної культури і спорту в набутті компетентностей для організації освітньої діяльності в інтересах сталого розвитку та розуміння ними причетності галузі фізичної культури і спорту до реалізації цілей сталого розвитку.

Матеріали і методи. У дослідженні брали участь 106 фахівців фізичної культури і спорту різних регіонів України (73 особи жіночої статі та 33 особи чоловічої статі). Серед них представники закладів загальної середньої освіти (шкіл, ліцеїв, гімназій) – 70,7 % респондентів (75 осіб), представники закладів вищої освіти (університетів та академій) – 11,3 % респондентів (12 осіб), представники спортивних закладів (дитячо-юнацьких спортивних шкіл та спортивних комплексів) – 10,4 % респондентів (11 осіб), представники закладів професійної освіти (училищ, коледжів) та центрів позашкільної роботи з молоддю – 7,5 % (8 осіб). Стаж роботи респондентів у сфері фізичної культури і спорту становив від 1 до 45 років. У дослідженні використані методи анкетування, аналізу та синтезу інформації, математичної обробки інформації.

Результати. У результаті анкетування виявлено, що більша частина опитаних фахівців фізичної культури і спорту недостатньо обізнані з проблематикою сталого розвитку. 51,89 % респондентів вказують на часткову обізнаність з поняттям та цілями сталого розвитку, 5,66 % стверджують, що взагалі не знайомі з такою інформацією. Більшість фахівців фізичної культури і спорту, які взяли участь в експерименті, не розуміють сутності й глибини цілей сталого розвитку і встановлюють зв'язок фізичної культури і спорту тільки з такими Цілями сталого розвитку як міцне здоров'я (№3), якісна освіта (№4), гендерна рівність (№5).

Висновки. Виявлено, що тільки 3,8 % опитаних можуть знаходити взаємозв'язок між галуззю фізичної культури і спорту та сімнадцятьма цілями сталого розвитку. 62,26 % опитаних вказують, що потребують розширення кола знань і вмінь з питань сталого розвитку, 46,23 % опитаних хочуть поглибити знання і вміння з методики впровадження освіти для сталого розвитку. Більшість опитаних фахівців фізичної культури і спорту потребують підвищення кваліфікації з метою набуття компетентностей, необхідних для здійснення освітньої діяльності для сталого розвитку.

Ключові слова: сталий розвиток, освіта, фізична культура, спорт, учитель фізичної культури, тренер.

Information about the authors:

Tsyhura, Halyna: zygura.g@ukr.net; <https://orcid.org/0000-0002-2998-7537>; Department of Biological Foundations of Physical Education, Health and Sports, T. H. Shevchenko National University "Chernihiv Colehium", Hetman Polubotka St, 53, Chernihiv, 14013, Ukraine.

Harkusha, Serhii: biomex@ukr.net; <https://orcid.org/0000-0002-7120-1446>; Department of Pedagogy, Psychology and Methodology of Physical Education, T. H. Shevchenko National University "Chernihiv Colehium", Hetman Polubotka St, 53, Chernihiv, 14013, Ukraine.

Cite this article as: Tsyhura, H., & Harkusha, S. (2023). Education for Sustainable Development: Understanding by Physical Education and Sports Specialists. *Physical Education Theory and Methodology*, 23(4), 614-621. <https://doi.org/10.17309/tmf.2023.4.17>

Received: 03.07.2023. Accepted: 14.08.2023. Published: 30.08.2023

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ORIGINAL SCIENTIFIC ARTICLE

COMPARISON OF BODY COMPOSITION CHANGES AND NON-CONTACT MUSCULOSKELETAL INJURIES AMONG PROFESSIONAL FIRST-CLASS CRICKET PACE BOWLERS

Manish Shukla^{1ABCD} and Vivek Pandey^{2ACD}

¹Agra College

²Lakshmibai National Institute of Physical Education

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Manish Shukla, E-mail: manish.shukla1992@gmail.com

Accepted for Publication: August 18, 2023

Published: August 30, 2023

DOI: 10.17309/tmfv.2023.4.18

Abstract

Background. Pace bowling is the most injury susceptible position in cricket due to repeated high intensity maneuvers. Previous studies on pace bowlers have considered anthropometric, biomechanical, and kinesiological factors for deciphering the injury etiology.

Study purpose. The purpose of this study was to prospectively investigate the association of body composition parameters with the incidence of musculoskeletal injuries among pace bowlers in cricket.

Materials and methods. A total of 44 healthy professional male pace bowlers (N=44; Age: 22.89±4.5 years; Height: 176±9 cm; Body weight: 76.34±8.09 kg; BMI: 21.4±3.1) were recruited from various cricket academies. They were assessed on anthropometrics, body composition, and aerobic fitness before the start of Indian cricket season (typically mid-September). Any non-contact sports injury accounting for significant time loss during the season was recorded followed by assessment of change in body composition status among injured and non-injured pace bowlers.

Results. We found hamstring injury as the most prevalent injury (05/12). Lower back injury accounted for highest severity with time loss of 48 matches. Injured pace bowlers underwent higher training volume (hours/day; p=.009) prior to injury incidence, were significantly heavier, and had greater volume of total body water. All the pace bowlers gained significant amount of fat-free mass (FFM) from pre- to post-season.

Conclusions. Higher training workload and higher body weight were associated with more injury risk among pace bowlers. Further research accommodating other predictive factors of body composition and psychomotor learning must be carried out to precisely predict injury risk among pace bowlers in cricket.

Keywords: pace bowling, musculoskeletal injury, body composition, fat-free mass (FFM), training load.

Introduction

Multi-format cricket (Test cricket, One-day, and T20) has placed greater physiological and psychological demands on the players to fulfil national and franchise-level commitments. Since pace bowling requires high number of explosive sprints, jumps, twist and throws, it is considered as the most injury-susceptible department in cricket (Olivier et al., 2015). With the increment in number of fixtures, they have limited time for recovery and hence, are at greater risk of sustaining acute and/or overuse injuries (Dennis et al., 2004; Dennis et al., 2005; Dovbysh et al., 2021; Orchard et al., 2015). Common injuries related to pace bowling are

lumbar spine pathologies (particularly stress fractures), muscle strains, acute and chronic knee, ankle, hip and shoulder sprains (Constable et al., 2021; Pardiwala et al., 2018; Stronach et al., 2014). A high bowling workload along with other intrinsic and extrinsic factors contributes to a higher risk of injury among pace bowlers (Olivier et al., 2016). Body weight and body composition have turned out to be potentially modifiable intrinsic risk factor for sport injury risk (Caine et al., 2008; Emery, 2003).

Most researches have focused only on epidemiology, anthropometric measurements, and biomechanical analysis for deciphering the injury etiology in cricket pace bowlers (Johnstone et al., 2014; Pyne et al., 2006; Stuelcken et al., 2007) and there has been limited amount of research on the association of body composition to musculoskeletal injuries among pace bowlers in cricket. Since, BMI has

been an inconsistent indicator of body composition in sports (Lambert et al., 2012; Ode et al., 2007; Torstveit & Sundgot-Borgen, 2012); we aimed to analyze the association of different body composition parameters with the incidence of musculoskeletal injuries among pace bowlers in cricket.

Materials and Methods

Participants of the study

A total of 44 previously healthy professional male pace bowlers (N=44; Age: 22.89±4.5 year; Height: 176±9 cm; Body weight: 76.34±8.09 kg; BMI: 21.4±3.1) with a minimum of inter-state level cricket participation were recruited at the start of the cricket season. This prospective study expanded over one year comprising one cricket season and one off-season (typically mid-September to mid-June). Dhillion et al. (2012) defined cricket season as “the time period when players play competitive matches whereas off season is defined as the one when players keep on practicing daily and often play local matches on weekends” (Dhillion et al., 2012). The purpose of research was explained to them and they provided their written informed-consent. All the players completed a questionnaire on general details, details about sports training, and history of any injury at the time of data collection. The study involved data collection in non-invasive manner and conducted in accordance with the guidelines of the Declaration of Helsinki.

Design of the study

The anthropometric, aerobic fitness, and body composition were evaluated at the start of the season. Height was measured using stadiometer (AVI Healthcare Stadiometer, India). Body weight was measured to the nearest 0.1 kg on an electronic scale (Tanita BWB-800S, Tanita Corporation, Tokyo, Japan). BMI was calculated using the formula: Weight (kg)/Height (m)². Body composition parameters were measured using Bio-Electrical Impedance (BIA) (BioScan 916, Maltron International Ltd, Rayleigh, Essex, UK) according to the standard protocol (Walter-Kroker et al., 2011). Aerobic fitness was assessed using the Yo-Yo Intermittent Recovery Test Level 1 (YYIRT1) at the start of the season. The details about testing protocol and scientific authenticity of this field-based test can be found elsewhere (Bangsbo et al., 2008; Deprez et al., 2014).

To record their injury status, we encouraged the pace bowlers to immediately report any playing-related injury

or discomfort to us telephonically. Thereafter we met them in-person and assessed their injury severity as described (Orchard et al., 2016). Severity was determined based on the numbers of matches missed until the player returned to play (Blanch et al., 2015). Any acute or chronic injury during competition/training accounting for significant loss of playing time fell into the category of sports injury, as described previously (Orchard et al., 2016). We took their body composition assessment within a day of injury incidence at their places. We recorded only non-contact injuries during pace bowling and those occurring during batting and fielding were not considered.

Statistical analysis

The statistical analysis of the collected data was performed using IBM SPSS 22 (IBM Corp. USA). The mean and standard deviation were calculated for the continuous variables. Groupwise comparisons were made using independent sample t-test between healthy and injured pace bowlers' groups. Also, pairwise comparisons were made between pre- and post-season body composition parameters among healthy and injured pace bowlers. P-value <0.05 was considered statistically significant.

Results

The descriptive characteristics of the pace bowlers included in the present study are presented in Table 1. Shapiro-Wilk test for normality showed insignificance for all the descriptive variables except for Yo-Yo test (p=0.03) among healthy pace bowlers because the participants were physically active and participated in training and match-play uniformly. Levene's test for equality of variances showed insignificance for all the variables except training hours (hours/day; p=0.023), so we performed independent sample t-test with unequal variances.

The injured pace bowlers had undergone significantly greater amount of training volume (training hours (hours/day)) than healthy pace bowlers (p=0.009; table 1). The incidence of hamstring injury was the most among 05 pace bowlers with mean severity (no. of matches missed due to injury) of 13.2 matches (figure 1).

Among injured pace bowlers, the one with lower back injury suffered the highest time loss of 48 matches, followed by one with knee injury (21 matches' loss due to injury) (table 2).

