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Functional Joint Mobility in Young Athletes Practicing Bocce Raffa: Implications for the Performance Model

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Abstract

Objectives. Bocce is a precision sport that requires coordination and technical control. In the Raffa specialty, upper limb coordination and postural control are particularly important. Despite its widespread practice, research on the functional characteristics of youth players remains limited. This exploratory analytical pilot study aimed to examine joint mobility as a functional configuration within the movement system underlying the Raffa technical gesture.

Materials and Methods. Twenty-five athletes aged 14–18 years were assessed during regional training events organized by the Campania Bocce Committee. Joint mobility was evaluated using three field tests: the Shoulder Mobility Test, a scapulo-humeral mobility test with stick rotation, and a seated forward trunk flexion test. Descriptive statistics, independent samples t-tests, and Pearson correlations were calculated. Bartlett's test of sphericity and an exploratory Cronbach's alpha were used to assess the integrative structure of mobility parameters.

Results. Significant differences emerged in scapulo-humeral mobility and spinal flexibility, whereas no differences were found in shoulder mobility. Correlation analyses revealed weak to moderate relationships among the variables. Bartlett's test ($\chi^2_{(3)}$=9.63, p=0.022) and a Cronbach's alpha of 0.65 supported the presence of an integrated mobility structure, indicating interdependence among segments.

Conclusions. Joint mobility acts as a non-linear, context-dependent resource, functioning as both a facilitator and a constraint depending on its integration within the movement system. Functional effectiveness in the Raffa gesture depends on the balance among shoulder, scapulo-humeral, and spinal components rather than on isolated maximal values. The study proposes a preliminary explanatory framework in which joint mobility mediates the relationship between movement amplitude and control.

Keywords: Raffa specialty, joint mobility, youth athletes, flexibility, sport performance.

Introduction

The game of bocce represents one of the most deeply rooted sporting disciplines in European and Mediterranean traditions, characterized by a long cultural history and by a progressive technical and regulatory evolution that has consolidated its identity within the contemporary sports landscape (Febrianingrum, & Diana, 2021). Today this discipline is recognized as a highly codified precision sport in which technical skills, motor control, and the management of environmental variables play a central role in determining performance outcomes. Within the international organizational framework, the sport of bocce is structured into three main specialties, Volo, Pétanque, and Raffa, each characterized by specific technical, regulatory, and biomechanical dynamics. Among these, the Raffa specialty represents one of the most widespread and practiced forms in Italy, distinguished by the particular technical complexity of the motor actions required and by the high level of precision demanded during the phases of play (Türkmen et al., 2018).

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The growing attention toward the scientific analysis of sports performance has progressively involved disciplines traditionally considered less investigated compared with team sports or widely practiced Olympic disciplines. In this context, bocce is increasingly emerging as a field of interest within sport and exercise sciences, particularly with regard to the study of performance models and the physical and coordinative components that contribute to the effectiveness of the technical gesture. Despite the apparent simplicity of the actions involved, performance in bocce, and especially in the Raffa specialty, requires a sophisticated balance between motor precision, intersegmental coordination, postural control, and the management of force (Şimşek, & Kesilmiş, 2022). These elements become particularly evident during the phases of shooting and pointing, in which the player must accurately regulate the trajectory and velocity of the bowl while maintaining stability and fluidity of movement (Irawan et al., 2024).

Within this framework, one of the least investigated yet potentially relevant aspects for understanding performance concerns the role of joint mobility. Joint mobility represents a fundamental component of motor functionality, understood as the capacity of a joint to move within its physiological range of motion in a controlled and efficient manner. Joint mobility should not be considered as an isolated characteristic, but rather as a functional element within the kinetic chain, contributing to the coordination between proximal stability and distal movement control required for precise motor execution, and enabling the efficient transmission of forces along the movement sequence. In the context of sports technique, it contributes to the quality of motor execution, influencing coordination, movement economy, and injury prevention. In disciplines that require precision gestures and repetitive movements, such as bocce, joint mobility assumes particular significance because it allows the optimization of the kinetic chain involved in the execution of the technical gesture. However, in precision-based motor tasks, joint mobility should not be interpreted as a uniformly beneficial attribute, as both insufficient and excessive mobility may alter the balance between movement amplitude and control, potentially affecting the stability and reproducibility of the gesture. In the game of Raffa, the motor gesture that characterizes the principal actions of play involves a coordinated sequence of movements engaging several body segments, particularly the dominant upper limb, the trunk, and the lower limbs (Helmi, et al., 2024). During the execution of shooting or pointing actions, the player performs a coordinated movement that begins with body positioning and develops through a progressive activation of the kinetic chain, culminating in the release of the bowl. Within this motor sequence, the mobility of the shoulder, elbow, and wrist joints plays a decisive role in ensuring fluidity and precision of the gesture. At the same time, the mobility of the pelvis and lower limbs contributes to postural stability and to the correct distribution of forces during the execution phase (Gür et al., 2022). In this perspective, joint mobility assumes a regulatory role within the movement system, influencing the balance between movement amplitude and control, and determining the conditions under which the technical gesture can be executed with accuracy and consistency. Accordingly, joint mobility may be conceptualized as a resource operating under specific functional conditions, rather than as a linear determinant of performance.

Despite these biomechanical and functional considerations, the scientific literature dedicated to the analysis of the physical characteristics of bocce players still appears limited, particularly when compared with the large body of studies available in other sporting contexts (Firdaus, & Irfan, 2023). Most of the existing research mainly focuses on the technical and tactical aspects of the game or on competitive dynamics, while the physiological and motor components that characterize the athlete's performance model remain insufficiently explored (Hafidz et al., 2024). This gap becomes even more evident when attention shifts to the youth sector, an area in which knowledge of athletes' motor characteristics can represent a fundamental tool for guiding processes of sports training and the development of technical competencies (Latino et al., 2019).

The study of motor abilities in young athletes represents a field of considerable interest within sport sciences because it allows researchers to understand how processes of growth and maturation interact with motor learning and with the development of specific abilities required by a given discipline (Susanto et al., 2024). In the case of bocce, and particularly within the Raffa specialty, youth development represents a crucial phase for the acquisition of the technical and coordinative foundations of the game gesture. During this stage, joint mobility may play a particularly relevant role because it supports motor learning and the development of efficient movement patterns (Scamardella et al., 2025).

Joint mobility in young athletes is influenced by several factors, including biological age, level of physical activity, individual morphological characteristics, and previous motor experiences. During growth phases, the musculoskeletal system undergoes important structural and functional changes that may influence the movement capacity of the joints. A proper evaluation of joint mobility during this stage of development can therefore provide useful indications both for optimizing training programs and for preventing possible functional limitations that might negatively affect the quality of the technical gesture (Raiola et al., 2015).

Furthermore, the analysis of joint mobility in young bocce players may contribute to the definition of a more precise performance model for this sport discipline. The concept of a performance model represents a fundamental tool within training methodology because it allows the identification of the set of physical, technical, and psychological characteristics that contribute to the realization of effective performance. Through the identification of the variables that most strongly influence performance, it becomes possible to guide training processes and athlete development in a more targeted and evidence-based manner (Irawan, 2019). From this standpoint, joint mobility can be conceptualized as a functional variable within the performance model, interacting with coordination, postural control, and movement stability to influence the effectiveness and reproducibility of the technical gesture. In this sense, its contribution to performance should be interpreted in relation to its capacity to remain within functional limits compatible with control demands, rather than in terms of maximal range of motion alone.

