



Applying a 12-Week TRX Suspension and Plyometric Training Program: Effects on Biomotor Abilities and Physiological Adaptations in Volleyball Players

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Abstract

Background. Volleyball players require a combination of physical and physiological abilities to enhance performance, and TRX suspension and plyometric training are known to improve these abilities. However, evidence comparing their effectiveness in volleyball players is limited.

Objectives. This study aimed to investigate the effects of a 12-week TRX suspension and plyometric training program on biomotor abilities and physiological adaptations in male volleyball players.

Materials and methods. Forty-five male athletes (age: 21.91 ± 1.10) from Calicut University, Kerala, India, were involved in the study. The participants were divided into three groups: TRX suspension training, plyometric training, and a control group. Speed, agility, explosive power, vital capacity, and resting heart rate were measured before and after the intervention. The data were then subjected to statistical analyses, including linear mixed-effects models and repeated measures ANOVA, in order to assess group-by-time interactions.

Results. The findings indicate significant improvements in speed ($p < 0.001$), agility ($p = 0.003$), and explosive power ($p < 0.001$) in both training groups, with notable group-by-time interactions. Vital capacity also showed substantial enhancements ($p < 0.001$), while resting heart rate remained unchanged.

Conclusions. In conclusion, both TRX suspension and plyometric training have been revealed to be effective in enhancing biomotor abilities and vital capacity in volleyball players, making them viable options for improving performance, without affecting resting heart rate.

Keywords: speed, agility, explosive power, volleyball, resting heart rate.

Introduction

Volleyball is an extremely demanding sport that requires a combination of varying levels of speed, agility (change of direction), power production and endurance (Weldon et al., 2021). These physical traits are indispensable as athletes must

perform quick, powerful movements such as jumps, strikes and lateral sprints, making the training of these biomotor skills essential to success (Bashir et al., 2022; Cao et al., 2024). With all the physical work required, specific training methods are essential for improving key volleyball performance fundamentals, such as block-jumping ability and overall physiological fitness (Keoliya et al., 2024). TRX Suspension and Plyometric training are widely recognized among the various existing training methods but have not yet been systematically compared in the perspective of volleyball players.

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TRX Suspension training is a form of bodyweight exercise which develops strength, balance, flexibility and core stability (Gaedtke & Morat, 2015). It is a whole body method to training that uses several muscle groups at the same time. This makes it extremely advantageous for those athletes who need as much coordination or even cross enabled strength possible (Khorjahani et al., 2021a). TRX Suspension training provides improvements in core stability and functional strength, which are especially important for volleyball players that perform a variety of dynamic, multi-directional movements (Fong et al., 2015). However, this form of training has been proven to improve basic functions in volleyball, such as jumping, spiking with a spike jump and general balance mechanisms while performing defensive actions, e.g., blocking (Ozdamar et al., 2024). Several studies have highlighted that this type of training can improve components of cardiovascular fitness, strength and power, which are characteristics required for optimal performance in volleyball (Cardoso Marques et al., 2006; Niculescu, 2011; Thuc, 2018; Tinto et al., 2017). Furthermore, the instability properties of TRX exercises may enhance neuromuscular coordination and balance which are vital for the complex movement patterning required in volleyball (Nešić et al., 2020; Wang & Liang, 2021). Whilst the investigation into TRX Suspension Training effectiveness in volleyball players is scarce, available evidence provides some support for its inclusion as part of a balanced physical preparation program.

Plyometric training, on the other hand, is intended to improve explosive power and strength through rapid muscle contractions (Bastholm, 2024). Training in this way helps to utilize the stretch-shortening cycle of the muscles, which can help developing greater forces at a faster rate in athletes (Wang et al., 2023). This exercises are predominantly effective in improving athletes' vertical jump height, which is important for volleyball players who frequently jump to spike or block during games (Tupinambá Oliveira et al., 2023). Several existing research supports Plyometric training for its ability to enhance rapid force production, speed, and agility qualities which are fundamental to the quick, powerful movements required in volleyball (Booth & Orr, 2016; Chaturvedi et al., 2023; Kons et al., 2023).