Injured pace bowlers also had greater amount of total body water as compared to healthy pace bowlers (table 3).

Table 1. Descriptive statistics of the pace bowlers included in the present study

Parameter	Healthy Pace Bowlers (n=32)			Injured Pace Bowlers (n=12)			Levene's test ^a	p-value ^b
	Mean±SD	95% CI	Shapiro-Wilk	Mean±SD	95% CI	Shapiro-Wilk		
Age (yrs)	22.2±2.2	21.4-23.03	0.26	22.5±2.5	20.9-24.1	0.63	0.704	0.743
Height (cm)	171.9±5.4	169.9-173.8	0.52	170.9±5.4	167.5-174.4	0.55	0.888	0.606
TrainingHour (hour/day)	5.7±1.2	5.2-6.1	0.13	6.4±0.7	6.0-6.9	0.25	0.023 ^c	0.009 ^c
Yo-Yo Test (m)	1584.4±191.7	1515.2-1653.5	0.03 ^c	1590.8±164.7	1486.2-1695.5	0.05	0.414	0.918

a. Levene's test for equality of variance among groups.

b. P-value for independent sample Student's t-test statistics.

c. P-value significant at 0.05.

Table 2. Descriptive details of the pace bowlers with injury-wise stratification of data

Parameter	Healthy PB (n=32) Mean±SD	Injured PB (n=12) Mean±SD					
		GI (n=01)	LBI (n=01)	CI (n=02)	HI (n=05)	KI (n=01)	AI (n=02)
Age (years)	22.2±2.2	20	24	21.5±0.77	21.92±3.08	26	23.65±2.19
Height (cm)	171.9±5.4	172	177	173.5±2.12	169.6±6.98	172	167.5±6.36
TrainingHour (hour/day)	5.7±1.2	6.5	6	6.5±0.70	6.8±0.57	6	6±1.41
Yo-Yo Test (m)	1584.4±191.7	1690	1180	1680±28.3	1592±151.39	1580	1660±42.43
Severity (match loss)		08	48	11±1.41	13.2±2.95	21	12.5±0.71
Pre Body weight	68.09±4.33	77.0	78.1	73.95±2.75	68.36±4.05	68.4	71.5±3.53
Post Body weight	68.58±4.02	76.4	76.9	73.6±1.55	69.04±5.20	68.3	71.45±1.91
Pre BMI	23.05±1.13	26.02	24.93	24.58±1.52	23.78±1.14	23.12	25.49±0.68
Post BMI	23.23±1.28	25.82	24.54	24.46±1.11	23.99±0.91	23.08	25.49±1.25
Pre FFM	83.58±2.36	81.4	78.9	81.8±0.28	83.6±1.83	82.6	82.3±3.25
Post FFM	84.47±2.43	81.9	80.9	82.65±0.07	84±2.18	83.2	82.5±3.25
Pre FM	16.41±2.36	18.6	21.1	18.2±0.28	16.4±1.83	17.4	17.7±3.25
Post FM	15.53±2.43	18.1	19.1	17.35±0.07	16±2.18	16.8	17.5±3.25
Pre TBW	40.18±2.55	45.43	46.08	43.63±1.63	40.33±2.39	40.35	42.18±2.08
Post TBW	40.46±2.37	45.07	45.37	43.42±0.92	40.73±3.07	40.3	42.15±1.12

PB: Pace bowlers; GI: Groin injury; LBI: Lower back injury; CI: Calf injury; HI: Hamstring injury; KI: Knee injury;
AI: Ankle injury; Pre: Pre-season; Post: Post-season

Table 3. Comparative analysis for Body Composition parameters among cricket pace bowlers

Parameter	Pace Bowlers	Pre-season (Mean±SD)	Post-season (Mean±SD)	Mean Diff.	t-statistics (p-value)
Body Weight (kg)	Healthy	68.1±4.3	68.6±4.0	0.48	-1.8 (0.087)
	Injured	71.4±4.6	71.4±4.4	0.05	-0.13 (0.899)
	Mean Diff.	3.3	2.8		
	t-statistics (p-value)	2.2 (0.034*)	2.0 (0.049*)		
BMI	Healthy	23.1±1.1	23.2±1.3	0.18	-1.9 (0.065)
	Injured	24.4±1.2	24.4±1.1	0.01	-0.09 (0.923)
	Mean Diff.	1.4	1.2		
	t-statistics (p-value)	3.5 (0.001*)	2.9 (0.006*)		
FFM (kg)	Healthy	83.6±2.4	84.5±2.4	0.89	-6.5 (0.000*)
	Injured	82.4±2.0	83.0±1.9	0.60	-3.8 (0.003*)
	Mean Diff.	1.2	1.5		
	t-statistics (p-value)	-1.5 (0.140)	-1.9 (0.071)		
FM (kg)	Healthy	16.4±2.4	15.5±2.4	0.89	6.5 (0.000*)
	Injured	17.6±2.0	17.0±1.9	0.60	3.8 (0.003*)
	Mean Diff.	1.2	1.5		
	t-statistics (p-value)	1.5 (0.140)	1.9 (0.071)		
TBW (liter)	Healthy	40.2±2.6	40.5±2.4	0.28	-1.8 (0.087)
	Injured	42.1±2.7	42.1±2.6	0.03	-0.13 (0.899)
	Mean Diff.	1.9	1.7		
	t-statistics (p-value)	2.2 (0.034*)	2.0 (0.049*)		

*P-value significant at 0.05.

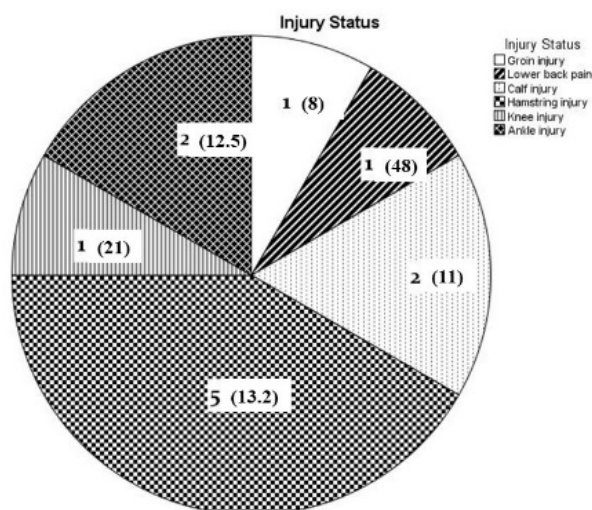


Fig. 1. Frequency of Injuries among professional first-class cricket pace bowlers with severity (no. of matches missed due to injury) shown in parentheses

Discussion

Pace bowling is the most injury susceptible playing position in cricket due to performing high intensity movements repeatedly (Dovbysh et al., 2021). This season-long study investigated the association of different body composition parameters with musculoskeletal injury risks among pace bowlers in cricket. Twelve pace bowlers (12/44; 27.3%) sustained acute/chronic musculoskeletal injuries during the course of this study with hamstring injury being the most prevalent (41.7%; 05 out of 12; figure 1), in line with the previously published literature (Dovbysh et al., 2021). The pace bowlers included in our study were relatively younger with mean age of injured and healthy pace bowlers being 22.5 ± 2.5 years and 22.2 ± 2.2 years respectively (table 1). Younger age is associated with an increased injury risk among pace bowlers probably due to skeletal immaturity, disproportionate bowling workload, and nutritional limitations (Blanch et al., 2015).

Our results showed that the injured pace bowlers had undergone greater training volume or workload (hours/day) as compared to healthy pace bowlers before the onset of injury (6.4 ± 0.7 vs. 5.7 ± 1.2 hours/day; $P=.009$; table 1). Amount of bowling workload (the number of overs bowled) has been directly related to the risk of lower back and other musculoskeletal injuries among pace bowlers (Constable et al., 2021; Dennis et al., 2003). The pace bowlers who sustained injury during the season were significantly heavier than healthy pace bowlers at pre- (71.4 ± 4.6 kg vs. 68.1 ± 4.3 kg; $P=.034$) and post-season (71.4 ± 4.4 kg vs. 68.6 ± 4.0 kg; $P=.049$). We also investigated the training-associated changes in body composition parameters among pace bowlers from pre- to post-season and found that FFM increased significantly from pre-season to post-season among healthy (83.6 ± 2.4 vs. 84.5 ± 2.4 ; $P=.000$) as well as among injured fast bowlers before injury onset (82.4 ± 2.0 vs. 83.0 ± 1.9 ; $P=.003$) (table 3). Similar trend was observed among injured and healthy pace bowlers in TBW composition (table 3).

Conclusions

These results indicate positive changes towards a loss in FM as a result of training. We did not find any meaningful differences between injured and healthy pace bowlers in other body composition parameters at pre- and post-season (table 2 & 3). The findings of present study must be interpreted cautiously keeping certain limitations in mind. The participants in our study were male only and since, gender has a proven impact on anatomical, anthropometric, and physiological aspects of sports performance, similar studies must be carried out on female participants. Since most of the assessment was field-based, the effect of temperature, climate, and sun could have an impact over the outcomes of our study. Nutritional and dietary information of participants was self-reported and the type and amount of nutritional supplementation might affect the body composition of the participants.

Recommendations

Pace bowlers in cricket should be strictly screened for body composition before, during and after the competitive seasons to maximize injury prevention. With BMI unable to predict sports injury accurately, other techniques of body composition assessment should be extensively utilized. Further research should be carried out to accommodate more predictive factors needed to accurately predict injury risk among pace bowlers in cricket. Variables related to psychomotor learning should be included in future studies.

Acknowledgements

A word of gratitude is expressed to Mr. Arun Singh (Cricket coach, Sports Authority of India) for his support during the injury screening of participants and providing valuable insights into the topic. All the participants of this study and laboratory staff at LNIPE Gwalior is appreciated for their support.

Conflict of Interests

The authors report there are no competing interests to declare.

Funding Info

No funding to report for this article.

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ПОРІВНЯННЯ ЗМІН СКЛАДУ ТІЛА ТА БЕЗКОНТАКТНИХ ТРАВМ ОПОРНО-РУХОВОГО АПАРАТУ СЕРЕД ПРОФЕСІЙНИХ ШВИДКИХ БОУЛЕРІВ У КРИКЕТІ ПЕРШОГО РІВНЯ

Маніях Шукла^{1ABCD}, Вівек Пандей^{2ACD}

¹Агрський коледж

²Національний інститут фізичного виховання імені Лакшмі Бай

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 6 с., 3 табл., 1 рис., 24 джерела.

Історія питання. Швидкий боулінг є найуразливішою до травм позицією в крикеті через багаторазові високоінтенсивні маневри. У попередніх дослідженнях швидких боулерів для визначення етіології травм брали до уваги антропометричні, біомеханічні та кінезіологічні фактори.