In the specific case of bocce, the definition of a performance model appears particularly complex because the discipline lies at the intersection between precision sports and technical coordinative activities. Competitive success does not depend exclusively on traditional conditional abilities such as strength or endurance but rather on a combination of fine motor skills, neuromuscular control, concentration capacity, and the management of the playing space. Within this framework, joint mobility may represent a functional component capable of indirectly influencing the effectiveness of the technical gesture and the overall quality of performance (Eler, & Eler, 2018).

Another element of interest concerns the possibility of using joint mobility assessment as a monitoring tool within the developmental pathway of young athletes. The introduction of functional evaluation protocols within bocce schools and youth sectors could foster greater awareness of athletes' motor characteristics, enabling coaches to adapt training programs to the specific needs of individual players (Badruzaman, 2021).

In light of these considerations, there is a clear need to further investigate the motor characteristics of young practitioners involved in the Raffa specialty, with particular attention to joint mobility and its potential role in supporting the effectiveness of the technical gesture. The lack of systematic data in this field makes it necessary to initiate exploratory studies and pilot projects capable of providing initial indications useful for the construction of a more solid knowledge base (Yuan, & Li, 2022).

The present study is positioned within this exploratory perspective, with the aim of contributing to the understanding of joint mobility characteristics in young bocce players engaged in the Raffa specialty. Through the assessment of selected mobility parameters involving the shoulder complex and the spinal column, this research seeks to provide an initial functional profile of joint mobility in youth athletes practicing this discipline. In particular, the study aims to analyze joint mobility not only in terms of variability, but also in relation to its potential functional role within the movement system underlying the technical gesture of bocce. Furthermore, the study seeks to provide an initial interpretative framework for understanding how different mobility characteristics may influence movement control, coordination, and the balance between stability and mobility in young athletes. More specifically, the study adopts a functional systems perspective in which joint mobility is interpreted as an organized set of interdependent components within the movement structure of the Raffa technical gesture. Within this framework, shoulder mobility is considered to support distal segment orientation and fine modulation of the release phase, scapulo-humeral mobility contributes to the regulation of movement amplitude and trajectory continuity, and spinal flexibility plays a key role in postural organization and in the transmission of forces along the kinetic chain. The interaction among these components is hypothesized to determine the functional balance between movement amplitude and control, which is essential for ensuring accuracy, consistency, and reproducibility of the technical gesture. From this standpoint, the effectiveness of joint mobility depends on its capacity to operate within a functional range that simultaneously allows sufficient movement amplitude and adequate control, whereas deviations toward either insufficient or excessive mobility may compromise the stability and precision of the gesture. By framing joint mobility in terms of coordinated functional roles rather than isolated measures, the study seeks to move toward a preliminary explanatory model of how mobility operates within the movement system of young Raffa athletes.

In doing so, the study intends not only to address a gap in the existing literature but also to contribute to the development of greater scientific awareness surrounding a sporting discipline that, although deeply rooted in tradition, continues to evolve and offer new research perspectives within the field of sport and exercise sciences.

Materials and Methods

The present research was designed as a cross sectional exploratory analytical pilot study aimed at investigating joint mobility characteristics in young athletes practicing bocce in the Raffa specialty. The study sought to provide an initial functional interpretation of joint mobility parameters potentially associated with the technical gesture required in this precision sport. Rather than focusing exclusively on descriptive profiling, the study aimed to examine joint mobility as a functional configuration within the movement system underlying the execution of the technical gesture. Given the limited scientific literature focusing on the physical and functional characteristics of bocce athletes, particularly within youth categories, the study was conceived as an exploratory investigation intended to collect preliminary data useful for future research and for the development of a more structured performance model in this discipline. Within this framework, the study adopts an explanatory perspective by proposing a preliminary model in which joint mobility is interpreted as an intersegmental component contributing to movement organization and control.

The research focused on the evaluation of joint mobility through a set of field based motor tests commonly used in sport sciences for the assessment of shoulder complex mobility and trunk flexibility. The tests were selected for their simplicity of administration, their suitability for use in sports training environments, and their relevance to the biomechanical characteristics of the motor actions required in the Raffa specialty. In this context, the selected tests were intended to capture functionally relevant aspects of mobility related to the coordination between upper limb movement, trunk control, and the overall organization of the kinetic chain. Accordingly, each measure was considered not only as an isolated indicator of range of motion, but as a proxy of specific functional contributions within the coordinated movement system.

Data collection was carried out during regional training events organized by the Campania Bocce Committee, allowing the evaluation of athletes within a standardized sporting environment. The study design allowed the collection of objective measurements of joint mobility while minimizing interference with the athletes' regular training activities. This approach ensured that the observed mobility characteristics could be interpreted in relation to real training conditions, supporting their relevance within the practical movement context of the sport. This design supports the interpretation of mobility data not only as descriptive

measures, but as elements contributing to a preliminary explanatory framework of the movement system in young Raffa athletes.

Participants

The study involved a sample of twenty five young athletes practicing bocce in the Raffa specialty. All participants belonged to the junior category and were aged between fourteen and eighteen years. The sample included both male and female athletes, specifically fifteen males and ten females. This age range represents a critical developmental phase in which motor control, coordination, and mobility characteristics are still evolving and may influence the structuring of the technical gesture.

All athletes were actively involved in regional training programs and participated regularly in sporting activities related to the Raffa discipline. The participants were recruited during regional training stages organized by the Campania Bocce Committee, which represented collective technical training sessions involving selected youth players.

The inclusion criteria required that athletes were actively practicing the Raffa specialty and were regularly participating in training activities. All participants were physically able to perform the motor tests included in the study.

Procedures

The motor evaluations were conducted during regional training camps organized by the Campania Bocce Committee. All tests were performed in January 2026 within the context of these collective training sessions.

Before the administration of the tests, the athletes received clear instructions regarding the execution procedures. The tests were conducted under the supervision of trained evaluators in order to ensure consistency in the measurement procedures and to minimize potential execution errors. Each athlete performed the motor tests according to standardized protocols. When required by the test procedure, multiple attempts were allowed in order to obtain the best possible performance. Adequate recovery time was provided between attempts to avoid fatigue effects that could influence the results. The evaluation sessions were organized in a structured manner, allowing athletes to complete the different mobility assessments sequentially while maintaining comparable testing conditions for all participants.

The study was conducted in accordance with the principles of the Declaration of Helsinki. The research protocol was approved by the Institutional Review Board of the University of Naples "Parthenope" (DiSMMeB Prot. N. 88592/2024). Written informed consent was obtained from all participants and, in the case of minors, from their parents or legal guardians prior to participation in the study.

Measures

Three motor tests were administered in order to evaluate different aspects of joint mobility involving the shoulder complex and the spinal column. The selection of these tests was intended to capture functionally relevant components of mobility associated with the execution of the technical gesture in bocce, particularly in relation to upper limb coordination and trunk control. More specifically, each test was selected to represent a distinct functional component within the movement system underlying the Raffa technical gesture, allowing the identification of segment-specific roles related to distal control, movement amplitude regulation, and postural stabilization. In this perspective, the assessment protocol was designed not only to quantify joint mobility, but to capture functionally meaningful dimensions directly involved in the organization and control of the Raffa throwing gesture.