While TRX suspension and plyometric training have both been extensively studied for their benefits to athletes, however most of the existing literature tends to focus on general populations or athletes from sports such as soccer, basketball, and track and field, rather than volleyball players (Aslani et al., 2018; Bastholm, 2024; Cao et al., 2024; Liu et al., 2024; Negra et al., 2017). Few studies specifically explore the impact of these training methods on volleyball players' performance, particularly in terms of key outcomes like vertical jump height, agility, and speed. Additionally, the physiological adaptations brought about by these training methods, such as changes in resting heart rate and vital capacity, have rarely been examined in volleyball players (MacInnis & Gibala, 2017; Manna et al., 2012; Périard et al., 2021).

Given the limitations in existing research, there is a need for studies that compare the effectiveness of TRX Suspension and Plyometric training on both bio motor abilities and physiological parameters in volleyball players. Therefore, this study aims to investigate the effects of a 12-week training program incorporating both methods on performance indicators such as speed, agility, and explosive power, as well

as on physiological variables like resting heart rate and vital capacity, to determine which approach is more effective in enhancing volleyball performance.

Materials and Methods

This study utilized a randomized control trial with pre-test, post-test, TRXG, PTG, and CG. Every research participant was randomly divided into three groups (TRXG, PTG, or CG). Subjects were asked to continue their voluntary participation throughout the program. The study included three phases: pre-testing, training interventions, and post-testing. Furthermore, pre-and post-test procedures were carried out two days before and following the 12-week training program. All participants underwent a trial testing session prior to the pre- and post-test. Before beginning the entire study process, the research study and study procedure were approved (HEC/PU/2023/10/07-08-2023) by the Institutional Ethical Committee at Pondicherry University, India, in accordance with the Helsinki Declaration.

Study Participants

Initially, the study comprised 47 male volleyball players from various affiliated colleges in Calicut University, Kerala, India, aged between 18-24 years. All of the participants (n = 47) participated in intercollegiate tournaments. However, two volleyball players were excluded from the study due to pre-existing musculoskeletal injuries. The remaining participants (n = 45) had no history of injury. Each player had a minimum of two years of prior volleyball experience and at least six months of training experience in plyometric and traditional resistance training; they were considered as study participants. Before the commencement of the training and testing procedures, the researcher provided a detailed explanation of the research objective, both verbally and in writing, to ensure their complete understanding of the study. Informed consent was obtained from all participants in written form, including their voluntary consent to participate in the study. Once the procedure for inclusion and exclusion was completed, the characteristics of the participants who remained in the study were as follows: age = 21.91 ± 1.10 , weight = 82 ± 6.35 , and height = 1.84 ± 0.6 . The study design and sample sizes at various stages of the research are depicted graphically in Figure 1.

Outcome Measures

In this study, the outcome measures assessed including bio motor abilities such as speed, agility, and explosive power, alongside physiological adaptation, which includes resting heart rate and vital capacity. All testing measurements were conducted both before and after (pre and post-test) the 12 weeks of the intervention period (TRX and PT). Throughout the testing process, the researcher ensured participant safety by supervision and implementing proper warming up and warming down procedures to minimize the risk of injury and optimize performance during the assessment.

Speed

The speed was evaluated by means of a 50-meter run that was adapted from the procedures described in earlier