Мета дослідження. Метою цього дослідження було перспективне вивчення зв'язку параметрів складу тіла із частотою травм опорно-рухового апарату серед швидких боулерів у крикеті.

Матеріали та методи. Загалом у дослідженні взяли участь 44 здорові професійні швидкі боулери чоловічої статі (N=44; вік: 22,89±4,5 року; зріст: 176±9 см; маса тіла: 76,34±8,09 кг; ІМТ: 21,4±3,1) з різних академій крикету. Перед початком сезону крикету в Індії (зазвичай у середині вересня) їх оцінювали за антропометричними характеристиками, складом тіла та рівнем аеробної підготовленості. Реєстрували будь-яку безконтактну спортивну травму, яка зумовлює значні втрати часу протягом сезону, з подальшою оцінкою зміни стану складу тіла серед травмованих і нетравмованих швидких боулерів.

Результати. За результатами дослідження було встановлено, що найпоширенішою травмою (05/12) є травма підколінного сухожилля. Травма нижнього (поперекового) відділу спини відповідала найвищому ступеню тяжкості із втратою часу 48 матчів. Травмовані швидкі боулери проходили більший обсяг тренувань (годин/день; $p=0,009$) до випадків травмування, були значно важчими та мали більший об'єм загального вмісту води в організмі. За час від передсезонного до післясезонного періоду всі швидкі боулери набрали значний обсяг маси тіла без жиру (FFM).

Висновки. Більше тренувальне навантаження та більша вага тіла були пов'язані з більшим ризиком травмування серед швидких боулерів. Для точного прогнозування ризику травмування серед швидких боулерів у крикеті необхідно проводити подальші дослідження з урахуванням інших прогностичних факторів складу тіла та психомоторного навчання.

Ключові слова: швидкий боулінг, травма опорно-рухового апарату, склад тіла, маса тіла без жиру (FFM), тренувальне навантаження.

Information about the authors:

Shukla, Maniah: manish.shukla1992@gmail.com; <https://orcid.org/0000-0002-3568-8496>; Department of Physical Education and Sports, Agra College, Mahatma Gandhi Rd, Mantola, Agra, Uttar Pradesh 282002, India.

Pandey, Vivek: pandey_vivek61@yahoo.com; <https://orcid.org/0000-0003-2247-0671>; Department of Exercise Physiology, Lakshmibai National Institute of Physical Education, Shakti Nagar, Mela Road, Gwalior, 474002, India.

Cite this article as: Shukla, M., & Pandey, V. (2023). Comparison of Body Composition Changes and Non-Contact Musculoskeletal Injuries Among Professional First-Class Cricket Pace Bowlers. *Physical Education Theory and Methodology*, 23(4), 622-627. <https://doi.org/10.17309/tmf.2023.4.18>

Received: 25.07.2023. Accepted: 18.08.2023. Published: 30.08.2023

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ORIGINAL SCIENTIFIC ARTICLE

A STUDY OF MOTOR FUNCTIONAL ASYMMETRY INDICATORS IN DIFFERENT SPORTSMANSHIP LEVEL ESPORTS ATHLETES

Svitlana Piatysotska^{1ABCDE}, Leonid Podrigalo^{1ABCDE}, Vyacheslav Romanenko^{1ABCDE},
Andrii Yefremenko^{1BCDE}, Yuliia Petrenko^{1BDE} and Hanna Poltoratska^{1BCE}

¹Kharkiv State Academy of Physical Culture

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Svitlana Piatysotska, E-mail: piatsvit25@gmail.com

Accepted for Publication: August 18, 2023

Published: August 30, 2023

DOI: 10.17309/tmfv.2023.4.19

Abstract

Study purpose. The study purpose was to investigate and analyze the indicators of functional asymmetry in different sportsmanship level esports athletes.

Materials and methods. The study involved 20 middle-aged athletes (18 ± 1.53 years old) divided into two groups according to their sportsmanship level. Group 1: elite players of semi-professional teams in CS:GO and DOTA 2 disciplines, $n=10$, aged 19.2 ± 0.50 years. Group 2: amateur CS:GO and DOTA 2 players, $n=10$, aged 18.2 ± 1.04 years. The functional asymmetry of the movements of the upper limbs was determined using a special program for tablet computers running iOS developed at the departments of martial arts, computer science and biomechanics of KhSAPC.

Results. It was established that, in terms of the number of clicks per unit of time, elite esports athletes are outperformed by amateurs by 5.54% on the left hand and by 5.14% on the right hand; in terms of visual motor reaction time, elite esports athletes prevail by 5.54% on the left hand and by 5.07% on the right hand; elite esports athletes showed a 13.3% shorter left-hand click duration, but amateurs showed a 6.83% shorter right-hand click duration.

Conclusions. Players with a higher level of preparedness tend to have less asymmetrical movements. In the proposed test, elite athletes demonstrate a greater number of movements per unit of time; at the 2nd stage of testing, the differences are significant ($p < 0.05$). At the same time, the reaction time of more skilled players is less than that of amateurs; at the 2nd and 4th stages of the test, the differences are significant ($p < 0.05$). Indicators of functional asymmetry of movements of the upper limbs informatively characterize the level of preparedness of esports athletes and can be included in the program for monitoring the physical condition of players in esports.

Keywords: esports, psychophysiological research, functional asymmetry, reaction time, elite esports athletes, amateur esports athletes.

Introduction

The popularity of esports as a competitive activity is growing every year due to the increase in the number of viewers, revenues, competitions and elite players (Hilvoorde, 2022). The difference between professional, semi-professional athletes, amateur esports athletes and ordinary gamers is becoming more and more noticeable (Hedlund, 2021).

Professional esports athletes are defined as players who are full-time esports players in the major league(s) of their game and are part of professional teams. Semi-

professional athletes participate in esports part-time at a lower level/league than professional players and other forms of paid work. Amateurs are defined as part-time esports players at a lower level/league than semi-professional athletes (Hong & Connelly, 2022). Their experience of participating in tournaments of various levels, in particular international ones, distinguishes them from casual players. These categories of players are also united by a relatively narrow gaming specialization – focusing on one esports discipline, and professional and semi-professional players even have a corresponding gaming role (role) in the team, which also deepens the specificity of their activities (Bihari & Pattanaik, 2023). Gamers who usually practice various gaming disciplines do not necessarily have esports status. They experiment a lot with different genres and directions,

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the main motives of their gaming activities are pleasure, establishing social contacts, etc.

To become a professional athlete in the esports industry, 15 to 17 year old players train hard to acquire exceptional skills and qualities. The fight for a spot in a highly competitive industry is tough, with only a few thousand players reaching the status of a professional competitor out of an estimated 1.5 billion gamers (Toth et al., 2021). Esports athletes perform over 400 fine motor movements per minute, and professional and elite players report training and playing over 10 hours a day, which can lead to overuse, especially of the upper limbs. Carpal tunnel syndrome, lateral epicondylitis, and tendinopathies are reported to be the most common upper limb musculoskeletal disorders in esports athletes that can lead to career termination (McGee, & Ho, 2021). The health risks for players are also related to the duration of the gameplay. A study by Podrigalo L. et al. showed a significant difference in the biochemical status of video game players depending on the duration of the sessions. We observed an increase in the concentration of adrenaline in saliva, a significant decrease in the concentration of catalase, the level of SH-groups and reduced glutathione, that is, the depletion of the protective antioxidant system (Podrigalo et al., 2020). Such conditions of competitive activity require well-planned, thorough preparation of athletes for competitions, organization of the training process in compliance with the requirements of the modern system of sports training.

While the training of athletes in professional sports is based on many years of theoretical and practical scientific research, the training of esports athletes does not yet have permanent traditions and systems and is not covered by sports science. With a few exceptions, there is little research on esports training specifically. They concern, first of all, the search for effective ways to increase the efficiency of players and the definition of professional properties that ensure this efficiency (Mateo-Orcajada et al., 2023). Separate works concern the definition of the peculiarities of training athletes in various esports disciplines (Nagorsky & Wiemeyer, 2020). Particular attention deserves the construction of a long-term training system in esports, taking into account the age characteristics of players and the requirements of esports discipline. To implement this task, it is necessary to determine the most significant abilities and properties of esports athletes, allowing them to achieve maximum results in individual or team competition (Bubna et al., 2023).

Because esports games are controlled by HMI electronic systems such as keyboards and mice (Toth et al., 2021; Pluss et al., 2019), players must anticipate and respond to an opponent's stimulus as quickly and accurately as possible. Developed perceptual-motor abilities are necessary for success in e-sports, since deft control of the keyboard and mouse is the key to the effective execution of techniques (Pluss et al., 2020). At the same time, in many esports disciplines, the player must simultaneously perform different movements with the right and left hand to control the character and perform tactical tasks. Thus, high demands are placed on the speed and coordination of movements of professional players, in particular fine motor skills of the hands. This fact determines the importance of controlling the functional asymmetry of the movements of the upper limbs of athletes as a factor of professional suitability and selection parameters (Podrigalo O. et al., 2020).

In sports science, considerable attention is paid to the study of various parameters of the body asymmetry of athletes in terms of improving the quality of performing technical actions (Krstulović et al., 2017; Warmenhoven et al., 2018; Chapelle et al., 2022), as well as from the side of possible injuries when significant indicators of asymmetry are detected (Keith et al. 2014; Read et al., 2018). The asymmetry of motor actions may be due to natural differences in the anatomical structure of the body, as well as the consequence of past diseases or injuries. Scientists note that a higher level of symmetry of movements indicates better sports preparedness and the level of physical development of athletes in various sports (Svetlana et al., 2018; Hernandez-Garcia et al., 2020; Romanenko et al., 2020).

In a study by Pluss et al. (2020) determined the perceptual-motor abilities of esports athletes according to the level of experience separately for the dominant and non-dominant hand. They found that professional players have faster two-choice response times and better accuracy, and are less responsive to distracting stimuli.

Among a significant number of publications on the psychophysiological characteristics of esports athletes, insufficient attention is paid to the study of functional asymmetry of movements and features of sensorimotor reactions of the right and left hands.

Purpose of the research: to research and analyze of the indicators of functional asymmetry in esports athletes of different levels of sportsmanship.

Materials and methods

This study was approved by the Bioethics Committee for Clinical Research and conducted according to the Declaration of Helsinki (protocol of the Commission on Bioethics of the Kharkiv State Academy of Physical Culture No. 38).