Shoulder Mobility Test

The Shoulder Mobility Test was used to assess the global mobility of the shoulder joint. The test was performed in a standing position with the athlete maintaining an upright posture, feet together, and fists closed with the thumbs placed inside the hands. One arm was positioned over the shoulder while the other was placed behind the back, and the athlete attempted to bring the fists as close as possible behind the back. The distance between the closest bony landmarks of the fists was measured in centimeters using a measuring tape. The test was performed three times for each side and the best result was recorded. This test provided an indication of the functional range of motion of the shoulder complex, which is involved in the execution and control of the throwing movement. From a functional perspective, this measure was interpreted as reflecting the capacity of the shoulder joint to support distal segment orientation and fine modulation of the release phase, contributing to the precision and directional control of the technical gesture. More specifically, adequate shoulder mobility allows the athlete to position the upper limb effectively during both the preparatory and release phases, facilitating fine adjustments of trajectory and enhancing the accuracy and repeatability of the gesture in a precision task such as Raffa.

Scapulo-humeral Girdle Mobility

The mobility of the scapulo humeral girdle was assessed through a stick rotation test. The athlete stood upright holding a stick with both hands positioned at its extremities and arms extended in front of the body. The movement consisted of a full circumduction of the arms performed forward, upward, backward, and downward until the stick touched the body, followed by a return to the starting position while maintaining the arms fully extended. During the test, the evaluator ensured that the movement of the arms remained symmetrical and that the elbows were not flexed. At each attempt the grip distance on the stick was progressively reduced. The final measurement corresponded to the minimum distance between the hands, expressed in centimeters, that allowed the athlete to perform the complete movement correctly. This measure reflects the coordination and mobility of the scapulo-humeral complex, which contributes to the control of movement amplitude and fluidity during the execution of the technical gesture. Within the functional model adopted in this study, this parameter was considered indicative of the ability to regulate movement amplitude and ensure continuity of the kinematic chain, supporting the generation of a smooth and

coordinated trajectory during the execution of throwing actions. Functionally, this component is particularly relevant in the Raffa gesture because it mediates the transition between proximal stability and distal control, allowing the athlete to generate sufficient movement amplitude without compromising trajectory continuity and coordination.

Spinal Flexibility

The flexibility of the spinal column was evaluated through a seated forward flexion test similar to the sit and reach protocol. The athlete sat with the feet fully placed against the testing bench and performed several preparatory stretching movements of the lower limb muscles. The arms were then raised upward and, at the signal, the athlete slowly bent forward attempting to reach the furthest possible point on the graduated measuring surface. The position was maintained for a few seconds before returning to the starting posture. Two attempts were performed and the best result was recorded. The measurement was expressed in centimeters based on the position reached by the fingertips. Values were recorded as negative when the athlete was unable to reach the toes and positive when the fingertips passed beyond them. This test provided an indication of trunk flexibility, which is functionally related to postural control and the transmission of forces along the kinetic chain. In the proposed functional framework, spinal flexibility was interpreted as a key component for postural organization and for the effective transmission of forces between lower and upper body segments, contributing to the stabilization of the movement and to the maintenance of control during the execution phase. In the context of the Raffa specialty, this dimension is crucial for maintaining postural stability during the execution phase, ensuring that the movement remains controlled and repeatable while allowing efficient force transfer along the kinetic chain.

The instruments used for the administration of the tests included a measuring tape, a graduated testing bench, a measuring wheel, spatial markers, and a graduated stick.

Statistical Analysis

The collected data were analyzed using descriptive statistical methods in order to summarize the mobility characteristics of the sample. For each test the maximum value, minimum value, mean score, and standard deviation were calculated separately for the male and female groups. These indicators were considered not only to describe variability, but also to identify potential functional ranges and distribution patterns relevant to movement execution.

In addition, frequency distributions were examined in order to identify the most recurrent values within each dataset. This approach allowed the identification of central tendencies that may reflect typical mobility conditions within the analyzed group. The descriptive statistical approach adopted in this study allowed the identification of general trends and variability patterns within the mobility performances of the athletes.

Independent samples t-tests were conducted in order to support a more analytical interpretation of the data. Differences between male and female groups were examined using independent samples t-tests. In addition to statistical significance, effect sizes (Cohen's d) were calculated to estimate the magnitude of between-group differences. Furthermore, correlation analyses (Pearson's r) were performed to explore the relationships between the different mobility parameters assessed.

To further examine whether the three mobility parameters could be interpreted as part of a common functional configuration, the correlation matrix was additionally assessed through Bartlett's test of sphericity. An exploratory estimate of internal coherence was also calculated using Cronbach's alpha. These analyses were intended to support the interpretation of shoulder mobility, scapulo-humeral mobility, and spinal flexibility as interrelated components of an integrated mobility profile.

Given the exploratory nature of the research and the relatively small sample size, the statistical analysis focused primarily on descriptive indicators intended to provide an initial overview of the joint mobility characteristics of young athletes practicing the Raffa specialty. Within this framework, the integration of descriptive and inferential analyses including effect size estimation was intended to support a preliminary functional interpretation of mobility parameters in relation to the organization of the movement system.

Results

The analyzed sample consisted of 25 young athletes practicing bocce in the Raffa specialty, belonging to the junior category (aged between 14 and 18 years). The group included 15 male and 10 female participants. All athletes were subjected to three joint mobility assessments: the Shoulder Mobility Test, the scapulo-humeral girdle mobility test, and the spinal flexibility test. The results are presented separately for the male and female samples. Comparisons between groups were performed using independent samples t-tests (Tab. 1), including effect size estimation (Cohen's d), and relationships among mobility variables were examined using Pearson's correlation analyses. Descriptive statistics for the total sample and by sex are summarized in Table 1.

Table 1. Descriptive statistics of joint mobility parameters.

Variable	Group	Min	Max	Mean	SD	Range
Shoulder Mobility	Total	0	23	6.2	5.8	23
	Male	0	23	8.0	6.8	23
	Female	0	10	3.5	3.6	10
Scapulo-humeral Mobility	Total	29	120	81.3	25.4	91
	Male	66	120	96.46	15.3	54
	Female	29	86	58.8	19.8	57
Spinal Flexibility	Total	-4	27	9.0	8.0	31
	Male	-4	22	7.0	7.41	26
	Female	5	27	12.0	8.42	22

Note. Values are reported for the total sample and by sex. Mean values are presented with standard deviations (SD). Range is calculated as the difference between maximum and minimum values.

Shoulder Mobility Test

In the male sample, the values recorded in the Shoulder Mobility Test ranged from a minimum of 0 cm to a maximum of 23 cm. The mean value was 8 cm with a standard deviation

of 6.8 cm. The most frequently observed values were 1 cm, 13 cm, and 16 cm, each with an absolute frequency of 2 (Fig. 1).

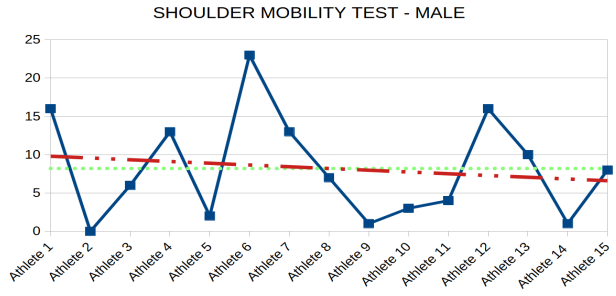

Fig. 1. Shoulder mobility – male sample.

In the female sample, the observed values ranged from a minimum of 0 cm to a maximum of 10 cm. The mean value was 3.5 cm with a standard deviation of 3.6 cm. The most frequently recorded values were 0 cm and 6 cm, both with an absolute frequency of 3 (Fig. 2).

