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Physical performance profiling of elite female sepak takraw national athletes: A modern sport science approach

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ABSTRACT

Background: Sepak takraw is an explosive sport that requires a combination of multiple physical abilities such as speed, agility, muscular strength, flexibility, and endurance. However, most previous studies have focused on the separate analysis of these components with little emphasis on their combined contribution to overall performance. Therefore, the aim of the present study was to explore the multidimensional physical performance profile of elite female athletes within a contemporary sports science framework.

Methods: The study was cross-sectional descriptive study of 20 elite female sepak takraw athletes (age 18-25 years) selected by using total sampling from the national training camp of 2025. The criteria in the study included active participation in the national level, at least three years of competitive experience, and no injury at the time of testing. All players had competed in national and international level. Physical performance was measured using standard field tests, including: 20-m sprint (speed), sagittal split (flexibility), Russian twist (core strength), back-up test (back muscle endurance), 4 × 5-m shuttle run (agility), and vertical jump (lower body strength). Aerobic capacity was estimated by multistage fitness testing with maximum oxygen uptake (VO 2max) calculated based on the performance of the test.

Results: The results of the study show that the average time taken by female national team athletes to complete a 20-meter sprint was 3.15 seconds; the average flexibility score was 24.20 cm; the average Russian Twist and Back-Up scores were 46.80 and 38.50 repetitions; the shuttle run time was 12.20 seconds; the average vertical jump was 38.10 cm; and the VO_2max value was 48.70 ml/kg/minute.

Conclusion: This study emphasizes the importance of applying an inclusive physical performance profiling model to elite female national-level sepak takraw athletes using a contemporary sports science approach.

Keywords: agility, elite athletes, physical performance, power, sepak takraw, VO_2max.
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INTRODUCTION

Sepak takraw is a high-intensity net-based obstacle game that has become a popular sport due to the acrobatic kicks, explosive power, and multidimensional movements required in the game; therefore, physical qualities are a crucial factor determining performance.[1] Despite its past and current popularity in Southeast Asia and the increasing level of international competition, there remains a lack of scientific studies in understanding the physical performance characteristics of elite female sepak takraw athletes compared to more extensively explored team sports such as soccer or volleyball. The specific nature of this sport, which involves jumping, kicking, and rapid changes of direction, requires a holistic performance profiling system that combines physiological, biomechanical, and neuromuscular testing.[1,2]

Performance profiling in sports science requires the measurement of specific physical components, such as speed, endurance, agility, strength, and power, which form the foundation of success in a competitive environment.[3] Previous studies on sepak takraw have focused on physical variables separately, such as general physical fitness components among mixed groups of athletes, indicating that agility, balance, and strength do have an influence, but cannot fully predict performance outcomes at the elite level.[4]

A recent observational study on limb asymmetry in female sepak takraw players reported the greatest bilateral differences in the unilateral counter-movement jump test and the three-step jump test. Studies on elite female soccer players have also used global positioning system-based motion analysis and performance quantiles to map speed and acceleration patterns, revealing the depth of sport-specific profiles.[5,6] Other observational studies have linked physical components, such as vertical jump height, flexibility, and self-confidence, to technical performance (e.g., smash accuracy), confirming a significant relationship between physical outcomes and skill.[7] However, the current literature still lacks large-scale, standardized physical performance profiles capable of distinguishing elite national female athletes from lower-level players, thereby limiting

evidence-based training design. Although biomechanical analysis has been proposed to enhance performance and prevent injuries in sepak takraw, its integration into comprehensive competitive-level profiles remains limited.[8]

Integrated performance profiles enable coaches and sports scientists at the national level to identify individual strengths and weaknesses, monitor changes over time, and link physical capacity to competition outcomes.[9] The need for gender-specific performance profiles is suggested by evidence that female athletes often present with different movement patterns and asymmetries compared to male athletes, with significant implications for injury prevention and performance optimisation.[5] In strength and conditioning training, coaches frequently use performance profiles to assess key physiological, psychological and tactical attributes, subsequently informing more individualised training strategies.[10] Moreover, research in elite team sports has shown the importance of normative physiological data for classifying performance levels and guiding position-specific conditioning requirements.[11] In recent years, cross-sectional profiles integrating multidimensional datasets and machine learning techniques have gained interest, providing a more holistic approach to athlete selection and the determination of training priorities.[12]