Participants

The study involved 20 athletes with an average age of (18 ± 1.53) years, divided into groups according to their skill level. Group 1: elite players of semi-professional teams in the disciplines of Counter-Strike: Global Offensive (CS:GO) and DOTA 2, $n=10$, age (19.2 ± 0.50) years. Group 2: amateur players with CS:GO and DOTA 2, $n=10$, age (18.2 ± 1.04) years.

Procedure

With the help of the Reaction SM Dual computer program, the level and features of the manifestation of motor functional asymmetry in esports athletes of different skill levels were determined. This program was developed at the departments of martial arts, computer science and biomechanics of KhSAPC for tablet computers running iOS. For testing, a test model was chosen from six stages, the duration of which was 20 s, the total test execution time was 120 s. The task of this model (model 5) during 6 stages provides for the sequential execution of actions with the hand, both hands under the influence of knocking signals and without them.

After the end of the test, the program provides the following indicators (for the left and right hands separately):

the number of clicks at each stage of the test (n); total number of clicks (n); visual-motor reaction time at each stage of the test (ms); touch duration when pressed at each stage of the test (ms); the average value of the duration of the touch when clicking on the test (ms); minimum and maximum values of visual-motor reaction for the test (ms); reaction time variation coefficient for the entire test (%); the duration of the touch when pressed at each stage of the test (ms); the average value of the duration of the touch when clicking on the test (ms); differences between hands in the speed of visual-motor reaction (ms); differences between the hands in the number of clicks (n).

Statistical analysis

Statistical processing of the results of the study was carried out using the Statistica 13 program, the following methods were used: descriptive statistics, checking the compliance of the distribution of the sample population with the normal law according to the Shapiro-Wilk criterion, testing statistical hypotheses using the Student's criterion.

Results

It was found that according to the Shapiro-Wilk criterion, the distribution in both groups corresponds to the normal one at the level of $\alpha=0.05$. For testing, a test model was chosen from six stages, the duration of which was 20 s, the total test execution time was 120 s. The task of this model during 6 stages provides for the sequential performance of actions with one hand, with both, under the influence of knocking signals and without them (Table 1).

Comparison of the test results of esports athletes of different levels of sportsmanship made it possible to establish the magnitude of the differences between the main test indicators. It was found that in terms of the number of clicks, elite esports athletes prevail by 5.54% on the left and 5.14% on the right hand; in terms of visual motor reaction

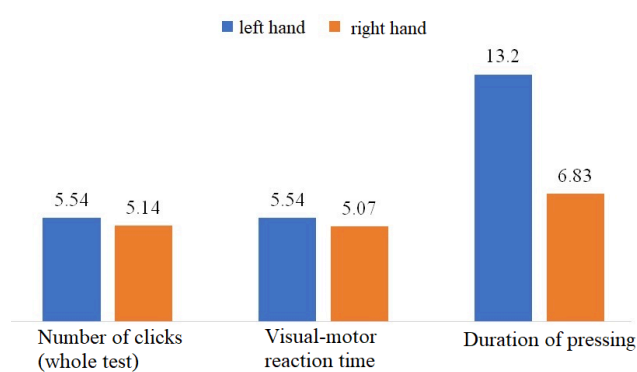


Fig. 1. Differences between the indicators of esports athletes of different levels of sportsmanship (%)

time, elite cyber-athletes prevail by 5.54% on the left hand and 5.07% on the right hand; elite esports athletes showed a 13.3% shorter duration of pressing on the left hand, however, amateurs showed a 6.83% shorter duration of pressing on the right hand (Figure 1).

Amateur esports athletes showed a tendency to a greater asymmetry of movements with their right and left hands compared to elite athletes (Figure 2). Thus, the difference between the number of clicks with the right and left hand at different stages of the test for elite athletes is in the range from 0 to 0.14 clicks, and for amateurs – from 0 to 0.44 clicks. In both groups, more pressings were performed with the right hand. In elite athletes, three of the six stages show no difference between the number of movements of the right and left arms; amateurs have a zero difference only in 2 of the 6 stages.

The difference between the duration of pressing the right and left hand at different stages of the test for elite esports athletes is in the range from 0.29 to 3.13 ms, and for amateurs – from 6.76 to 13.14 ms (Figure 3). Elite athletes had a shorter duration of left hand pressing at all stages except the sixth. In the group of amateurs, the shorter duration of pressing was on the right hand at all stages of the

Table 1. Test results of motor functional asymmetry in esports athletes of different levels of sportsmanship (n=20)

Indicator	Hand	Elite esports athletes, n=10	Amateur esports athletes, n=10	t
		$\bar{x} \pm m$		
Number of clicks (whole test)	Left	225.86±5.30	214.00±5.11	1.61
	Right	226.29±5.34	215.22±4.98	1.51
Visual-motor reaction time (ms)	Left	53.39±1.21	56.34±1.31	1.66
	Right	53.30±1.22	56.00±1.24	1.55
Time variation coefficient (%)	Left	14.23±1.25	18.22±0.96	2.53*
	Right	13.81±1.31	17.22±0.86	2.18*
Min. response value (ms)	Left	37.81±2.64	38.52±2.90	0.18
	Right	38.89±1.36	41.57±1.27	1.44
Max. response value (ms)	Left	97.49±5.35	116.54±2.24	2.32*
	Right	93.46±5.64	115.70±7.18	2.44*
Duration of pressing (ms)	Left	56.69±4.04	64.17±2.96	1.49
	Right	58.49±2.49	54.74±2.98	0.96

Note: * significance of differences $p<0.05$

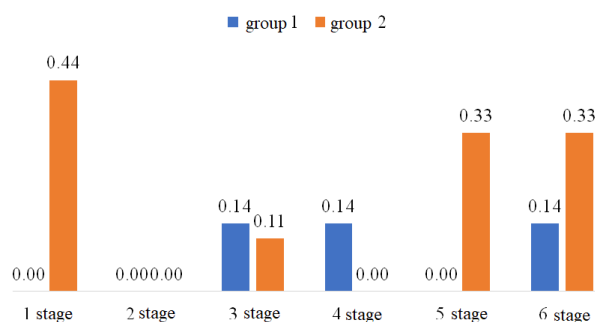


Fig. 2. The difference between the number of clicks with the right and left hand at different stages of the test among esports athletes of different levels of sportsmanship

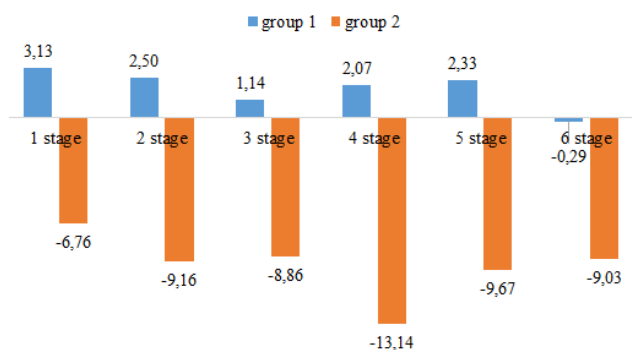


Fig. 3. Difference between the duration of pressing the right and left hand at different stages of the test in esports athletes of different levels of sportsmanship

test. At the same time, there is no difference in reaction time at all stages of the test in both groups.

Comparison of the test results of esports athletes of different skill levels made it possible to establish the magnitude of the differences between the number of clicks at different stages of the test. It has been established that elite cyber-athletes outperform amateurs in terms of results at all stages of the test. So, at the 1st stage of the test, elite cyber-athletes prevail by 1.54% on the left and 0.46% on the right hand; on the 2nd – by 9.24% on the left and right hand (differences are significant, $p < 0.05$); on the 3rd – by 4.51% on the left and 4.58% on the right hand; on the 4th – by 7.07% on the left and 7.51% on the right hand; on the 5th – by 5.57% on the left and 4.65% on the right hand; on the 6th – by 6.63% on the left and 5.98% on the right hand (Figure 4).

Analyzing the reaction time at different stages of the test, it was found that elite esports athletes have a shorter reaction time compared to amateurs at all stages of the test. So, at the 1st stage of the test, elite cyber-athletes prevail by 2.94% on the left and 2.26% on the right hand; on the 2nd – by 9.28% on the left and 9.52% on the right hand (differences are significant, $p < 0.05$); on the 3rd – by 4.11% on the left and 4.70% on the right hand; on the 4th – by 8.10% on the left and 7.64% on the right hand (differences are significant, $p < 0.05$); on the 5th – by 4.20% on the left and 4.44% on the right hand; on the 6th – by 6.27% on the left and 5.10% on the right hand (Figure 5).

As a result of comparing the duration of pressing at different stages of the test, it was found that elite esports athletes have a shorter duration on the left hand compared to amateurs at all stages of the test; on the right hand, amateurs

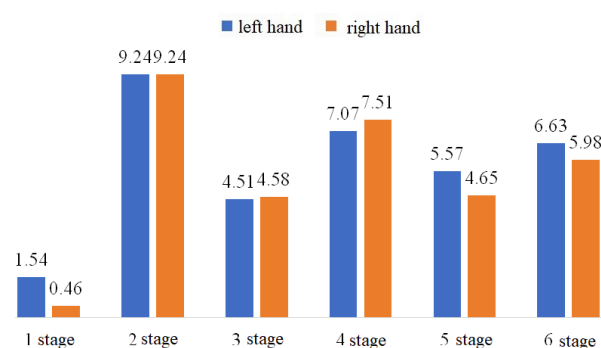


Fig. 4. Differences between the number of clicks at the stages of the test among esports athletes of different levels of sportsmanship (%)

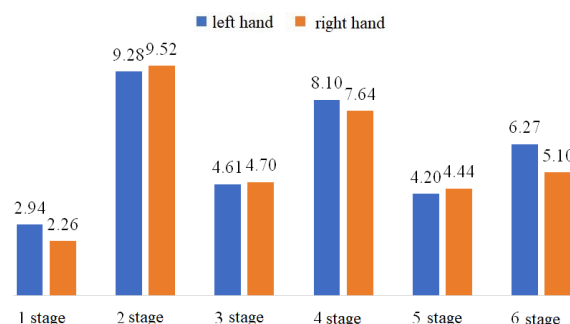


Fig. 5. Differences between the reaction time at the stages of the test for esports athletes of different levels of sportsmanship (%)

showed a shorter duration of pressing at all stages of the test. Thus, at the 1st stage of the test, elite esports athletes showed a shorter duration of pressing by 5.38% on the left hand; on the 2nd – by 11.93%; on the 3rd – by 14.14%; on the 4th – by 18.05%; on the 5th – by 15.81%; on the 6th – by 14.81%. Amateur esports athletes at the 1st stage of the test showed a shorter duration of pressing by 11.77% on the right hand; on the 2nd – by 9.30%; on the 3rd – by 2.88%; on the 4th – by 9.94%; on the 5th – by 5.90%; on the 6th – by 1.37% (Figure 6).