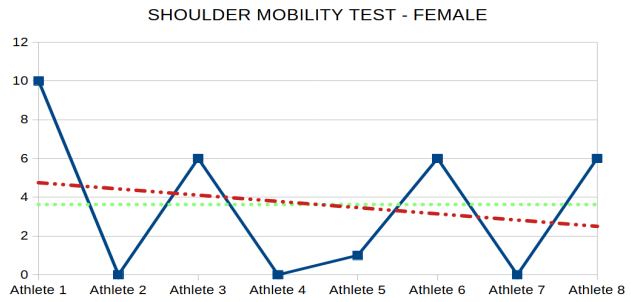

Fig. 2. Shoulder mobility – female sample.

The comparison between male and female groups did not show statistically significant differences in shoulder mobility ($t = 1.92$, $p = 0.067$), with a moderate effect size ($d = 0.85$), indicating a non-negligible magnitude of difference despite the lack of statistical significance.

Scapulo-humeral Girdle Mobility

Regarding the scapulo-humeral girdle mobility test, the values observed in the male sample ranged from a minimum of 66 cm to a maximum of 120 cm. The mean value was 96.46 cm with a standard deviation of 15.3 cm. The value most frequently observed was 120 cm, with an absolute frequency of 3 (Fig. 3).

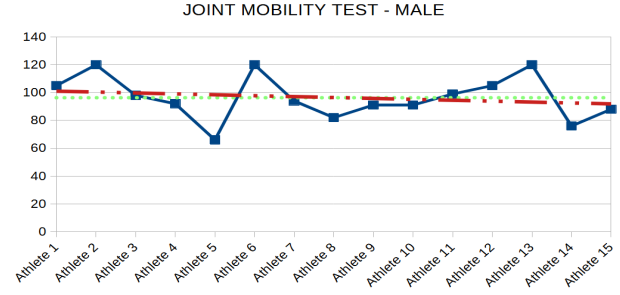

Fig. 3. Scapulo-humeral mobility – male sample.

In the female sample, the recorded values ranged from a minimum of 29 cm to a maximum of 86 cm. The mean value was 58.8 cm with a standard deviation of 19.8 cm. The values were evenly distributed, with an absolute frequency of 1 for each recorded value (Fig. 4).

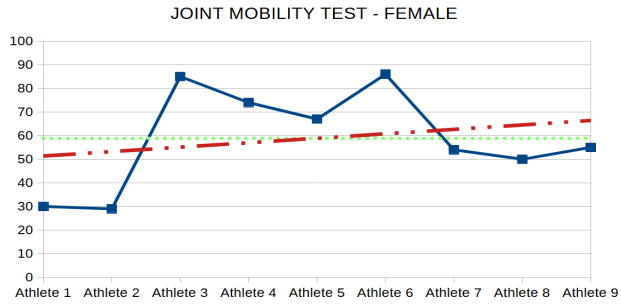

Fig. 4. Scapulo-humeral mobility – female sample.

The comparison between groups revealed statistically significant differences in scapulo-humeral mobility, with higher values observed in the male sample ($t = 5.12$, $p < 0.001$), with a large effect size ($d = 2.10$), indicating a substantial between-group difference.

Spinal Flexibility

In the spinal flexibility test, the male sample showed values ranging from a minimum of −4 cm to a maximum of +22 cm. The mean value was +7 cm with a standard deviation of 7.41 cm. The most frequently observed values were 0 cm and +12 cm, each with an absolute frequency of 3 (Fig. 5).

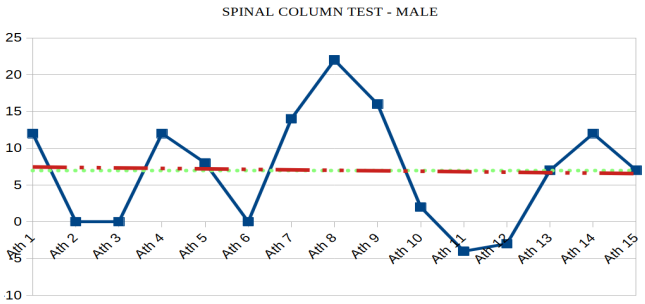

Fig. 5. Spinal flexibility – male sample.

In the female sample, all recorded values were positive and ranged from a minimum of +5 cm to a maximum of +27 cm. The mean value was +12 cm with a standard deviation of 8.42 cm. The most frequently observed value was +7 cm, with an absolute frequency of 3.

The comparison between male and female groups indicated statistically significant differences in spinal flexibility, with higher mean values in the female sample ($t = -2.12$, $p = 0.045$), with a moderate effect size ($d = 0.63$), suggesting a meaningful difference in trunk flexibility between groups (Tab. 2).

Pearson's correlation analyses

Pearson's correlation analyses were also performed to examine the relationships among the three mobility parameters assessed (Fig. 6). A moderate positive correlation

Table 2 - Summary of joint mobility parameters by gender.

Test	Male (Mean ± SD)	Female (Mean ± SD)	p-value	Cohen's d
Shoulder Mobility (cm)	8.0 ± 6.8	3.5 ± 3.6	0.067	0.85
Scapulo-humeral Mobility (cm)	96.46 ± 15.3	58.8 ± 19.8	< 0.001	2.10
Spinal Flexibility (cm)	7.0 ± 7.41	12.0 ± 8.42	0.045	0.63

Note. Values are presented as mean ± standard deviation. p-values refer to independent samples t-tests comparing male and female groups. Effect sizes are expressed as Cohen's d. Conventional thresholds for Cohen's d were applied (small = 0.2, medium = 0.5, large = 0.8).

Table 3. Correlation matrix among joint mobility parameters in young athletes practicing Raffa Bocce.

Variable	Shoulder Mobility	Scapulo-humeral Mobility	Spinal Flexibility
Shoulder Mobility	—	0.46* (p = 0.023)	0.28 (p = 0.174)
Scapulo-humeral Mobility	—	—	0.41* (p = 0.047)
Spinal Flexibility	—	—	—

Note. Values are reported for the upper triangular matrix to avoid redundancy. Diagonal elements (r = 1.00) are not shown. p < 0.05.

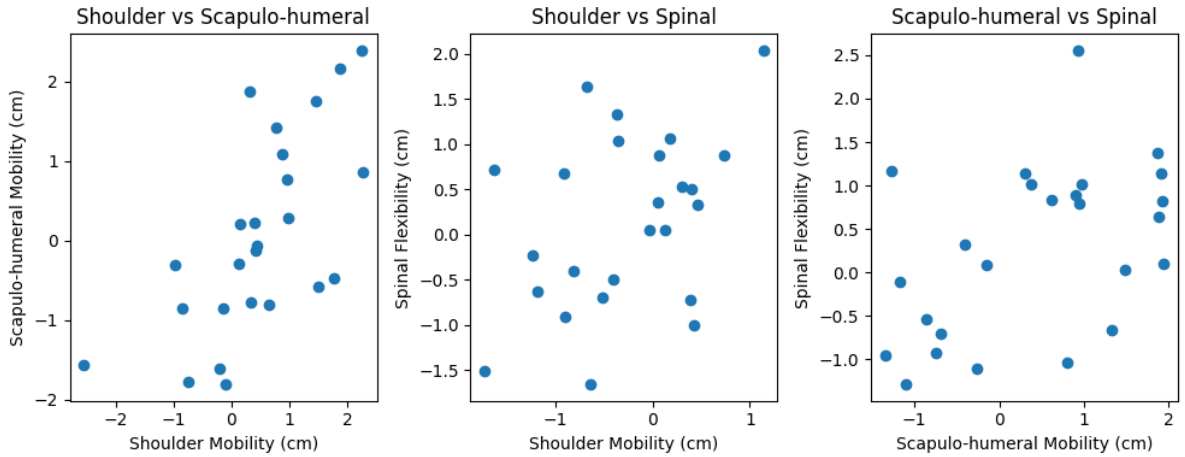

Fig. 6. Scatter plots illustrating the relationships between joint mobility variables in young bocce (Raffa specialty) athletes.

was observed between shoulder mobility and scapulo-humeral girdle mobility (r = 0.46, p = 0.023). A weak positive correlation was found between shoulder mobility and spinal flexibility (r = 0.28, p = 0.174). A moderate correlation was observed between scapulo-humeral girdle mobility and spinal flexibility (r = 0.41, p = 0.047). These findings indicate a pattern of interdependence among segmental mobility components, supporting their interpretation as functionally related rather than independent variables.