Recent bibliometric and narrative reviews point towards a more holistic view of the athlete performance profiling, merging the physical, technical and psychological components within a single framework. This has been applied in team sports such as futsal and soccer to better describe the patterns of competition load and to promote more individualized sports science assessment. Instead of single attributes, recent studies increasingly investigate the interrelationship between strength, endurance, skill execution and psychological aspects. This multidimensional view enhances the understanding of the elite athlete performance and is representative of the ongoing evolution of performance analysis in sports science.[13]

One of the main barriers to developing evidence-based training strategies for elite female sepak takraw athletes is the lack of standardized reference values and a complete profiling framework. Because of the unique biomechanical and physiological demands of the sport, systematic evaluation via valid and sport-specific assessments is crucial. A multidimensional profiling approach may not only enhance performance optimization but also play a role in injury prevention and long-term athlete development. Therefore, this study aimed to analyze the multidimensional physical performance profiles of elite female sepak takraw athletes using a contemporary sports science approach by addressing the following questions: What are the physical performance characteristics (speed, agility, power, flexibility, strength, and aerobic capacity) of elite female sepak takraw athletes? And how do these components reflect the athletes' readiness to meet the demands of elite competition?. The hypothesis was that elite female sepak takraw athletes have well-developed and balanced components of physical performance that match the physiological demands of high-level competition.

METHODS

This study employed a descriptive quantitative design with a cross-sectional approach to assess the physical performance profile of elite female sepak takraw athletes at a specific point in time. This design allows for an objective evaluation of physiological and biomechanical characteristics without experimental intervention, using standard testing procedures and descriptive statistical analysis (mean, standard deviation, minimum, and maximum values).[14] A quantitative descriptive design is used to identify population characteristics based on systematically measured numerical data. In sports science, this approach is widely used to develop performance profiles of elite athletes, which serve as a foundation for evidence-based training program design.[15]

Twenty elite female sepak takraw athletes aged 18-25 years were included using a total sampling approach. All participants were members of the 2025 national training camp. Inclusion criteria