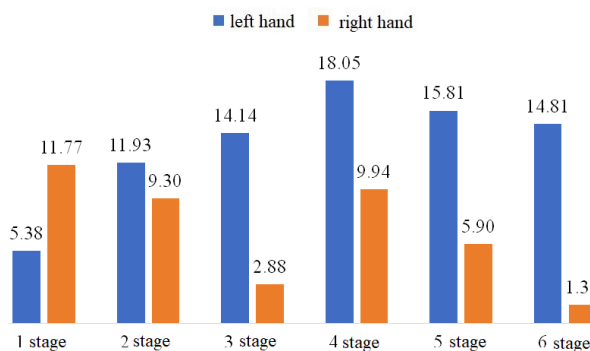


Fig. 6. Differences between the duration of pressing at the stages of the test for esports athletes of different levels of sportsmanship (%)

Discussion

The design of the study involved a comparison of athletes involved in the same sport, differing in the level of sportsmanship. This allows you to appreciate the importance

of asymmetry to achieve a high level of skill. A similar design was used by Rovnaya et al. (2016) to compare the functional state of female athletes of aesthetic swimming of different skill levels, which made it possible to identify quality predictors of academic performance. The study of the psychophysiological characteristics of athletes allows us to identify the most important factors influencing the effectiveness of competitive activity. The results in a certain way reflect the specific impact of a sport on the state of the body of athletes (Podrigalo, O. et al., 2020). A similar design variant was used by Podrigalo L. et al. when comparing the biochemical parameters of children depending on the frequency and duration of contact with video games. This approach made it possible to identify significant differences in homeostatic indicators in children belonging to the group of active players compared to those who do not have contact with computer games. Activation of the sympathoadrenal system and lipid peroxidation were accompanied by a decrease in antioxidant protection and inhibition of nonspecific resistance of the body (Podrigalo L. et al., 2020).

In this study, a modern, effective and convenient tool for the study of functional asymmetry in the upper limb was used – the “Reaction SM Dual” program for tablet computers. Despite its universality, the expediency of its use for the study of esports athletes is due to the structure of movements familiar to them, which is the basis of the test. The frequency and nature of the signals that appear on the screen during testing are also somewhat similar to the stimuli in the game. The study involved athletes specializing in the disciplines CS:GO and DOTA 2. The legitimacy of their association in one group is explained by the fact that in both disciplines the players perform basic techniques using a computer mouse and keyboard. The touch control panel that was used in testing is not a specific way to control any of the games, so all athletes were on a relatively equal footing.

In esports, both specific and general components of motor actions play an important role. The game is controlled by specific sensorimotor actions (skills) on interfaces and sensors, such as hand-mouse, finger-keyboard or hand-joystick interaction, as well as body-camera or body-force-platform interaction (Hebbel-Seeger A., 2012). To move avatars, change or use weapons, or control vehicles, you need to control input devices such as mouse, gamepad, and keyboard in some way. Therefore, esports includes complex physical interactivity, but adapted to the specific perceptual and sensorimotor conditions of the virtual world (McCutcheon. 2017). For successful and purposeful interaction, either hand and finger movements (“manual dexterity”) or body movements are used.

The results of the study indicate that elite players tend to have better rates of movement frequency, reaction time, and greater symmetry of motor actions with the right and left hand. No significant differences were found in the average test results, however, the analysis of these values at all stages of the test indicates the best results of more qualified athletes. Also, elite athletes have significantly better maximum reaction times in the test ($p < 0.05$). In terms of reaction time variation, there are also significant differences with amateurs – the group of elite athletes turned out to be more homogeneous in terms of reaction time ($p < 0.05$). Better test scores for more qualified athletes reflect their better performance levels. Experienced athletes

are quicker to cope with the task. Therefore, they show a greater number of clicks per unit of time, a shorter response time to a signal. The best mobilization score is also displayed when you reduce the time you tap on the device screen. That is, according to all indicators of the test, experienced athletes have an advantage. This is confirmed by preliminary studies of qualified athletes in tkhekondo, taekwondo, karate (Podrigalo L. et al., 2019; Romanenko et al., 2020), judo (Krstulović et al., 2017), rowing (Warmenhoven et. al., 2018).

The study of asymmetry is an actual area of research in sports. Hernandez-Garcia et al. (2020) emphasize that asymmetry analysis is a simple, economical and informative tool for monitoring the condition of athletes. In particular, the study of the asymmetry indicators of athletes of different skill levels allows us to determine their characteristics and apply this knowledge in the construction of training programs. In this case, the goal is to achieve greater symmetry between the right and left parts of the body (Warmenhoven et. al., 2018; Romanenko et al., 2020).

Hilvoorde and Pot (2016) consider that snooker and billiards show some similarities with esports, since the main skill is associated with skillful aiming and indirect movement of objects. Although the intensity of the movements may vary, these sports involve the development of complex coordination skills and the ability to move the body and/or the tool used to move the object. Although in e-sports the whole body is not displaced, but the existing indirect nature of the action aimed at controlling the virtual object. In billiards, players must also master the technique of hitting the ball from different positions of the table with both hands, but there are no requirements for the speedy execution of techniques.

Kim H. et al. (2022) investigated the perceptual-motor abilities of professional esports athletes and amateurs. Professional esports athletes demonstrated better latency and peripheral perception (wider field of view in degrees) than amateurs. Professional esports athletes constantly pressed the button before the stimulus arrived, but the eye-hand coordination was the same as amateurs. These results indicate that esports can further develop perceptual motor skills and lead to higher levels of certain perceptual motor skills.

Ersin et al. (2022) assessed the auditory, visual and aim reaction time of the players according to the duration of the playing time. Visual and aim reaction times were higher for gamers who practiced for more than 14 hours. The study showed that the visual and aim reaction time had a greater effect on the game time than on the players' auditory reaction time.

In the work of Nagorsky and Wiemeyer (2020), a six-factor structure of esports competencies was defined: 1) physical skills (conditional training); 2) sensorimotor or coordination competencies; 3) strategically cognitive competencies; 4) mental competencies; 5) social competencies; 6) competencies related to media. In the course of the following analysis, the factor structure of the critical components of training in e-sports was determined: 1) the speed of actions; 2) strategy and psychophysical readiness; 3) sensorimotor control. This study confirms our data on the importance of sensorimotor qualities in esports.

The new generation of first-person shooter (FPS) games (compared to previous generation games) is not only about

pressing one button at the right time, but also requires players to have flexible thinking, allowing them to participate in complex scenarios, quickly respond to moving visual and sudden acoustic events, as well as switching between different subtasks (Colzato et al., 2010). So, cognitive properties occupy an important place in the professional profile of a cyberathlete.

Previous research has also shown that experienced video game players outperform amateurs on cognitive and perceptual tasks related to visual selective attention (Leigh & Clark, 2022), visual stimulus detection and visual search performance (Pluss et al., 2020) contrast sensitivity (Kim et al., 2022), cognitive flexibility (Colzato et al., 2010), visual short-term memory (Bubna et al., 2023), decision making and attention switching (Bihari & Pattanaik, 2023).

Green and Bavelier (2010) have shown that action games improve behavioral performance in a wide range of perceptual tasks, from those that require efficient allocation of attentional resources across a visual scene to those that require successful identification of fleeting stimuli. This effect has not only been observed in experienced esports athletes, but a causal relationship has also been established between playing video games and improved information processing.

Conclusions

The competitive activity of athletes in a number of eSports disciplines, in particular CS:GO and DOTA 2, requires fast and accurate finger and hand movements. Such movements predetermine the performance of technical methods, which consist in controlling a virtual game character. Technical actions are performed simultaneously with both hands on the keyboard and mouse. In right-handed people, the mouse is usually supervised by the right hand, and the keyboard by the left. Left-handers have different ways of arranging control devices – similar to right-handers or located the other way around. The requirements of competitive activity lead to the need for well-coordinated work of hands and quick sensorimotor reactions of athletes. Therefore, the study of functional asymmetry indicators is an important area of scientific research in esports.

The study of the functional asymmetry of the upper limbs in esports athletes was carried out using the “Reaction SM Dual” program for tablet computers. This program is a reliable, informative and convenient tool for assessing the indicators of sensorimotor reactions and the frequency of movements per unit of time with the right and left hands.

Comparison of the results of testing esports athletes of different skill levels showed that players with a higher level of preparedness demonstrate a tendency to less asymmetric movements. In the proposed test, elite athletes demonstrate a greater number of movements per unit of time; at the 2nd stage of testing, the differences are significant ($p < 0.05$). At the same time, the reaction time of more skilled players is shorter compared to amateurs; at the 2nd and 4th stages of the test, the differences are significant ($p < 0.05$).

Indicators of functional asymmetry of movements of the upper limbs informatively characterize the level of preparedness of esports athletes and can be included in the program for monitoring the physical condition of players in cybersport.

Conflict of interests

The authors declare no conflict of interest.

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ДОСЛІДЖЕННЯ ПОКАЗНИКІВ МОТОРНОЇ ФУНКЦІОНАЛЬНОЇ АСИМЕТРІЇ КІБЕРАТЛЕТІВ РІЗНОГО РІВНЯ МАЙСТЕРНОСТІ

Світлана Пятисоцька^{1ABCE}, Леонід Подрігалo^{1ABCE}, Вячеслав Романенко^{1ABCE}, Андрій Єфременко^{1BCE}, Юлія Петренко^{1BDE}, Ганна Полторацька^{1BCE}

¹Харківська державна академія фізичної культури

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 8 с., 1 табл., 6 рис., 31 джерело.

Мета дослідження. Дослідити та проаналізувати показники функціональної асиметрії у кібератлетів різного рівня майстерності.

Матеріали і методи. У дослідженні взяли участь 20 атлетів середній вік (18±1,53) років, розподілених на групи відповідно до рівня майстерності. 1 група: елітні гравці напівпрофесійних команд з дисциплін CS:GO і DOTA 2, n=10, вік (19,2±0,50) років. 2 група: гравці-аматори з CS:GO і DOTA 2, n=10, вік (18,2±1,04) років. Функціональну асиметрію рухів верхніх кінцівок визначали за допомогою спеціальної програми для планшетних комп'ютерів під управлінням iOS, розробленої на кафедрах єдиноборств, інформатики та біомеханіки ХДАФК.

Результати. Встановлено, що за кількістю натискань за одиницю часу елітні кібератлети переважають аматорів на 5,54% на лівій та 5,14% на правій руці; за часом зорово-моторної реакції елітні кібератлети переважають на 5,54% на лівій та 5,07% на правій руці; елітні кібератлети показали меншу на 13,3% тривалість натискань на лівій руці, проте аматори показали меншу на 6,83% тривалість натискань на правій руці.