The correlation matrix is reported in Table 3.

Integrated analysis of joint mobility parameters

To verify whether the three mobility parameters could be interpreted as part of a shared functional configuration, the correlation matrix was additionally examined using Bartlett's test of sphericity. The test was statistically significant ((3) = 9.63, p = 0.022), indicating that the observed correlations were sufficient to reject the hypothesis of independence among variables. In addition, an exploratory estimate of internal coherence showed a Cronbach's alpha of 0.65, suggesting a moderate but meaningful degree of consistency among the three indicators. Taken together, these results support the interpretation of shoulder mobility, scapulo-humeral mobility, and spinal flexibility as components of a preliminary integrated mobility profile rather than as entirely separate parameters (Tab. 4). Overall, these results support the identification of a preliminary "mobility balance profile", in which the functional value of joint mobility emerges from the coherence among segmental contributions rather than from isolated parameter values.

Table 4. Integrative analysis of joint mobility parameters based on Bartlett's test of sphericity and Cronbach's alpha.

Analysis	Statistic	Value	p-value
Bartlett's test of sphericity	χ^2 (df = 3)	9.63	0.022
Internal consistency	Cronbach's α	0.65	–

Note. Bartlett's test evaluates whether the correlation matrix significantly differs from an identity matrix. Cronbach's alpha is reported as an exploratory estimate of internal coherence among mobility parameters.

An exploratory classification of functional mobility profiles is presented in Table 5.

Within this exploratory framework, mobility values were interpreted relative to the internal distribution of the sample. Lower values were considered indicative of

Table 5. Exploratory classification of functional mobility profiles in young Raffa Bocce athletes.

Profile Type	Description	N (Estimated)
Balanced profile	Comparable values across shoulder, scapulo-humeral, and spinal mobility	8
Upper limb dominant	Higher shoulder and scapulo-humeral mobility relative to spinal flexibility	7
Trunk dominant	Higher spinal flexibility relative to upper limb mobility	6
Unbalanced profile	Marked discrepancies among the three parameters	4

potentially insufficient mobility, intermediate and balanced values as functionally adequate, and disproportionately high values relative to other segments as potentially excessive. This classification does not define normative thresholds but provides a sample-based functional interpretation of mobility ranges.

Discussion

The present pilot study aimed to investigate joint mobility characteristics in young athletes practicing bocce in the Raffa specialty, with the intention of providing a preliminary functional profile of mobility parameters potentially related to technical performance in this precision sport. Beyond a purely descriptive approach, the study was oriented toward interpreting joint mobility as a functional component within the movement system underlying the technical gesture. Given the limited scientific literature specifically focused on the physical and functional characteristics of bocce players, particularly in youth categories, the study was conceived as an exploratory investigation designed to collect initial data useful for future research and for the development of a more structured understanding of the performance model associated with this discipline. Within this context, the study not only documents variability in joint mobility, but proposes a preliminary interpretation of joint mobility as an intersegmental functional configuration that mediates the relationship between movement amplitude and execution control in a precision-based task such as the Raffa gesture. Importantly, this interpretation is grounded in the observed variability, the pattern of between-group differences, and the interrelations identified among the assessed mobility parameters, rather than on direct measures of technical performance.

From a functional approach, the results of the present study can be interpreted within a system-based framework in which joint mobility operates as an organized set of interdependent components contributing to the control and reproducibility of the technical gesture. In this model, shoulder mobility primarily supports distal segment orientation and fine modulation of the release phase, scapulo-humeral mobility contributes to the regulation of movement amplitude and trajectory continuity, and spinal flexibility ensures postural organization and the effective transmission of forces along the kinetic chain. The interaction among these components determines the functional balance between movement amplitude and control, which is essential for achieving accuracy and consistency in the Raffa technical gesture. In the context of the present study, functional ranges should be interpreted as relative intervals within which mobility supports an effective balance between movement amplitude and control. Values below this range may limit movement adaptability, whereas values exceeding this range, particularly when not compensated by adequate control in other segments, may compromise movement stability. In this sense, joint mobility does not act as a single isolated factor, but as a coordinated system in which segmental contributions are functionally integrated. Crucially, within this system, joint mobility assumes a dual functional role, acting both as a facilitator of movement when it supports adequate amplitude and coordination, and as a potential constraint when excessive or insufficient levels disrupt the balance between control and stability. More specifically, the Raffa technical gesture requires a high level of repeatability, and such repeatability depends on maintaining a stable balance between movement amplitude and control; this balance is not generated by a single joint, but emerges from the coordinated interaction among shoulder, scapulo-humeral, and trunk mobility. Within the limits of the present design, this mechanism should be interpreted as a plausible functional explanation supported by the observed relationships among variables rather than as a directly tested causal pathway.

The main hypothesis underlying the research was that joint mobility, particularly at the level of the shoulder complex and spinal column, represents an important functional component for the execution of technical gestures in the Raffa specialty. In precision sports such as bocce, the quality of motor execution depends not only on technical skill and perceptual accuracy but also on the functional efficiency of the musculoskeletal structures involved in the movement. The throwing and pointing actions typical of the Raffa specialty require coordinated activation of the upper limb, trunk stabilization, and controlled movement amplitude, all of which may be influenced by joint mobility levels (Turkmen et al., 2013). In this perspective, joint mobility can be interpreted as a regulatory factor within the kinetic chain, influencing the balance between movement amplitude and control. More specifically, the effectiveness of the gesture may depend on the capacity of different joint segments to operate within a coordinated functional configuration, in which excessive or insufficient mobility in one segment may alter the overall organization of the movement. In this sense, insufficient mobility may limit movement amplitude and reduce the fluidity and adaptability of the gesture, whereas excessive mobility may compromise segmental stability and fine motor control, leading to reduced consistency and precision. Taken together, these elements support a functional interpretation in which the precision demands of the task require repeatable motor execution, repeatability depends on the balance between amplitude and control, and this balance is functionally mediated by the coordinated configuration of joint mobility across segments. However, this interpretation should be considered as a preliminary explanatory framework, as no direct performance outcomes were measured in the present study.