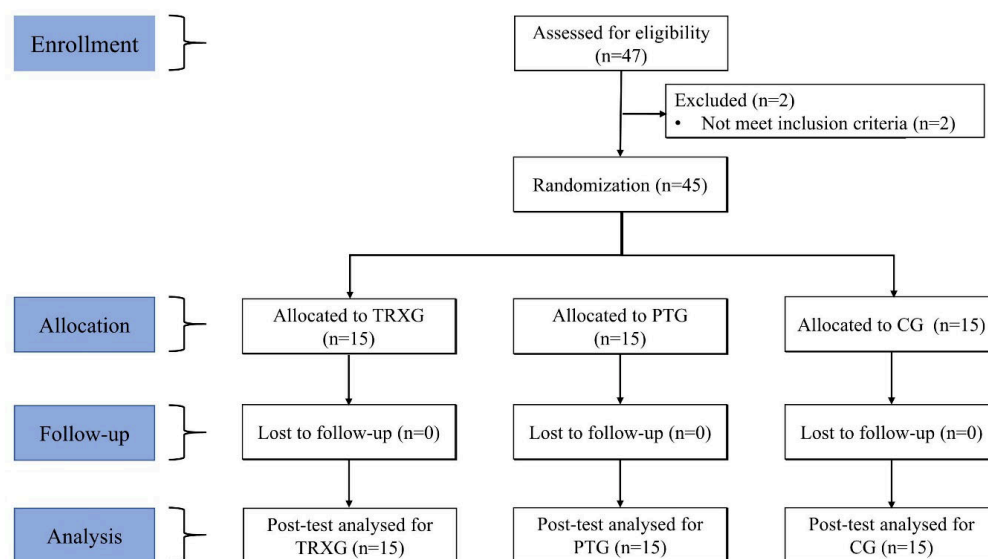


Fig. 1. Semantic representation of research study

research (Astuti et al., 2024; K V et al., 2024; Mahalingam et al., 2024) known for its dynamic training potential, offers multi-planar movements to enhance strength, endurance, and coordination. However, its impact on Kabaddi players still needs to be explored. To assess the effects of Bulgarian Bag training (BBT), and the test was carried out on an outdoor track. The participants were positioned behind the starting line with preferred leg forward and instructed to begin the test only upon the tester's signal. Each participant completed three timed trails, with time recorded by the timekeeper. The best performance from the three trials was selected as the final speed test score. Sufficient rest (5 minutes) interval was provided between trials to allow for full recovery.

Agility

The t-test was utilized to assess agility. The T-test was carried out in accordance with the procedure that was stated in the prior research (França et al., 2022). The participants were positioned behind the starting line with their preferred leg forward, and they were instructed to begin the test only upon the tester's signal. Starting the signal participants were run (strait run) 9.14 meters straight to the center marker. Then the participants turned left and ran (sideward run) towards the left 4.75-meter marker. Participants then make a right turn and run (sideward run) to the 9.14-meter marker, turning around to return 4.75 meters to the center marker (sideward run). Finally, the participant run (backward) towards the finish line. Participants should touch each marker as they approach it. Every participant finished three timed trails, and the timer kept track of their times. The final agility test score was determined by taking the best result out of the three trials. There was a sufficient rest period of five minutes in between every test to ensure full recovery.

Explosive Power

Vertical jump was tested using VERTEC vertical jump test, which is a valid tool to measure vertical jump

(Markwell et al., 2023). vertical jump administered in line with the guidelines provided in the earlier research (Lee et al., 2020) body mass index: 22.5 kg/m². First, the standing arm reach on Vertec was measured based on standing height. participants stand with their feet planted firmly on the ground, their trunk held erect, and they raised their dominant arm as high as they can. When the middle finger touched the highest point, the first score was recorded. Then, with the heel resting on the ground, participants step one foot away from the wall, jump to the highest point possible, and use their hands to touch Vertec. It is advised to jump with your hands swinging for maximum reach. The vertical jump score was calculated from the initial touch (standing reach) to the maximum jump height.

Resting Heart Rate

The resting heart rate (RHR) was measured by manual radial palpation in the early hours of the morning, before proceeding with the daily activity, which was valid test to measure the resting heart rate (Sharma & Singh, 2020). Manual radial palpation method administered in line with the guidelines provided in the earlier research (Stankute, 2022). While doing the measurement the researcher located the radial artery at the wrist. Once the pulse was detected, the evaluation process commenced, lasting for duration of one minute (beats per minutes).

Vital Capacity

Vital capacity was measured using spirometer and the values expressed in liters (Govindasamy et al., 2024; Sukadiono et al., 2022). During the assessment, each participant was allowed three attempts to ensure accurate results. The highest value out of three trials was recorded as the final vital capacity of the participants. After each trail, the spirometer was carefully inspected and calibrated to ensure the optimal functioning before the next trail in the earlier research (Govindasamy et al., 2023).