Висновки. Гравці вищого рівня підготовленості демонструють тенденцію до меншої асиметричності рухів. У запропонованому тесті елітні атлети демонструють більшу кількість рухів за одиницю часу, на 2-му етапі тестування відмінності мають достовірний характер ($p < 0,05$). При цьому час реакції більш кваліфікованих гравців є меншим у порівнянні із аматорами, на 2-му та 4-му етапах тесту відмінності мають достовірний характер ($p < 0,05$). Показники функціональної асиметрії рухів верхніх кінцівок інформативно характеризують рівень підготовленості кібератлетів та можуть бути включені до програми моніторингу фізичного стану гравців у кіберспорті.

Ключові слова: кіберспорт, психофізіологічне дослідження, функціональна асиметрія, час реакції, елітні кібератлети, кібератлети аматори.

Information about the authors:

Piatysotska, Svitlana: piatsvit25@gmail.com; <https://orcid.org/0000-0002-2246-1444>; Department of Informatics and Biomechanics, Kharkiv State Academy of Physical Culture, Klochkivska St, 99, Kharkiv, 61022, Ukraine.

Podrigalo, Leonid: leonid.podrigalo@gmail.com; <https://orcid.org/0000-0002-7893-524X>; Department of Medical Discipline, Kharkiv State Academy of Physical Culture, Klochkivska St, 99, Kharkiv, 61022, Ukraine.

Romanenko, Vyacheslav: slavaromash@gmail.com; <https://orcid.org/0000-0002-3878-0861>; Department of Martial Arts, Kharkiv State Academy of Physical Culture, Klochkivska St, 99, Kharkiv, 61022, Ukraine.

Yefremenko, Andrii: pierreroberle@gmail.com; <https://orcid.org/0000-0003-0924-0281>; Department of Athletics, Kharkiv State Academy of Physical Culture, Klochkivska St, 99, Kharkiv, 61022, Ukraine.

Petrenko, Yuliia: horbatenko1604@gmail.com; <https://orcid.org/0000-0002-6549-3729>; Department of Informatics and Biomechanics, Kharkiv State Academy of Physical Culture, Klochkivska St, 99, Kharkiv, 61022, Ukraine.

Poltoratska, Hanna: anna15kaya@gmail.com; <https://orcid.org/0000-0002-0076-4727>; Department of Informatics and Biomechanics, Kharkiv State Academy of Physical Culture, Klochkivska St, 99, Kharkiv, 61022, Ukraine.

Cite this article as: Piatysotska, S., Podrigalo, L., Romanenko, V., Yefremenko, A., Petrenko, Yu., & Poltoratska, H. (2023). A Study of Motor Functional Asymmetry Indicators in Different Sportsmanship Level Esports Athletes. *Physical Education Theory and Methodology*, 23(4), 628-635. <https://doi.org/10.17309/tmfv.2023.4.19>

Received: 25.07.2023. Accepted: 18.08.2023. Published: 30.08.2023

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ORIGINAL SCIENTIFIC ARTICLE

JUMPS AND LOWER LIMB STRENGTH ASYMMETRY IN YOUNG SOCCER PLAYERS: DIFFERENCES BETWEEN SAND AND CONVENTIONAL SURFACES

Italo Sannicandro^{1ABCD}, Giacomo Cofano^{1ABCD},
Rosario D'Onofrio^{2ABCD} and Andrea Piccinno^{3ABCD}

¹University of Foggia

²Italian Football Doctors Association – L.A.M.I.CA. Italy

³University of Salento

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Italo Sannicandro, E-mail: italo.sannicandro@unifg.it

Accepted for Publication: August 14, 2023

Published: August 30, 2023

DOI: 10.17309/tmfv.2023.4.20

Abstract

Study purpose. The aim of the study was to evaluate jumping performance and lower limbs strength asymmetry in young soccer players by comparing this movement performed on both a conventional surface and a sand surface.

Materials and methods. 20 young soccer players under 17 years old randomly performed a standing long jump, a single hop jump in the sagittal plane (Hop Jump Test) and a single side hop jump in the frontal plane (Side Hop Jump Test), first on a conventional surface (natural grass) and then on sand. The jump distance and strength asymmetry was calculated using the formula: $(NDL / DL) \times 100$.

Results. The values from the two different jumping conditions showed a statistically significant decrease in the Broad Jump Test ($p < 0.001$, ES: 3.56), Hop Jump Test left limb ($p < 0.001$, ES: 4.99), Hop Jump Test right limb ($p < 0.001$, ES: 3.95), Side Hop Jump Test left limb ($p < 0.001$, ES: 4.67) and Side Hop Jump Test right limb ($p < 0.001$, ES: 2.98) in the sand condition.

The asymmetry values in the Hop Jump Test and the Side Hop Jump Test showed a statistically significant increase (+21.5%, $p < 0.001$, ES: 3.66 and +41.1%, $p < 0.001$, ES: 1.99, respectively) when comparing the performance on grass and sand.

Conclusions. This different performance response in the two different jumping modes leads to the hypothesis that young soccer players who want to stress their explosive strength ability and joint stability should favor the use of one-leg rather than two-leg jumps.

The values described in the study lead to the hypothesis that training on sand should be suggested when the young soccer player presents modest values of inter-limb asymmetry measured on a conventional surface.

Keywords: sand, jump, inter-limb asymmetry, young soccer player, soccer.

Introduction

Training makes use of a variety of equipment and surfaces in an attempt to stimulate the athlete's neuromuscular apparatus in an increasingly specific manner.

In a particular way, soccer training at both youth and professional levels tries to make use of new motor tasks and new strategies to prepare the athlete, whether young or advanced, in a way that is increasingly adapted to the demands of the performance model.

Training, therefore, over the years has proposed multiple ways of performing general and specific exercises in order to

identify strategies and methodologies capable of returning the best performance benefits, perhaps reducing the injury risk.

The increasing diffusion of sports disciplines very similar to football (futsal and beach soccer in the first instance) and the spread of playing surfaces of different nature (artificial vs. natural, artificial of different and latest generation) have highlighted the need to investigate the role that these play in the realisation of the performance (Gould et al., 2023; López-Fernández et al., 2018; Williams et al., 2011), load and skills associated with the sport (Strutzenberger et al., 2022; Kuitunen et al., 2023; Xiao et al., 2022).

Notably, the sandy surface, in the face of widespread and widespread use in both rehabilitation courses and specific training sessions (Rago et al., 2018; Pereira et al., 2023), is

only recently gaining research attention in soccer (Cetolin et al., 2021; Larsen et al., 2021; Costa et al., 2022).

An interesting review on the use of different training grounds in soccer reveals a heterogeneity of surfaces that determine specific functional adaptations in the soccer players (Rago et al., 2018).

Just as it emerges that surfaces with greater compliance, such as sand, return adaptations in the lower limb strength ability (de Lira et al., 2017).

In the case of sand, it is evident in the literature that energy expenditure (Zamparo et al., 1992; Pinnington & Dawson, 2001a & 2001b), as well as the response of maximal oxygen consumption, peak heart rate value, exertion perception and lactate, are significantly higher when analysing high and very high intensity exercise (Cetolin et al., 2021).

Initially, the focus of research on understanding the different energy expenditure between more conventional and sandy surfaces arose years ago for military purposes; conversely, today, the increase in the sporting qualification of some athletes and sports disciplines practised on sand has also begun to call for more scientific speculation for other activities and skills other than walking or running (Binnie et al., 2014; Gaudino et al., 2013).

This is the case for sports that, although practised on sand, require high performance demands in jumping skills (Ahmadi et al., 2021; Larsen et al., 2021; Leite, 2021). It is evident that the surface on which the performance is required is capable of altering the biomechanics of the jump (Pereira et al., 2021 & 2022; Binnie et al., 2014; Riggs & Sheppard, 2009), inducing substantial differences whether this movement is performed on sand or on a hard or conventional surface (Giatsis et al., 2004 & 2022; Riggs & Sheppard, 2009).

In this regard, it emerges that the lower performance values in sand jumping performances are attributable to a lower reuse of elastic energy and foot slippage (Binnie et al., 2014; Impellizzeri et al., 2008).

Furthermore, when observing the drop jump execution, there is evidence that confirms the energy-dissipating role of the sandy surface: in comparison to a hard surface, there is a significantly lower jump height, ground reaction force, peak power and peak angular velocity at the ankle; furthermore, a higher rate of force development is observed, as is a higher knee bend angle (Giatsis et al., 2022).

With regard to run performance, previous studies have found that on sand, the energy cost of a low-speed run is 24% higher than on a conventional surface (Zamparo et al., 1992).

Again, the specificity of sand has been described in observation in the biomechanics of high-intensity running and the energy cost of this type of performance: the results obtained by some researchers show, that on sand it is possible to perform maximal intensity sprints with higher energy expenditure and metabolic power values, without reaching maximum speed observed in maximal sprint test but with smaller impact shocks (Gaudino et al., 2013). Furthermore, exercises with change of direction carried out on this surface allow to reach higher deceleration values (Gaudino et al., 2013).

Ultimately, the compliance of sand attenuates and significantly reduces the efficiency of the mechanisms involved in the optimisation of performances that require elastic reuse, whether they are jumps or rapid movements that rely on the stretch-shortening cycle as in sprint running,

however, they determine a lower load in the ground contact phase (Giatsis et al., 2022).

This disadvantageous picture seems to be determined by the characteristics of sand: it differs from other types of surfaces in that the presence of air gaps means that the surface is displaced and compressed during footstrike or propulsive thrust (Gaudino et al., 2013).

Consequently, the foot slips and sinks, forcing the lower limb muscles to carry out additional work to stabilize the point of reaction force on the surface (Sanchez-Sanchez et al., 2020; Gaudino et al., 2013; Lejeune et al., 1998).

In the literature, however, there remains more than one open question: whether certain skills on sand, a surface that, in addition to dissipating elastic energy, is extremely unstable compared to more conventional ones, may represent a potential risk factor for the joints of the lower limb.

Furthermore, the behaviour of young athletes on a surface with such peculiar characteristics has been neglected, directing attention predominantly to adult or highly qualified athletes (Ahmadi et al., 2021; Cetolin et al., 2021).

The aim of the study is to evaluate jumping performance and lower limbs strength asymmetry by comparing this movement performed on both a conventional surface and a sand surface in young soccer players.