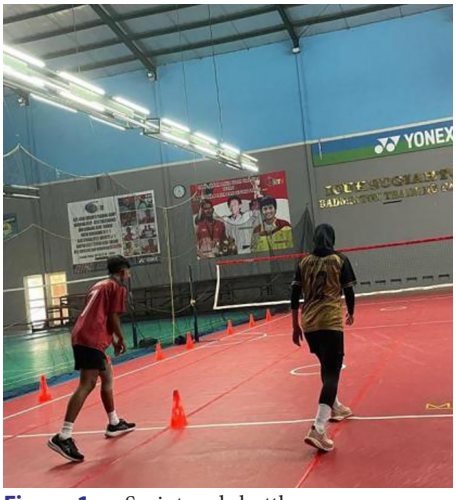

Figure 1. Sprint and shuttle-run performances test

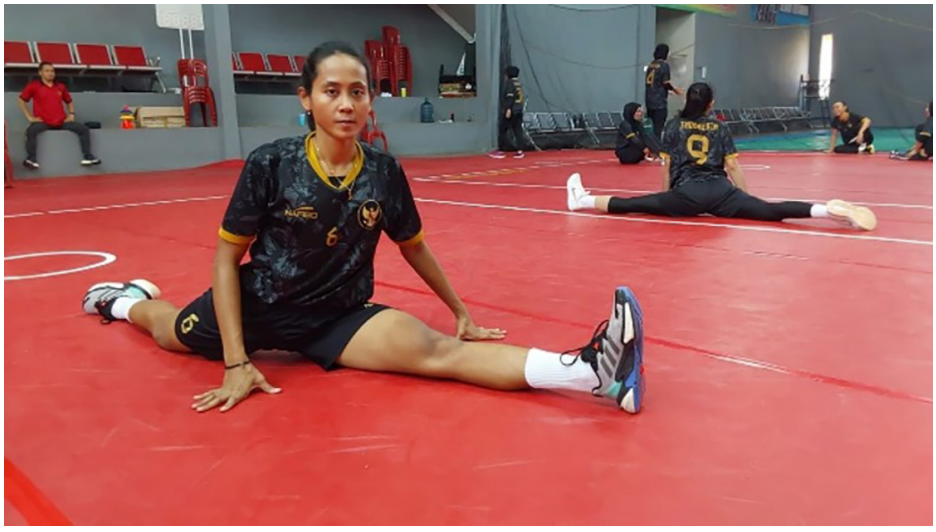

Figure 2. Flexibility test

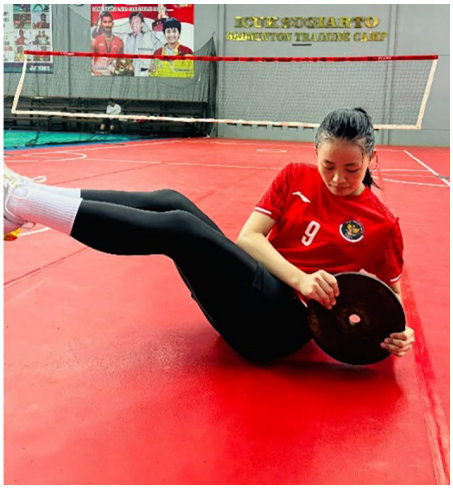

Figure 3. Core strength and trunk stability

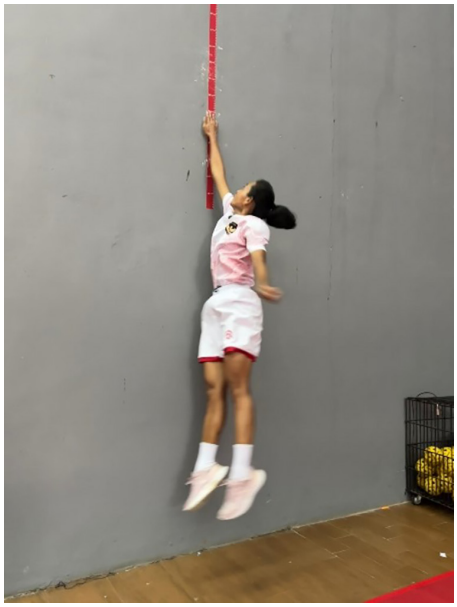

Figure 4. Vertical jump performance test

Figure 5. The VO2max test

were used to ensure homogeneity of the sample, requiring athletes to have a minimum of 3 years of structured training experience and have competed at a national and/or international level in order to reflect an elite competitive standard. Furthermore, participants were free of musculoskeletal injury or medical condition that could affect physical performance during testing. Athletes undergoing rehabilitation, with injury, and/or unable to complete the full testing protocol were excluded.[16] All athletes competed at the national elite level and had competed in international events such as the Southeast Asian Games and Asian Games qualification tournaments, reflecting a high-performance cohort with well-developed sport-specific adaptations. This study was conducted in the National Sepak Takraw Training Center, South Sulawesi, Indonesia at the general preparation phase of the athletes in early 2025 (January-February). All physical performance tests were conducted inside in controlled conditions (room temperature maintained at 24-26°C) and on the same surface for each test to minimize environmental effects. Data collection was conducted in the morning (08.00-11.00 AM) in order to reduce weariness and diurnal changes. For each test, participants undertook a standardized warm-up routine consisting of 10-15 minutes with light aerobic activity, dynamic stretching, and sport-specific drills. Between tests, a rest interval of 3–5 min was included to optimize performance and maintain freshness.

Table 1. Participant characteristics

Characteristic	Mean (SD)	Min-max
Age (years)	21.3 (2.1)	18.0-25.0
Height (cm)	163.5 (5.8)	155.0-172.0
Body mass (kg)	55.2 (4.9)	48.0-64.0
Training experience (years)	6.2 (1.8)	3.0-10.0

cm, centimeter; kg, kilogram; max, maximum; min, minimum; SD, standard deviation

Table 2. Descriptive data of testing variables

Variable	Mean (SD)	Min-Max
20 m Sprint (s)	3.2 (0.1)	3.0-3.5
Flexibility (cm)	24.2 (3.9)	17.0-31.5
Russian twist (reps)	46.8 (6.5)	34.0-61.0
Back-up (reps)	38.5 (5.2)	29.0-48.0
Shuttle run (s)	12.2 (0.8)	11.1-13.9
Vertical jump (cm)	38.1 (4.8)	30.5-47.2
VO_2max (ml·kg^{-1}·min^{-1})	48.7 (4.0)	42.6-54.2

Cm, centimeter; m, meter; max, maximum; min, minimum; ml·kg^{-1}·min^{-1}, milliliter per kilogram per minute; reps, repetitions; s, second; SD, standard deviation; VO_2max, maximal oxygen uptake.