Training Intervention Procedure

Based on the information shown in Table 1 and 2, the training intervention for both the TRXG and the PTG was intended to be gradual and planned over a period of 12 weeks. Three weeks of familiarization were provided to each group of participants before to the beginning of each training intervention. This familiarization is equivalent to fifty percent of the intensity of the actual training program. There are three sessions each week (Monday, Wednesday, and Friday) during which TRX bands and unsuspension training utilizing body-weight are performed. TRX Squats, TRX Rows, TRX Chest Press, TRX Mountain Climbers, TRX Lunges, TRX Inverted Rows, TRX Push-ups, TRX Jump Squats, TRX Chest Fly, TRX Box Jumps and TRX Power Pulls were the exercises that were included in the training regimens. These movements were designed to target important muscle groups in the lower body and upper body. A warming for both training intervention lasting 10-15 minutes which includes general and specific warming ups and dynamic stretching, a training session lasting 45-60 minutes, and a cool-down lasting 5-7 minutes are all included in each session. Similarly, Plyometric training takes place over the course of three weekly sessions on Tuesdays, Thursdays and Saturdays. The exercises in the training regimens includes Box Jumps, Medicine Ball Overhead Throws, Tuck Jumps, Lateral Bounds, Depth Jumps, Plyometric Push-ups, Split Squat Jumps, Standing Long Jumps, Medicine Ball Slam, Single-Leg Bounds and Depth Jumps with Medicine Ball Slam. which also targeted the muscular areas in the upper and lower bodies. In the TRX training program, the intensity was predetermined by the number of repetitions, the number of sets, the number of exercises performed per session, and the difficulty of the activity. The intensity of the plyometric training was determined by several key variables, which included the number of repetitions, the number of sets, the number of exercises performed per session. Especially, for the lower body exercises, box height was progressively increased; 12 inches during 1-4 weeks, 18 inches during 5-8 weeks, and 24 inches

during 9-12 weeks. Upper body training intensity was adjusted based on the weight of the medicine ball, starting with 3 kg in 1-4 weeks, 5 kg in 5-8 weeks, and 7 kg in 9-12 weeks. Participants in both the TRXG and PTG groups were given the instruction to rest for a period of 120 seconds between sets and for a period of 30-40 seconds between exercises. This was done to ensure that they had ample time to recover while still maintaining an appropriate intensity level throughout the training sessions.

Statistical Analyses

The data are presented as means with corresponding standard deviations (\pm SD). Normality across variables was assessed and confirmed using the Shapiro-Wilk test, while Levene's test was employed to verify the homogeneity of variance. Training-related effects were examined via a linear mixed-effects model, which was applied in the form of a repeated measures analysis of variance (ANOVA) with two factors: group (TRXG, PTG, CG) and time (pre, post). When significant group-by-time interactions were observed, post hoc comparisons using the Bonferroni correction were conducted. In cases where the assumption of sphericity was violated, as indicated by Mauchly's test, Greenhouse-Geisser corrections were applied. Partial eta squared (η^2) values were extracted from the ANOVA results to indicate effect sizes, and Cohen's d was calculated to assess the magnitude of differences, classified as trivial (< 0.2), small ($0.2-0.59$), medium ($0.60-1.19$), large ($1.2-1.99$), or very large (≥ 2.0). A predefined contrast analysis was employed to evaluate the hypothesis (H1) that both training groups (TRXG, PTG) would show more significant improvements in outcome variables compared to the control group. Specifically, we compared the control condition against the combined effect of the two training groups (TRXG and PTG). This analysis method allowed us to assess theoretical expectations in relation to observed group means, providing more nuanced insight beyond what post hoc analyses typically offer. Statistical significance was set at $p < 0.05$.