The results obtained in the present study indicate a certain degree of variability in joint mobility parameters among the young athletes examined. In the Shoulder Mobility Test, the male sample showed higher maximum values and greater variability compared with the female sample, while the female athletes generally presented lower average distances between the fists, suggesting relatively greater shoulder mobility. These findings may reflect differences in flexibility characteristics typically observed between male and female athletes during adolescence, as reported in several studies investigating joint mobility and flexibility in youth populations. Previous research in sport sciences has consistently highlighted that female athletes often display higher flexibility levels than males, particularly in movements involving the shoulder complex and posterior muscle chains (Şimşek et al., 2024). However, the absence of statistically significant differences in shoulder mobility between groups suggests that this parameter may fall within a functional range common to both sexes, rather than representing a discriminative factor for performance. Within the proposed functional model, this finding may indicate that shoulder mobility alone is not sufficient to determine movement effectiveness, but rather contributes to performance only when integrated with the functional behavior of other segments. This further supports the idea that mobility does not exert a linear effect on performance, but operates within a functional range in which both lower and higher values may have different implications depending on their interaction with other components of the movement system.

Regarding the assessment of scapulo-humeral girdle mobility, the results reveal a relatively wide range of values in both male and female samples. The variability observed in this test may be related to individual differences in training experience, motor coordination, and anthropometric characteristics. The scapulo-humeral joint complex plays a crucial role in the execution of throwing movements, as it contributes to the generation and control of movement amplitude and trajectory. Adequate mobility in this region allows athletes to perform smoother and more controlled arm movements, which may support the precision required in the technical gestures typical of bocce. In this perspective, the variability observed among participants may reflect different stages of motor development and technical adaptation to the sport. The statistically significant differences observed between male and female athletes indicate that this parameter may represent a more sensitive functional component, potentially influencing the organization of the upper limb movement within the kinetic chain. From a functional standpoint, scapulo-humeral mobility may represent a central regulatory element within the system, as it mediates the relationship between proximal stability and distal control, thereby influencing the continuity and efficiency of the movement trajectory. However, also in this case, an excessive increase in movement amplitude without adequate control may reduce movement consistency, highlighting again the non-linear contribution of mobility to performance.

The spinal flexibility test also revealed interesting patterns. While the male sample displayed both positive and negative values, indicating heterogeneous levels of trunk flexibility, the female sample showed exclusively positive values and a higher mean score. These results appear consistent with previous studies on flexibility development in adolescent athletes, which frequently report greater trunk flexibility among female participants. From a biomechanical perspective, adequate spinal mobility may contribute to improved postural control and balance during the execution of throwing movements, facilitating the transmission of force along the kinetic chain and allowing more efficient movement coordination (Costa, 2021). The presence of statistically significant differences between groups suggests that trunk mobility may play a differentiated functional role, particularly in relation to postural stabilization and force transmission during the technical gesture. Within the proposed model, spinal flexibility can be interpreted as the structural base that supports the integration of upper limb actions, ensuring that movement amplitude generated at the scapulo-humeral level is effectively controlled and transferred without compromising balance and stability. At the same time, excessive trunk mobility without sufficient neuromuscular control may reduce postural stability, potentially affecting the precision of the technical gesture.

The correlation analyses provide additional insight into the functional organization of joint mobility within the movement system. The moderate relationships observed between shoulder mobility and scapulo-humeral mobility, as well as between scapulo-humeral mobility and spinal flexibility, suggest the existence of coordinated functional interactions between different segments of the kinetic chain. In contrast, the weaker association between shoulder mobility and spinal flexibility indicates a more indirect relationship, highlighting the role of intermediate segments in linking upper limb movement and trunk function. These findings support the interpretation of joint mobility not as isolated parameters, but as interdependent components contributing to the overall organization of movement. In particular, the observed pattern of correlations supports the idea of a hierarchical and coordinated system, in which the scapulo-humeral complex acts as an intermediate functional link connecting distal control and proximal stabilization. The statistical assessment of the correlation matrix further strengthens this integrative interpretation. The significant result of Bartlett's test of sphericity indicates that the relationships among the three mobility parameters are not random, supporting the presence of an underlying functional structure. Moreover, the moderate Cronbach's alpha suggests a meaningful level of internal coherence among shoulder mobility, scapulo-humeral mobility, and spinal flexibility. Taken together, these findings support the identification of a preliminary "mobility balance profile", in which the functional value of joint mobility depends on the coherence among segmental contributions rather than on the isolated magnitude of individual parameters. This interpretation is further supported by the exploratory classification reported in Table 4, which illustrates how different combinations of segmental mobility give rise to distinct functional profiles, reinforcing the concept of joint mobility as an integrated and configuration-dependent system. Within this perspective, the profiles reported in Table 5 can be interpreted as reflecting different functional conditions, ranging from relatively insufficient to balanced and, in some cases, to relatively excessive mobility configurations. These distinctions are based on the internal distribution of the sample and should

be considered exploratory rather than normative thresholds. It is important to note that these profiles are derived from exploratory criteria and should not be interpreted as normative classifications.

When interpreting these findings, it is important to consider the specific characteristics of bocce as a precision sport. Unlike high-intensity or endurance-based sports, the success of performance in bocce relies heavily on the quality of fine motor control, the stability of body segments, and the ability to reproduce consistent movement patterns. Within this context, joint mobility does not necessarily act as a direct determinant of performance but rather as a functional prerequisite that may facilitate efficient motor execution (Geçitli et al., 2021). This implies the existence of functional ranges of joint mobility, within which movement execution is supported, whereas values outside these ranges, either excessive or insufficient, may compromise movement control and coordination. Adequate ranges of motion in the shoulder complex and trunk may allow athletes to adopt more stable and biomechanically efficient positions during technical actions, thereby supporting accuracy and repeatability (Helmi et al., 2024; Bălan et al., 2020). In this perspective, the effectiveness of joint mobility depends not on its absolute magnitude, but on its alignment with the functional requirements of the movement system, reinforcing the idea of mobility as a context-dependent resource rather than a universally beneficial attribute. Accordingly, mobility should be interpreted as a resource operating under specific functional conditions, in which both insufficient and excessive levels may negatively affect performance if they disrupt the balance between amplitude and control.

The importance of the results presented in this study lies primarily in their contribution to the limited body of knowledge concerning the functional characteristics of bocce athletes. While the sport is widely practiced in several countries, scientific investigations focusing on its biomechanical and physiological aspects remain relatively scarce. By providing preliminary data on joint mobility profiles in young athletes, this research contributes to filling an existing gap in the literature and offers an initial reference point for future investigations focusing on performance-related variables in this discipline. In particular, the integration of the different mobility parameters allows the definition of a preliminary functional profile, in which upper limb mobility, scapulo-humeral coordination, and trunk flexibility interact within a unified movement system. This integrative interpretation represents a first step toward the formulation of a functional explanatory model, in which joint mobility is conceptualized as a coordinated configuration of segmental contributions rather than as a set of independent variables.

From a practical perspective, the findings of this study may have implications for training methodologies in youth bocce programs. Coaches and trainers working with young athletes may benefit from incorporating regular assessments of joint mobility within their monitoring protocols. Such evaluations could help identify individual mobility limitations that might influence the execution of technical gestures and could support the development of targeted training interventions aimed at improving functional mobility. In particular, mobility exercises focused on the shoulder complex and trunk may represent useful components of warm-up routines or complementary conditioning programs designed to enhance movement efficiency and prevent potential musculoskeletal imbalances. Within this framework, mobility assessment may also support process control, allowing coaches to monitor functional adaptations and adjust training loads accordingly. In line with the proposed functional model, training interventions should aim not only at increasing mobility, but at optimizing the balance and coordination among different joint segments in order to enhance movement control and technical consistency. This implies that training should avoid a simplistic "more mobility is better" approach and instead focus on achieving optimal functional ranges compatible with the demands of precision performance.