Materials and methods

Study participants

20 young soccer players under 17 years-old were recruited to participate voluntarily in this study (mean $\pm$ SD; age: 16.6 ± 0.3 ; height: 1.79 ± 0.12 ; body mass: 67.9 ± 4.7 ; body mass index: 21.48 ± 1.36). The study was carried out in Olympic Center of Comitato Olimpico Nazionale Italiano (C.O.N.I.).

Prior to the start of this investigation, all young soccer players were fully informed about the testing and warm-up's procedures and a written informed consent was obtained from the participants or their legal tutors before data collection.

Before participants recruitment, the study was approved by the Apulian Regional Ethics Committee of the F.I.G.C. Additionally, the research design and procedures complied with the standards set out in the Declaration of Helsinki.

Study organization

During the week before data collection tests, one familiarization session was performed to know the test protocol and execution technique.

Each participant performed an approximately 15-minute warm-up consisting of 5 minutes of moderate intensity running (at $\sim 60\%$ maximal heart rate and self-assessed), 5 minutes of dynamic stretching and mobility of the lower limbs, and 5 minutes of acceleration and deceleration, high knee running, bouncing, reactive pogo jumping and two near-maximal attempts of each test.

The tests were performed randomly by each participant both on sand and on a conventional surface (natural grass).

In particular, they performed a standing long jump, a single hop jump in the sagittal plane (hop jump test) and a single side hop jump in the frontal plane (side hop jump

test), first on a conventional surface (natural grass) and then on sand.

The lower limb strength asymmetry was calculated using the formula: $(NDL / DL) \times 100$ (Ceroni et al., 2012; Bishop et al., 2016).

Statistical analysis

Descriptive statistics (mean $\pm$ standard deviation) were performed for the data analysis. One-way analysis of variance (ANOVA) was used to determine within-group comparisons (conventional vs sand condition). For the differences between the averages that were significant, Cohen's d was used to check the effect size index (Effect Size, ES). As for the effect size index, after calculating the δ index it is possible to convert it into Effect Size: ≤ 0.20 small; 0.50 average; ≥ 0.80 large. All statistical analyses were performed using SPSS software, version 22.0 (IBM Corp., Armonk, NY, USA). The level of statistical significance was set at $p < 0.05$.

Results

The values from the two different jumping conditions showed a statistically significant decrease in the Broad Jump Test (224.1 ± 14.9 cm vs 171.1 ± 14.8 cm, $F_{(1,38)} = 126,743$, $p < 0.001$, ES:3.56), Hop Jump Test left limb (186.5 ± 12.8 cm vs 124.3 ± 12.1 cm, $F_{(1,38)} = 287,376$, $p < 0.001$, ES:4.99), Hop Jump Test right limb (194.9 ± 13.3 cm vs 142.1 ± 13.4 cm, $F_{(1,38)} = 134,980$, $p < 0.001$, ES:3.95), Side Jump Test left limb (161.5 ± 12.9 cm vs 110.2 ± 8.6 cm, $F_{(1,38)} = 219,919$, $p < 0.001$, ES:4.67) and Side Jump Test right limb (169.2 ± 15.3 cm vs 129.3 ± 11.1 cm, $F_{(1,38)} = 80,142$, $p < 0.001$, ES:2.98) in the sand condition.

The asymmetry values in the Hop Jump Test and the Side Jump Test showed a statistically significant increase (respectly, $+21.5\%$, $F_{(1,38)} = 40,408$, $p < 0.001$, ES:3.66 and $+41.1\%$, $F_{(1,38)} = 27,453$, $p < 0.001$, ES:1.99) when comparing the performance on grass and sand.

All values are summarised in the table 1.

Discussion

The aim of the study was to compare the values of jumping, two-legs jump and one-leg jump, and lower limb functional asymmetry values, performed on a conventional surface and on sand.

The issue of the use of different surfaces in the soccer's training is of topical relevance, as much for the performance-enhancing aspects as for the reduction of the injury risk.

In particular, this appears to be the first analysis of the jumping performance of young soccer players on sand and grass in order to understand performance differences and information regarding the injury risk reduction.

The percentage decreases achieved in both two-legs jumping and one-leg jumping performances are significantly higher than what has been identified in the literature with over 18-years-old beach soccer players of both genders, in which this difference stopped at approximately 16.7% (Larsen et al., 2021).

This value, which differs from what has been found in the literature, would lead one to assume two types of considerations: there could be a particular adaptation phenomenon in those who habitually perform on sand, such that they are able to 'compensate' for the biomechanical disadvantage resulting from the sandy surface; on the other hand, one could hypothesise a greater performance discomfort in young elite athletes and women than in highly qualified athletes.

From a methodological and organisational point of view, therefore, the sandy surface seems to lend itself effectively to the neuromuscular training of the young athlete as it appears to represent an adequate overload.

One-leg jumping values show greater performance decrements than two-legs jumping performances: probably a greater stability determined by the two-legs start allows for the expression of greater levels of explosive force.

This different performance response in the two different jump modes leads to the hypothesis that young soccer players who want to stress the explosive strength ability and joint stability should lean towards using one-leg jumps rather than two-legs jumps.

If this performance disadvantage on sand is substantially already described in the literature, especially with over 18 years-old athletes or highly qualified athletes, the new finding of this study is inherent in the strength asymmetry values found in young soccer players.

Lower limbs functional asymmetries are determined by strength deficits between the two limbs (Read et al., 2021; Loturco et al., 2019; Sannicandro et al., 2014) and differ from muscular imbalances, which represent an alteration in the strength relationship between agonist and antagonist muscles (Sannicandro et al., 2014).

Table 1. Jump and inter-limb asymmetry values obtained in evaluations

Indicator	Grass/conventional surface (X $\pm$ SD)	Sand (X $\pm$ SD)	Difference %	p	Cohen's d
Broad Jump (cm)	224.1 $\pm$ 14.9	171.1 $\pm$ 14.8	-23.7	0.001	3.56
Hop Jump Test left (cm)	186.5 $\pm$ 12.8	124.3 $\pm$ 12.1	-33.4	0.001	4.99
Hop Jump Test right (cm)	194.9 $\pm$ 13.3	142.1 $\pm$ 13.4	-27.1	0.001	3.95
Asymmetry Hop Jump Test (%)	6.2 $\pm$ 2.7	16.1 $\pm$ 6.3	21.5	0.001	3.66
Side Jump Test left (cm)	161.5 $\pm$ 12.9	110.2 $\pm$ 8.6	-21.8	0.001	4.67
Side Jump Test right (cm)	169.2 $\pm$ 15.3	129.3 $\pm$ 11.1	-23.5	0.001	2.98
Asymmetry Side Jump Test (%)	6.9 $\pm$ 3.3	14.1 $\pm$ 3.9	41.0 $\pm$ 1	0.001	1.99

Lower limb functional asymmetry has recently been the subject of numerous investigations concerning many sports (Filter et al., 2021; Rutkowska-Kucharska, 2020), including contact sports, limited-contact (Impellizzeri et al., 2007) and non-contact sports aimed at understanding the role of conditioning in performance (Madruga-Parera et al., 2020a & 2020b) and injury prevention (Bishop et al., 2017 & 2018; Markovic et al., 2021).

This factor becomes relevant in soccer performance because the game requires very high intensity actions performed unilaterally by the single lower limb (Helme et al., 2021): kicking, deceleration, jumping to hit the ball with the head, etc. are all unilateral skills (Raya-González et al., 2021; Keiner et al., 2021).

This asymmetry appears to significantly influence performance (Madruga-Parera et al., 2020a & 2020b; Filter et al., 2021) but more importantly it appears to be a injury risk factor when it exceeds the 10% or 15% cut-off value (Keiner et al., 2021; Carvalho et al., 2016; Fort-Vanmeerhaeghe et al., 2016).

It is precisely to this cut-off value that the data observed in the hop test and the side hop test with regard to the asymmetry parameter must direct the greatest attention (Raya-González et al., 2021; Keiner et al., 2021): the average asymmetry value of the hop shows an increase of around 21%, while that of the side hop reaches an increase of over 40% in the grass-sand comparison.

Another interesting consideration concerns the asymmetry values themselves, which exceed the cut-off of 10% and verge on that of 15%, presenting a significant variability within them, probably indicating a significant diversity of the sample's performance within itself.

The considerations inherent in this value, on the one hand, would suggest that this surface exalts the lower limb strength asymmetry to an even greater extent than grass; while on the other hand, they must lead to some reflections on the preventive evaluations that should be conducted before exploiting the performance advantages derived from the use of the sandy surface; especially if the staff intends to make use of sport-specific exercises that increase the frequency of contact or are carried out in a situational context.

Analytical tasks performed on unstable or reduced surfaces (i.e. also on a single limb), can be incorporated into a training plan as part of an injury prevention strategy.

An unstable surface imposes an effort on the neuromuscular system to stabilise the joints involved in the execution of the movement. All of the beneficial effects of movements performed on unstable surfaces are transferred into sport-specific performance; for example, in soccer, the correct activation of the core muscles achieved during the execution of balance training exercises is a good example of the positive transfers that can be achieved when performing sport-specific movements (Behm et al., 2010; Behm & Anderson, 2006).

The same considerations can be made for stabilisation tasks aimed at the joints of the lower limb with an internal or external focus (Ghanati et al., 2022; Sherwood et al., 2020).

Therefore, not only the type of exercise but also the duration of training loads on sand must be carefully considered to prevent fatigue from increasing the interlimb asymmetry value (Guan et al., 2021; Wrona et al., 2023).

A further prospect of this research could involve analysing the number of jumps or runs on sand that increase

the asymmetry value, thus putting the young soccer player at injury risk.

Furthermore, further studies could compare what emerges with young male footballers with what occurs with young female footballers, who present a gender-specific risk of injury.

Conclusions

In conclusion, the sandy surface requires further investigation in order to understand which volumes may prove effective for performance enhancement, as has been amply demonstrated in the literature, and which training loads, on the contrary, may predispose to the risk of non-contact injury due to the instability determined by the characteristics of the surface itself.

This aspect is to be considered not so much for the presentation of analytical tasks that allow the activation of an internal focus during execution, but rather for the use of sport-specific exercises with the ball apparatus that, on the contrary, see the external focus prevail.

It remains to be understood whether, following prolonged periods of training on sand, phenomena of adaptation to the surface can occur and be observed that reduce the instability caused by the sand itself.

For these reasons, it is hoped that subsequent analyses may involve samples of athletes, young or highly qualified, who can be monitored and evaluated before undertaking sand training and at the end of it.