Table 1. TRX training program

Weeks	Number of Exercise per session	Volume (sets \times reps)	Rest in between sets (Minutes)	Rest in between exercise (Seconds)
Week 1-4	5	3 \times 6-8	2	30-40
Week 5-8	7	3 \times 8-10	2	30-40
Week 9-12	9	3 \times 6-10	2	30-40

Exercise: TRX Squats, TRX Rows, TRX Chest Press, TRX Mountain Climbers, TRX Lunges, TRX Inverted Rows, TRX Push-ups, TRX Jump Squats, TRX Chest Fly, TRX Box Jumps, TRX Power Pulls

Table 2. Plyometric training program

Weeks	Number of Exercise per session	Volume (sets \times reps)	Rest in between sets (Minutes)	Rest in between exercise (Seconds)
Week 1-4	5	3 \times 6-8	2	30-40
Week 5-8	7	3 \times 8-10	2	30-40
Week 9-12	9	3 \times 6-10	2	30-40

Exercise: Box Jumps, Medicine Ball Overhead Throws, Tuck Jumps, Lateral Bounds, Depth Jumps, Plyometric Push-ups, Split Squat Jumps, Standing Long Jumps, Medicine Ball Slam, Single-Leg Bounds, Depth Jumps with Medicine Ball Slam

Results

All volleyball players completed the study without any withdrawals, injuries, or missed training sessions. The results for the dependent variables from the main analysis are provided in Tables 3 and 4. The pre- and post-intervention percentage changes are illustrated in Figure 2.

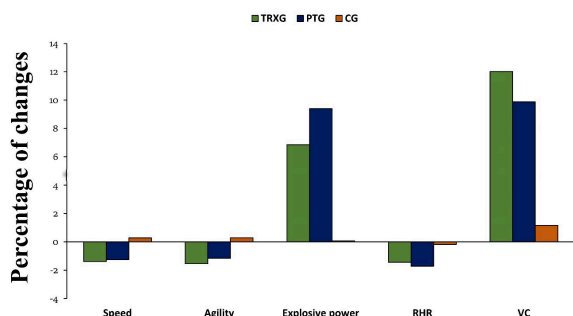


Fig. 2. Pre- and post-intervention percentage changes of outcome measures

Bio motor variables

Table 3 presents the results for bio-motor variables. A significant main effect of time was identified for speed ($p < 0.001$; $F = 13.26$, $\eta^2p = 0.240$), agility ($p = 0.003$; $F = 10.24$,

$\eta^2p = 0.196$), and explosive power ($p < 0.001$; $F = 214.97$, $\eta^2p = 0.837$). However, a significant main effect of group was only noted for explosive power ($p = 0.004$; $F = 6.37$, $\eta^2p = 0.233$). Additionally, significant group-by-time interactions were observed for speed ($p = 0.005$; $F = 6.03$, $\eta^2p = 0.223$), agility ($p = 0.007$; $F = 5.64$, $\eta^2p = 0.212$), and explosive power ($p < 0.001$; $F = 54.46$, $\eta^2p = 0.722$). There were no significant main effects of group for speed ($p = 0.330$; $F = 1.13$, $\eta^2p = 0.051$) or agility ($p = 0.522$; $F = 0.66$, $\eta^2p = 0.030$). Post-hoc analyses showed significant decreases from pre- to post-tests for both speed ($p < 0.001$; $d = 0.29$) and agility ($p = 0.003$; $d = 0.33$). Furthermore, post-hoc tests revealed significant improvements in explosive power for both the TRXG ($p = 0.012$; $d = 0.99$) and PTG ($p = 0.007$; $d = 1.12$), with both values under 0.05. Both TRXG and PTG demonstrated significant improvements from pre- to post-tests compared to the control group.