All tests used in this study were standard tests commonly used in sports science research with high reliability interclass correlation (ICC) values as follows: 20-meter sprint test (**Figure 1**; speed; ICC = 0.90-0.98); sagittal split test (**Figure 2**; flexibility; ICC = 0.89-0.99); Russian twist test (**Figure 3**; core strength; ICC ≈ 0.85-0.95); back-up test (back muscle strength; ICC = 0.88–0.97); 4 × 5 m shuttle run test (Figure 1; agility; ICC = 0.84-0.95); vertical jump test (**Figure 4**; lower-body strength; ICC = 0.93-0.99), and graded fitness test for VO2max (**Figure 5**; ICC = 0.90-0.95). The high validity and reliability of these tests allow confidence in the accuracy and consistency of the data.[17]

Normative values from previous sports science literature were used to assign meaning to the performance outcomes. Measures of sprint speed, agility, and

lower-body strength were referenced against data from elite athlete profiling, while aerobic capacity (VO2max) was assessed against norms from graded exercise testing. Classification was based on the degree to which the mean values observed in the present study aligned with reported ranges for trained and elite populations. However, given the limited availability of sport-specific normative data for elite female sepak takraw athletes, these interpretations should be treated with caution.

RESULTS

Table 1 shows the participant characteristics, including anthropometric measurements and training experience. Twenty elite female sepak takraw athletes aged 18-25 years were recruited from the National Sepak Takraw Training Center for this study. The mean age was 21.30 ± 2.10 years, mean height was 163.50 ± 5.80 cm and mean body mass was 55.20 ± 4.90 kg. The average training experience of the athletes was 6.20 ± 1.80 years.

Several physical performance variables were evaluated, including 20-meter sprint speed, flexibility (sagittal split), core strength (Russian twist), back strength (back-up), agility (4 × 5-meter shuttle run), lower-body strength (vertical jump), and aerobic capacity (VO_2max) shown in **Table 2**. The average 20-meter sprint time was 3.15 ± 0.12 seconds, indicating good speed capacity related to rapid offensive and defensive movements. Flexibility showed an average value of 24.20 ± 3.90 cm, reflecting the adequate range of motion required for high-intensity kicking techniques. Core strength and back strength showed average values of 46.80 ± 6.50 and 38.50 ± 5.20 repetitions, respectively, indicating sufficient trunk stability to support balance and explosive movements.

Athletes had a mean shuttle run time of 12.2 ± 0.8 seconds indicating a good change-of-direction speed needed to manage the fast turns and twists related to sepak takraw. They averaged 38.1 ± 4.8 cm in the vertical jump test which indicates they had adequate lower body explosive power to reach the high jumps necessary in the sport. In multistage fitness test they exhibited an aerobic capacity of 48.7 ± 4.0 ml·kg−1·min−1 which indicates a good level of cardiorespiratory fitness to support repeated bouts of intensity and recover effectively between matches. These results demonstrate a comprehensive physical capacity that is well matched to the demands of elite sepak takraw competition.

DISCUSSION

Speed and agility tests such as sprint and shuttle-run performance indicate a high level of neuromuscular efficiency in these athletes.[18] These attributes are important in intermittent sports where rapid transition, short distance acceleration and frequent changes of direction are fundamental performance requirements.[19] This is particularly true in sepak takraw during attacking and defensive sequences which often rely on repeated accelerations over short distances (2-5m). The present findings are in line with previous evidence highlighting the importance of neuromuscular factors such as motor unit recruitment and rate of force development in optimizing elite performance. From a practical perspective, profiling speed and agility can help coaches develop acceleration-focussed training programmes, in accordance with the principle of specific adaptation to imposed demands (SAID).[20]

The vertical jump scores suggest a well-developed lower-body explosive power, a major requirement to perform roll-spike attacks and jump kicks. These actions are based on the rapid activation of the stretch-shortening cycle, a main biomechanical mechanism also observed in volleyball attackers.[21] Previous studies have highlighted the close link between power output, neuromuscular performance and tendon stiffness.[22] Moreover, greater relative strength (force-to-body-mass ratio) appears to favor jump performance and aerial control in elite female athletes. In line with existing evidence, plyometric and speed-oriented resistance training are considered effective strategies to improve jump mechanics and maximize peak power output. Beyond performance, vertical jump assessments are increasingly used as a practical, non-invasive tool to monitor neuromuscular readiness in elite sport settings.[15]

The findings of Back-up Test and Russian Twist test showed the relevance of core strength and trunk stability in the execution of sepak takraw. Core stability is needed for the effective transmission of forces from the lower to the upper extremity in rotational motions and complex aerial skills. According to Kibler's concept of proximal stability and distal mobility, the increased musculature of the trunk could perhaps lead to enhanced kicking accuracy and control of movement.[23]