Conflict of interest

The authors declare no conflict of interest

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АСИМЕТРИЯ СТИБКІВ І СИЛИ НИЖНІХ КІНЦІВОК У МОЛОДИХ ФУТБОЛІСТІВ: ВІДМІННОСТІ МІЖ ПІЩАНОЮ ТА ТРАДИЦІЙНОЮ ПОВЕРХНЯМИ

Італо Саннікандро^{1ABCD}, Джакомо Кофано^{1ABCD},
Росаріо Д'Онофріо^{2ABCD}, Андреа Піччінно^{3ABCD}

¹Університет Фоджа

²Італійська асоціація футбольних лікарів – L.A.M.I.C.A. Італія

³Університет Саленто

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 8 с., 1 табл., 6 рис., 51 джерело.

Мета дослідження. Метою дослідження було проведення оцінки асиметрії результативності стрибків та сили нижніх кінцівок у молодих футболістів шляхом порівняння виконання цього руху на традиційній поверхні та на піщаній поверхні.

Матеріали та методи. 20 молодих футболістів віком до 17 років випадковим чином виконували стрибок у довжину з місця, один стрибок на одній нозі вперед у сагітальній площині (тест на стрибок на одній нозі вперед) та один стрибок на одній нозі вбік у фронтальній площині (тест на стрибок на одній нозі вбік), спочатку на традиційній поверхні (натуральна трава), а потім на піску. Асиметрію дистанції стрибків і сили обчислювали за формулою: (NDL (недомінантна нога) / DL (домінантна нога)) x 100.

Результати. Значення, одержані в цих двох різних режимах стрибків, показали статистично значуще зменшення в тесті на стрибок у довжину з місця ($p < 0,001$, ES (розмір ефекту): 3,56), тесті на стрибок на одній нозі вперед – ліва нога ($p < 0,001$, ES (розмір ефекту): 4,99), тесті на стрибок на одній нозі вперед – права нога ($p < 0,001$, ES (розмір ефекту): 3,95), тесті на стрибок на одній нозі вбік – ліва нога ($p < 0,001$, ES (розмір ефекту): 4,67) та тесті на стрибок на одній нозі вбік – права нога ($p < 0,001$, ES (розмір ефекту): 2,98) у режимі виконання стрибків на піску.

Під час порівняння результативності на траві та на піску значення асиметрії в тесті на стрибок на одній нозі вперед і в тесті на стрибок на одній нозі вбік показали статистично значуще збільшення (+21,5%, $p < 0,001$, ES (розмір ефекту): 3,66 та +41,1%, $p < 0,001$, ES (розмір ефекту): 1,99 відповідно).

Висновки. Цей різний ефект у показниках результативності в двох різних режимах виконання стрибків дає підстави для гіпотези, що молодим футболістам, які бажають піддати напрузі свою здатність до вибухової сили та міцність суглобів, слід віддавати перевагу використанню стрибків на одній нозі, а не на двох ногах.

Значення, описані в дослідженні, дають підстави для гіпотези, що тренування на піску слід рекомендувати, коли молодий футболіст демонструє невеликі значення асиметрії між кінцівками за результатами вимірювання на традиційній поверхні.

Ключові слова: пісок, стрибок, асиметрія між кінцівками, молодий футболіст, футбол.

Information about the authors:

Sannicandro, Italo: italo.sannicandro@unifg.it; <https://orcid.org/0000-0003-1284-2136>; Department of Humanities, Literature, Cultural Heritage, Education Sciences, University of Foggia, Via A. Gramsci 89/91, 71122 Foggia, Italy.

Cofano, Giacomo: giacomo.cofano@unifg.it; <https://orcid.org/0000-0001-9973-1740>; Sciences and techniques of preventive and adapted motor activities, Professional soccer strength and conditioning coach, University of Foggia, Via A. Gramsci 89/91, 71122 Foggia, Italy.

D'Onofrio, Rosario: donofrio.rosario@virgilio.it; <https://orcid.org/0000-0002-8995-3072>; Medical-Scientific Multidisciplinary Commission, Italian Football Doctors Association - L.A.M.I.C.A. Italy, Largo E. Berlinguer, 18, 04023 Formia (LT), Italy.

Piccinno, Andrea: andrea.piccinno@unifg.it; <https://orcid.org/0000-0002-4687-6652>; University of Salento, Piazza Tancredi, 7, 73100 Lecce LE, Italy.

Cite this article as: Sannicandro, I., Cofano, G., D'Onofrio, R., & Piccinno, A. (2023). Jumps and Lower Limb Strength Asymmetry in Young Soccer Players: Differences Between Sand and Conventional Surfaces. *Physical Education Theory and Methodology*, 23(4), 636-642. <https://doi.org/10.17309/tmf.2023.4.20>

Received: 25.07.2023. Accepted: 14.08.2023. Published: 30.08.2023

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RETRACTION NOTE

RETRACTION NOTE: THE RELATIONS BETWEEN BLOOD PRESSURE AND HANDGRIP STRENGTH IN CHILDREN (PHYSICAL EDUCATION THEORY AND METHODOLOGY, 23(2), 207–213. [HTTPS://DOI.ORG/10.17309/TMFV.2023.2.08](https://doi.org/10.17309/TMFV.2023.2.08))

The Editors have retracted the following article:

Ahmeti, G. B., Morina, B., Georgiev, G., & Gontarev, S. (2023). The Relations Between Blood Pressure and Handgrip Strength in Children. *Physical Education Theory and Methodology*, 23(2), 207–213. <https://doi.org/10.17309/tmfv.2023.2.08>

Following the publication of the article, the Organizata për Rritjen e Tëllësë në Arsim – ORCA contacted the journal. Upon editorial follow-up, similarities were noted between this article and a previous publication by another group (“Handgrip Strength and Blood Pressure in Children and Adolescents: Evidence From NHANES 2011 to 2014”, published in the *American Journal of Hypertension* in 2018, by Zhang, R., Li, C., Liu, T., Zheng, L., & Li, S.). Considering these issues, the Editors retract this article. The authors don't agree with the retraction.

We have been informed in our decision-making by our policy on publishing ethics and COPE guidelines.

The retracted article will remain online to maintain the scholarly record, but it will be digitally watermarked on each page as “Retracted”.

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Ahmeti, G. B., Morina, B., Georgiev, G., & Gontarev, S. (2023). RETRACTED ARTICLE: The Relations Between Blood Pressure and Handgrip Strength in Children. *Physical Education Theory and Methodology*, 23(2), 207–213. <https://doi.org/10.17309/tmfv.2023.2.08>

Zhang, R., Li, C., Liu, T., Zheng, L., & Li, S. (2018). Handgrip Strength and Blood Pressure in Children and Adolescents: Evidence From NHANES 2011 to 2014. *American journal of hypertension*, 31(7), 792–796. <https://doi.org/10.1093/ajh/hpy032>

ПОВІДОМЛЕННЯ ПРО ВІДКЛИКАННЯ

ПОВІДОМЛЕННЯ ПРО ВІДКЛИКАННЯ: ЗВ'ЯЗОК МІЖ АРТЕРІАЛЬНИМ ТИСКОМ І ДИНАМІЧНОЮ СИЛОЮ КИСТІ В ДІТЕЙ (ТЕОРІЯ ТА МЕТОДИКА ФІЗИЧНОГО ВИХОВАННЯ, 23(2), 207–213. [HTTPS://DOI.ORG/10.17309/TMFV.2023.2.08](https://doi.org/10.17309/TMFV.2023.2.08))

Редакція відкликала таку статтю:

Ахметі, Г. Б., Моріна, Б., Георгієв, Г., і Гонтарев, С. (2023). Зв'язок між артеріальним тиском і динамічною силою кисті в дітей. *Теорія та методика фізичного виховання*, 23(2), 207–213. <https://doi.org/10.17309/tmfv.2023.2.08>

Після публікації статті Organizata për Rritjen e Tëllësë në Arsim – ORCA зв'язалася з журналом. Під час редакційного контролю було відзначено подібність між цією статтею та попередньою публікацією іншого авторського колективу (“Handgrip Strength and Blood Pressure in Children and Adolescents: Evidence From NHANES 2011 to 2014”, опублікована в *American Journal of Hypertension* у 2018 році, автори Zhang, R., Li, C., Liu, T., Zheng, L., & Li, S.). Зважаючи на ці проблеми, редакція відкликає цю статтю. Автори не згодні з відкликанням.

Приймаючи рішення, ми керувалися нашою політикою щодо етики публікацій і рекомендаціями COPE. Відкликана стаття залишатиметься онлайн для збереження наукового запису, але на кожній сторінці буде позначено цифровим водяним знаком «Відкликано».

Посилання

Ahmeti, G. B., Morina, B., Georgiev, G., & Gontarev, S. (2023). RETRACTED ARTICLE: The Relations Between Blood Pressure and Handgrip Strength in Children. *Physical Education Theory and Methodology*, 23(2), 207–213. <https://doi.org/10.17309/tmfv.2023.2.08>

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ISSN 1993-7989 (print)
ISSN 1993-7997 (online)
ISSN-L 1993-7989

Теорія та методика фізичного виховання
Physical Education Theory and Methodology
Teoriã ta Metodika Fìzičnogo Vihovannã
Abbreviated key-title: Teor. metod. fiz. vihov.

Науково-методичний журнал
Scientific-methodological journal

Серпень 2023. Том 23, № 4
August 2023. Vol. 23, Num. 4
<https://doi.org/10.17309/tmfv.2023.4>

Відповідальний за випуск	О. М. Худолій
Комп'ютерна верстка	М. О. Худолій
Коректор	Є. Б. Бланк

Свідоцтво про державну реєстрацію серія КВ № 6255 від 21.06.2002 р. Засновник і видавець – ТОВ «ОВС».
Передплатний індекс **74667**. Адреса редакції: <https://www.tmfv.com.ua>. Тел.: (067) 578-40-08. E-mail: tmfv@tmfv.com.ua

Наказом МОН України від 26.11.2020 № 1471 журнал включено в категорію «А» фахових видань України.
Науки: фізичне виховання і спорт. Спеціальність: 017 – Фізична культура і спорт (26.11.2020).
Науки: педагогічні (26.11.2020). Спеціальності: 011 – Освітні, педагогічні науки (26.11.2020);
014 – Середня освіта (за предметними спеціальностями) (26.11.2020).

Підписано до друку 28.08.2023. Формат 60×84 1/8. Папір офсетний. Гарнітура Таймс. Друк офсетний.
Ум. друк. арк. 17,85. Обл.-вид. арк. 18,5. Вид. № 04-2023. Зам. № 156. Тираж 300 прим. Ціна договірна.

ТОВ «ОВС» Україна, 61003 Харків, пл. Конституції, 18, к. 11.
Свідоцтво Держкомінформу України Серія ДК № 331 від 08.02.2001 р.
Друкарня ТзОВ «Цифра прінт». 61166, м. Харків, вул. Культури, 20-В