Physiological Variables

Table 4 summarizes the results for physiological variables. A significant main effect of time was observed for vital capacity ($p < 0.001$; $F = 34.73$, $\eta^2p = 0.453$), while the main effect of group was also significant for vital capacity ($p = 0.011$; $F = 5.06$, $\eta^2p = 0.194$). Additionally, significant group-by-time interactions were found for vital capacity ($p = 0.004$; $F = 6.42$, $\eta^2p = 0.234$). However, no

Table 3. Comparisons for changes in bio motor variables between TRX Suspension (TRXG), Plyometric Training (PTG), and control groups

Variables	Group	Mean \pm SD		Paired t-test p-value	MD (95% CI)	p (Cohen's d)		
		Baseline	After			Main effect group	Main effect time	Interaction group x time
Speed (seconds)	TRXG	7.19 \pm 0.17	7.09 \pm 0.19	0.022	0.09 (0.01 to 0.17)	0.330 (0.051)	<0.001 (0.240)	0.005 (0.223)
	PTG	7.14 \pm 0.18	7.05 \pm 0.18	<0.001	0.09 (0.01 to 0.05)			
	CG	7.19 \pm 0.19	7.21 \pm 0.23	0.404	-0.02 (-0.07 to 0.03)			
Agility (seconds)	TRXG	10.35 \pm 0.23	10.19 \pm 0.20	0.004	0.15 (0.05 to 0.25)	0.522 (0.030)	0.003 (0.196)	0.007 (0.212)
	PTG	10.36 \pm 0.24	10.24 \pm 0.22	0.037	0.11 (0.00 to 0.22)			
	CG	10.35 \pm 0.24	10.38 \pm 0.25	0.234	-0.03 (-0.09 to 0.02)			
Explosive Power (centimeters)	TRXG	42.86 \pm 1.64	45.80 \pm 1.78	< 0.001	-2.93 (-3.50 to -2.36)	0.004 (0.233)	<0.001 (0.837)	<0.001 (0.722)
	PTG	42.53 \pm 1.64	46.53 \pm 1.40	< 0.001	-4.00 (-4.62 to -3.37)			
	CG	42.77 \pm 1.75	42.80 \pm 1.14	0.806	-0.06 (-0.63 to 0.50)			

TRXG: TRX suspension training group, PTG: plyometric training group, CG: control group

Table 4. Comparisons for changes in physiological variables between TRX Suspension (TRXG), Plyometric Training (PTG), and control groups

Variables	Group	Mean \pm SD		Paired t-test p-value	MD (95% CI)	p (Cohen's d)		
		Baseline	After			Main effect group	Main effect time	Interaction group x time
RHR (bpm)	TRXG	74.13 \pm 3.94	73.06 \pm 3.84	0.320	1.06 (-1.15 to 3.28)	0.374 (0.046)	0.156 (0.047)	0.689 (0.018)
	PTG	73.46 \pm 3.81	72.20 \pm 3.38	0.247	1.26 (-0.98 to 3.51)			
	CG	74.40 \pm 2.61	74.26 \pm 3.01	0.880	0.13 (-1.72 to 1.99)			
VC (mL)	TRXG	3.41 \pm 0.20	3.82 \pm 0.22	<0.001	-0.40 (-0.60 to -0.20)	0.011 (0.194)	<0.001 (0.453)	0.004 (0.234)
	PTG	3.44 \pm 0.17	3.78 \pm 0.24	0.001	-0.34 (-0.52 to -0.15)			
	CG	3.44 \pm 0.19	3.48 \pm 0.20	0.405	-0.04 (-0.14 to 0.06)			

VC: vital capacity, bpm: beat per minute, mL: milliliters, TRXG: TRX suspension training group, PTG: plyometric training group, CG: control group

significant time effect was detected for resting heart rate ($p = 0.156$; $F = 2.08$, $\eta^2p = 0.047$), and no main effect of group ($p = 0.374$; $F = 1.00$, $\eta^2p = 0.046$) or group-by-time interaction ($p = 0.68$; $F = 0.37$, $\eta^2p = 0.018$) was found for resting heart rate. Post-hoc analyses indicated significant improvements in vital capacity for both the TRXG ($p = 0.022$; $d = 0.71$) and PTG ($p = 0.022$; $d = 0.68$), with p -values below 0.05. Moreover, post-hoc tests demonstrated significant pre-to-post improvements in both the TRXG and PTG when compared to the control group.