Furthermore, the introduction of simple field-based mobility tests, such as those used in the present study, may represent a practical and accessible tool for monitoring the functional development of young athletes over time. These assessments require minimal equipment and can be easily implemented during training sessions or evaluation camps, providing coaches with valuable information about the physical readiness and functional status of their athletes. When interpreted within a functional framework, these measures may support the identification of imbalances between segmental contributions, offering actionable insights for individualized training adjustments.

Despite these potential applications, the present study also presents several limitations that should be acknowledged. First, the relatively small sample size limits the statistical power of the analyses and the generalizability of the findings. Second, the cross-sectional design does not allow the examination of causal relationships or the evolution of mobility characteristics over time. Third, the study did not include direct measures of technical performance (e.g., accuracy, consistency, or competition outcomes), which limits the possibility of establishing a direct link between joint mobility and performance effectiveness. Finally, the functional profiles and mobility balance configurations proposed in this study are exploratory in nature and should be interpreted as preliminary conceptual tools rather than definitive or normative thresholds. Future research could also explore the longitudinal development of mobility characteristics in young athletes practicing the Raffa specialty, examining how training exposure and technical experience influence functional adaptations over time. Moreover, comparative studies involving athletes from different levels of expertise or different bocce specialties or different disability and context (Di Palma et al., 2025; Latino et al., 2023) could provide further insights into the role of joint mobility within the broader performance model of this sport. Such investigations may contribute to refining the proposed functional framework and to identifying more precise criteria for the optimal organization of mobility within the movement system.

Therefore, the present study provides preliminary evidence regarding joint mobility characteristics in young athletes practicing bocce in the Raffa specialty. The findings highlight variability in shoulder and trunk mobility parameters and suggest potential gender-related differences in flexibility levels. More importantly, the results support an interpretation of joint mobility as a system of interrelated functional components, rather than isolated variables. In

particular, the study contributes to the conceptualization of joint mobility as a coordinated functional configuration that mediates the relationship between movement amplitude and control within the technical gesture of the Raffa specialty. Although exploratory in nature, the results contribute to the emerging scientific understanding of the functional aspects of bocce performance and underline the potential importance of mobility assessment within youth training contexts. Further research involving larger samples and more comprehensive performance analyses will be necessary to clarify the role of joint mobility within the technical and functional demands of this precision sport.

Conclusions

The present pilot study examined joint mobility characteristics in young athletes practicing bocce in the Raffa specialty. The results highlighted a certain variability in shoulder and spinal mobility within the analyzed sample and suggested some differences between male and female participants, particularly in trunk flexibility values. These findings contribute to outlining an initial functional profile of mobility parameters in youth bocce players. In particular, the results support the interpretation of joint mobility as a set of interrelated components within the movement system, rather than isolated variables. More specifically, the study supports the conceptualization of joint mobility as a coordinated functional configuration involving shoulder mobility, scapulo-humeral control, and spinal flexibility, whose interaction contributes to the regulation of movement amplitude, stability, and precision within the technical gesture of the Raffa specialty. Within this framework, joint mobility emerges as a non-linear factor, whose contribution to performance depends on its capacity to operate within functional ranges compatible with the demands of control and accuracy. These findings support a preliminary integrative rule according to which the functional value of joint mobility in the Raffa specialty depends on the balance and coherence among segmental components rather than on the maximal value of any single parameter. More broadly, the study suggests that the repeatability of the Raffa technical gesture is mediated by the capacity of the movement system to maintain a stable balance between movement amplitude and control through coordinated intersegmental contributions.

Although the study did not directly examine the relationship between joint mobility and technical performance, the results offer useful information about the functional characteristics of young athletes involved in this discipline. From a functional standpoint, joint mobility may be considered a regulatory factor influencing the balance between movement amplitude, coordination, and postural control during the execution of the technical gesture. Accordingly, joint mobility should be interpreted as a resource operating under specific functional conditions, in which both insufficient levels may limit movement amplitude and adaptability, and excessive levels may reduce segmental stability and fine motor control, ultimately affecting the consistency and precision of the gesture. In this perspective, the effectiveness of joint mobility depends on its integration within the movement system rather than on the isolated magnitude of individual parameters, highlighting the importance of coordinated segmental contributions. In this perspective, the assessment of joint mobility may represent a valuable component within the monitoring processes of youth training programs. This approach may also support process control, allowing practitioners to identify functional limits and adjust training interventions accordingly. Accordingly, training strategies should aim not only to improve mobility levels, but to optimize the balance and interaction among different joint segments in order to enhance movement control and technical consistency. This implies moving beyond a linear interpretation of mobility and focusing instead on the identification and maintenance of optimal functional ranges.

Given the exploratory nature of the research and the limited sample size, further studies involving larger samples and additional performance-related variables will be necessary in order to better understand the role of joint mobility within the technical and functional demands of the Raffa specialty. Future research should aim to integrate mobility assessment with biomechanical and performance indicators in order to refine the explanatory model and define more precise functional thresholds. In this sense, the present study provides a preliminary step toward the development of a functional explanatory model of joint mobility in bocce, in which mobility is interpreted as a system-level factor contributing to the organization and reproducibility of the technical gesture. Thus, the study contributes not only to describing joint mobility characteristics, but to proposing a functional interpretation of mobility as an intersegmental configuration that mediates the relationship between movement amplitude and execution control in precision performance. In particular, the study contributes to establishing the principle that the effectiveness of joint mobility lies not in its maximization, but in its functional calibration within the movement system.

Ethics Approval

The study was conducted in accordance with the principles of the Declaration of Helsinki. The research protocol was approved by the Institutional Review Board of the University of Naples "Parthenope" (DiSMMeB Prot. No. 88592/2024).

Informed Consent

Written informed consent was obtained from all participants prior to participation in the study. For participants under 18 years of age, written informed consent was additionally obtained from parents or legal guardians.

Data Availability Statement

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

AI Transparency Statement

The authors did not use AI-assisted tools in the preparation of this manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest.

References

Febrianingrum, P.S., & Diana, D. (2021). The enhancement of children's gross motor skill of group a through bocce games. *BELIA: Early Childhood Education Papers, 10*(2), 145-150. https://doi.org/10.15294/belia.v10i2.37201

Türkmen, M., Özkan, A., Bozkus, T., & Kul, M. (2018). Determination of some physical fitness and body composition characteristics of young bocce players in Turkish national team. *SportMont, 16*(2018) 1: 13-17. https://doi.org/10.26773/smj.2018.02.003

Şimşek, M., & Kesilmiş, İ. (2022). Predicting athletic performance from physiological parameters using machine learning: Example of bocce ball. *Journal of Sports Analytics, 8*(4), 299-307. https://doi.org/10.3233/JSA-220617

Irawan, F.A., Ramadhan, A.T., Junaidi, S., Hadi, H., Romadhoni, S., & Muhibbi, M. (2024). Effectiveness of muscle force and speed of movement carreau shot at distances of 6 and 7-meter petanque sport. *Journal Keolahragaan, 12*(1), 95-102. https://doi.org/10.21831/jk.v12i1.66405

Helmi, B., Hidayah, T., Pramono, H., Hartono, M., & Iskandar, T. (2024). Using a Biomechanical Analysis Approach to the Accuracy of Shooting Throws in Petanque Sport: Literature Review. *Physical Education Theory and Methodology, 24*(1), 130–135. https://doi.org/10.17309/tmfv.2024.1.16