Discussion

This research compared the motor skill performance and physiological feedback of 18-24-year-old male volleyball players performing 12-week TRX suspension and Plyometric Training. The findings establish that the modes enhance other crucial compartments of performance, such as speed, agility, and explosive power. For volleyball players, increases in these motor skills are critical since quick movement, quick direction changes, and explosive power are all important for in-game success.

The TRXG and PTG groups demonstrated marked improvements regarding speed and agility. The TRXG showed a 1.39% improvement in speed, while the PTG showed a 1.26% improvement. Similarly, agility improved by 1.55% in the TRXG and 1.16% in the PTG. These results highlight how both training approaches can be applied to help athletes become more adept at responding fast and effectively on the court, which can lead to better performance during competitive play. Of the improvements, the agility enhancement underscores the need to incorporate the training programs because volleyball players often change direction to cover for fast-moving balls. A breathtaking consideration is that PTG experiences a higher increase in the magnitude of explosive power than the TRXG. Whereas the TRXG recorded a more general uplift of 6.86 percent in explosive power, the PTG recorded a much higher recovery rate of 9.41 percent. This implies that plyometric training focuses more on rapid force production than power training and thus could be more suitable for enhancing explosive power, a skill seen frequently in volleyball. Plyometric exercises, including jumps and sprints, may engage fast-twitch muscle fibers to a more significant extent than the TRX suspension exercises, mainly based on strength and steadiness. Plyometric activities might help recruit the fast-twitch muscle fibers compared to the TRX suspension exercises, which involve strength and balance exercises (Aksović et al., 2021; Chandra et al., 2023; Wang et al., 2023).

The improvements in explosive power have functional implications beyond volleyball. Since explosive power plays a crucial role in many sports that demand sudden bursts of strength—like basketball, soccer, and track events—plyometric training can be vital to training programs across various disciplines (Aksović et al., 2020, 2021). This concurs with earlier studies' findings that sound Plyometric conditioning enhances explosive performance in sporting activities involving intermittent intensive efforts within a limited timeframe (Keoliya et al., 2024b; Mancini et al., 2024). In addition, the rise in the vital capacity by 12 percent in the TRXG and 9 percent in the PTG depicts a positive allochronic adjustment in athletes' respiratory systems,

resulting in increased stamina. This enhancement suggests that with training, the two programs enhance better oxygen delivery, and hence, athletes can sustain high energy output for a longer time.

This finding aligns with studies emphasizing the role of aerobic adaptations in athletic performance, especially in sports requiring sustained periods of effort (Hussein et al., 2024; Stensrud et al., 2020). Although no significant changes were observed in resting heart rates, this could indicate that a longer training duration is essential to achieve noticeable cardiovascular adaptations (Mannakkara & Finocchiaro, 2023; Parry-Williams & Sharma, 2020). Although TRX suspension and plyometric training programs significantly improve motor abilities, each method offers different advantages. Plyometric training's superior effectiveness in explosive power development indicates it primarily benefits movements that require rapid force production (Behm et al., 2024; Moran et al., 2021). Plyometric workouts may well be another effective model of training those invaluable skills since volleyball is a sport that considerably involves such aspects as repeated jumps, sprints to cover short distances, and rate turns (Keoliya et al., 2024; Watkins et al., 2021). However, TRX suspension training improves muscle strength, steadiness, and balance (Blasco et al., 2023; Khorjahani et al., 2021). This training modality involves only bodyweight movements targeting the core and stabilizer muscles for joint stabilization and overall control (Khorjahani et al., 2021; Piri et al., 2021). For volleyball players, where injury prevention and stability during dynamic movements are crucial, TRX training can serve as a practical tool for maintaining physical resilience and reducing the risk of injury (Aslani et al., 2018; Fayazmilani et al., 2022; Khorjahani et al., 2021). TRX exercises also help with general athletic development since they train several muscles simultaneously and are valuable, along with plyometrics regarding specific exercise types (Alhenawy, 2023; Moghadasi et al., 2024).

From the positive impact seen from each training method, it will significantly benefit if volleyball players integrate the TRX and plyometric exercises into their training program. A combination of both training types could train speed, agility, explosive power, and general strength, which seems apt to volleyball players as the game demands all-around physical endurance. This way, integrating TRX suspension training for enhancing the body's stability and control along with plyometric training for enhancing explosive power of the body, the athletes would come to much more improved performances on an all-around scale, which is always beneficial, especially in competitions. It would be necessary for future studies to look at the physiological and performance changes over more significant periods with these combined training schemes to pinpoint the precise lengths and intensities that would bring about the best changes in the body and, eventually, performance. Furthermore, evaluating the effects of TRX and plyometric training on the athlete's cross-sectional might help enhance the understanding of the possibility of these effects.

Conclusion

The study's conclusion reaffirms that suspension exercise, especially TRX and Plyometric Training, affects motor and physiological performance among male volleyball athletes.

Plyometric training is preferred to plyometrics for explosive power development and essential change of direction movements and jumps. On the other hand, TRX training strengthens muscular strength and postural and core muscle control and protects against physical injuries. Both methods also demonstrate increased vital capacity, which is generally significant, but no changes in resting heart rate, suggesting that longer training durations may be required to achieve cardiovascular changes. It is proposed that these training methods be incorporated to deal with the many tactical demands of volleyball to create speed, power, agility, and endurance among the athletes for competitive performance.

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Conflict of Interest

No conflict of interest was reported by the authors.

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Застосування 12-тижневої програми за методиками TRX-тренувань з власною вагою із використанням підвісних конструкцій та пліометричних тренувань: Вплив на показники біомоторних здібностей та фізіологічних адаптацій у волейболістів

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

Реферат. Стаття: 10 с., 4 табл., 2 рис., 52 джерела.

Історїя питання. Задля поліпшення показників результативності волейболїсти потребуєть поєднання фізичних і фізіологічних здібностей, а виконання TRX (Total Resistance exercises — вправи на загальний опір) тренувань з власною вагою із використанням підвісних конструкцій (петель) та пліометричних тренувань, як вїдомо, покращує такі здатності. Проте їснує недостатньо доказів щодо порівняння ефективності застосування зазначених методів у волейболїстів.

Мета дослідження. Мета дослідження полягала у вивченнї впливу 12-тижневої програми за методиками TRX-тренувань з власною вагою із використанням підвісних конструкцій та пліометричних тренувань на показники біомоторних здібностей та фізіологічних адаптацій у волейболїстів-чоловїків.

Матерїали та методи. У дослідженнї взяли участь сорок п'ять спортсменів-чоловїків (вік: 21,91 ± 1,10) з університету Калїкут, штат Керала, Індїя. Учасників було розподїлено на три групи: TRX-тренування з власною вагою із використанням підвісних конструкцій, пліометричнї тренування та контрольна група. Перед початком і після завершення інтервенції вимїрювали показники швидкості, спритності, вибухової сили, життєвої ємності легень і частоти серцевих скорочень у станї спокою. Після проведення цього етапу данї були підданї статистичному аналізу, включаючи лїнійнї

моделі змішаних ефектів і повторні вимірювання дисперсійного аналізу (ANOVA) з метою оцінки взаємодії між групами в залежності від часу.

Результати. Отримані дані свідчать про значне покращення показників швидкості ($p < 0,001$), спритності ($p = 0,003$) та вибухової сили ($p < 0,001$) в обох тренувальних групах, з помітною міжгруповою та часовою взаємодією. Також показано суттєве поліпшення показників життєвої ємності легень ($p < 0,001$), тоді як частота серцевих скорочень у стані спокою залишилася незмінною.

Висновки. Таким чином, доведена ефективність застосування TRX-тренувань з власною вагою із використанням підвісних конструкцій та пліометричних тренувань в контексті підвищення біомоторних здібностей, життєвої ємності легень у волейболістів, що дозволяє використовувати вищезазначені методики в якості дієвого інструменту для покращення показників результативності, не впливаючи на частоту серцевих скорочень у стані спокою.

Ключові слова: швидкість, спритність, вибухова сила, волейбол, частота серцевих скорочень у стані спокою.

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