Gür, Y., Taskin, S., Özaktas, E.S., & Taskin, C. (2022). The Effect of Life Kinetic Exercise on Performance in Bocce Athletes. *Journal of Educational Issues, 8*(1), 664-671. https://doi.org/10.5296/jei.v8i1.19858

Firdaus, F., & Irfan, I. (2023). The Effect of Bocce Games on the Physical Fitness of Children with Grahita SLB AL-GIFARI During the Covid-19 Pandemic. *Journal of Physical and Outdoor Education, 5*(1), 27-36. https://doi.org/10.37742/jpoe.v5i1.200

Hafidz, A., Wiriawan, O., Nugraha, A.D., Purnomo, M., Pratama, R.S., & Yudhistira, D. (2024). Mapping of Petanque Sports Research Trends for the period 2011-2024: A Bibliometric Analysis in the Scopus Database. *Physical Education Theory and Methodology, 24*(5), 808-818. https://doi.org/10.17309/tmfv.2024.5.17

Latino, F., Greco, G., Fischetti, F., & Cataldi, S. (2019). Multilateral training improves body image perception in female adolescents. *Journal of Human Sport and Exercise, 14*(4proc), S927-S936. https://doi.org/10.14198/jhse.2019.14.Proc4.55

Susanto, S., Setyawan, H., Susanto, N., García-Jiménez, J.V., Latino, F., Tafuri, F., & Eken, Ö. (2024). The Influence of Modified One-Hole Game Media in Improving Fine Motor Skills in Early Childhood. *Sports Science and Health, 14*(5), 151. https://doi.org/10.7251/SSH24V151S

Scamardella, F., Latino, F., & Tafuri, M.G. (2025). Anthropometric Characteristics of Young Bocce Athletes in the Raffa Specialty: An Analysis of Physical Parameters in Junior Players of National Level. *Physical Education Theory and Methodology, 25*(3), 652-659. https://doi.org/10.17309/tmfv.2025.3.22

Raiola, G., Tafuri, D., & Altavilla, G. (2015). Physical activity and its relation to body and ludic expression in childhood. *Mediterranean Journal of Social Sciences,* 6, 293-296. https://doi.org/10.5901/mjss.2015.v6n3s2p293

Irawan, F.A. (2019). Biomechanical analysis of concentration and coordination on the accuracy in petanque shooting. *ACTIVE: Journal of Physical Education, Sport, Health and Recreation, 8*(2), 96-100. https://doi.org/10.15294/active.v8i2.30467

Eler, N., & Eler, S. (2018). A Study on Somatotype Profiles of the Players in Turkish Bocce National Team. *Journal of Education and Training Studies, 6*(2), 28-35. https://doi.org/10.11114/jets.v6i2.2940

Badruzaman, B. (2021). Effect of Bocce Game on Perceptual Motor Ability and Object Control among Adolescents with Mental Retardation. *Jurnal Pendidikan Jasmani dan Olahraga, 6*(1), 129-136. https://doi.org/10.17509/jpjo.v6i1.32903

Yuan, H., & Li, M. (2022). Bocce training based on computer technology has an effect on physical education in colleges and universities. *Scientific programming, 2022*(1), 9111509. https://doi.org/10.1155/2022/9111509

Mutlu Turkmen, Taner Bozkus, Atahan Altintas (2013). The Relationship Between Motivation Orientations and Competitive Anxiety in Bocce Players: Does Gender Make a Difference. Psychology and Behavioral Sciences, 2(4), 162-168. https://doi.org/10.11648/j.pbs.20130204.12

Şimşek, B., Kilinçarslan, G., AVCI, P., & ÇAKIR, V. (2024). The Impact of Hemsball Training on Balance and Punto (Approaching) Scores in Boccia Athletes. *International Journal of Religion, 5*(5). https://doi.org/10.61707/5avtes43

Costa, M., (2021). *La boccia del punto,* Booksprint Editor, Salerno, Italy.

Geçitli, G., Kavak, S., Metiner, H., Esmece, M., & Kesilmiş, İ. (2021). Reaction Time in Target Shooting Sports: Perspective of Bocce and Archery. *Eurasian Research in Sport Science, 6*(2), 121-129. https://doi.org/10.29228/ERISS.10

Bălan, V., Strazdina, N., Dirzininka, I., & Mujea, A.M. (2020). Study on Learning the Bocce-Specific Technique. *In Book of Proceedings of the 10th International Congress of Physical Education, Sport and Kinetotherapy* (pp. 1-11). https://doi.org/10.51267/icpesk2020bp01

Di Palma, D., Tafuri, M.G., & Ogbondah, L.D. (2025). Sport as a tool for inclusion and sustainability in secondary school: A qualitative-quantitative analysis. Rivista di studi sulla sostenibilità, 10(1), 93-108. https://doi.org/10.3280/riss2025oa19679

Latino, F., Saraiello, E., & Tafuri, F. (2023). Outdoor Physical Activity: A Training Method for Learning in an Experiential and Innovative Way. *Journal of Physical Education and Sport, 23*(7), 1852-1860. https://doi.org/10.7752/jpes.2023.07225

Функціональна рухливість суглобів у юних спортсменів, які займаються боччe Раффа: імплікації для моделі спортивної результативності

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 13 с., 5 табл., 6 рис., 23 джерела.

Мета дослідження. Боччe є видом спорту на точність, що потребує координації та технічного контролю. У дисципліні «Раффа» особливо важливими є координація верхніх кінцівок і постуральний контроль. Незважаючи на широке поширення цього виду спорту, дослідження функціональних характеристик юних спортсменів залишаються обмеженими. Це пошукове аналітичне пілотне дослідження мало на меті вивчити рухливість суглобів як функціональну конфігурацію в межах рухової системи, що лежить в основі технічного жесту Раффа.

Матеріали та методи. Двадцять п'ять спортсменів віком 14–18 років були обстежені під час регіональних тренувальних заходів, організованих Комітетом боччe Кампанії. Рухливість суглобів оцінювали за допомогою трьох польових тестів: тесту рухливості плечового суглоба, тесту скапуло-гумеральної рухливості з ротацією палиці та тесту нахилу тулуба вперед у положенні сидячи. Було розраховано описову статистику, t-критерій Стьюдента для незалежних вибірок і кореляції Пірсона. Для оцінювання інтегративної структури параметрів рухливості застосовували тест сферичності Бартлетта та дослідницький коефіцієнт альфа Кронбаха.

Результати. Виявлено статистично значущі відмінності у скапуло-гумеральній рухливості та гнучкості хребта, тоді як відмінностей у рухливості плечового суглоба не встановлено. Кореляційний аналіз показав слабкі та помірні взаємозв'язки між змінними. Тест Бартлетта ($\chi^2_{(3)}$=9.63, p=0.022) і коефіцієнт альфа Кронбаха 0.65 підтвердили наявність інтегрованої структури рухливості, що свідчить про взаємозалежність між сегментами.

Висновки. Рухливість суглобів виступає нелінійним, контекстно-залежним ресурсом, який може виконувати як функцію сприяння, так і функцію обмеження залежно від рівня інтеграції в рухову систему. Функціональна ефективність технічного жесту Раффа залежить від балансу між плечовими, скапуло-гумеральними та спінальними компонентами, а не від окремих максимальних показників. У дослідженні запропоновано попередню пояснювальну модель, у якій рухливість суглобів опосередковує взаємозв'язок між амплітудою руху та контролем.

Ключові слова: дисципліна Раффа, рухливість суглобів, юні спортсмени, гнучкість, спортивна результативність.

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