Additionally, greater trunk stiffness may enhance movement control during high-skill acrobatic actions while also supporting more efficient recovery and lowering injury risk. This is particularly relevant in sports with repetitive loading of the lumbar–pelvic region. Accordingly, assessing core strength remains an important component of athlete monitoring, especially for identifying potential risks of overuse injuries in the lower back and hip complex.[24] Aerobic capacity (VO_2max) in the present sample reflects moderate-to-high fitness levels. Although sepak takraw is characterized by predominantly anaerobic and explosive actions, aerobic fitness plays a key role in facilitating recovery between rallies and sets. This is likely mediated through enhanced phosphocreatine resynthesis during repeated high-intensity efforts, as reported in previous studies.[25] In addition, high-intensity interval training has been shown to simultaneously improve aerobic and anaerobic energy systems in elite athletes.[26] From a practical standpoint, VO_2max profiling provides useful information for designing conditioning programs and for managing the balance between training load and recovery.[27]

Flexibility assessment shows adequate range of motion in the hamstring and lower back muscles, which are critical for extreme hip flexion and abduction in the smash action. Limited flexibility can impair technical efficiency and increase the risk of injury.[28] Dynamic flexibility, as mentioned in previous research, plays a key role in performance and should be incorporated into neuromuscular warm-up routines. Contemporary sports science places greater emphasis on functional mobility than on static flexibility, highlighting the importance of sport-

specific and movement-oriented ranges of motion.[29]

The multidimensional profiling approach applied in this study reflects current practices in elite sports monitoring systems, which emphasize objective measurement, long-term monitoring, the setting of individually tailored training loads, and evidence-based decision-making.[15] Previous research has shown that athlete profiling improves training precision and reduces the risk of maladaptation, while other studies highlight the importance of balanced training to optimize performance and minimize the risk of injury. Integrating physical profiling with tactical and biomechanical analysis can further enhance the overall performance model of elite women's sepak takraw athletes.[30]

Although this study provides a comprehensive overview of physical performance, it has several limitations. The relatively small sample size, while common in elite sports research, may limit the generalizability of the results. The cross-sectional nature of this study precludes conclusions about longitudinal adaptations and limits any inference of causality, as measurements were obtained at a single time point. In addition, the absence of a comparison group makes it difficult to contextualize the performance levels observed in the study, and we did not have access to biomechanical assessments and match-performance data, which would have provided a better insight into the factors affecting the performance of these athletes. Future research should focus on bigger and more diverse samples of players, longitudinal and comparative studies, and exploring biomechanics and match performance data to gain a thorough understanding of elite female sepak takraw athletes.

CONCLUSION

This study highlighted the need for a rounded approach to profiling physical performance to elite female sepak takraw athletes. The sport demands explosive power, acrobatics, and periods of high-intensity activity, requiring players to possess strong lower-body strength, speed, agility, flexibility, coordination, and both aerobic and anaerobic fitness. By employing the evidence-based tests across neuromuscular, physiological, and sport-specific skills, the coach could identify the individual level of talent, workout intensity, and progress. This study provided important data for elite female sepak takraw players and trigered for more science-driven training programs. The current findings can be incorporated into sport-specific plans to enhance performance and minimize injury risks. Larger group studies, detailed biomechanics, and match play with long-term follow-up would help to refine the assessment and training program.

ETHICAL CONSIDERATIONS

The study was conducted in accordance with the ethical standards as laid down in the Declaration of Helsinki and its later amendments. Ethical approval was obtained from the Research Ethics Committee of Universitas PGRI Adi Buana Surabaya, Indonesia (registration number of 126/KE/UNIPA/2025). All participants were fully informed about the aims and procedures of the study, possible risks and benefits of the study, and written informed consent was obtained prior to participation. Participation was entirely voluntary and participants were free to withdraw at any time without penalty. All data collected were treated confidentially and used only for research purposes.

CONFLICT OF INTEREST

The authors declare that this study involves no conflicts of interest. This study was conducted independently, without any commercial or financial relationships that could be considered a potential conflict of interest.

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No external funding sources, sponsors, or institutional affiliations influenced the study design, data collection, data analysis, interpretation of results, or the decision to publish these findings.

AUTHOR CONTRIBUTIONS

All authors made significant contributions to the conception and design of this study. R led the conceptualization, data collection, analysis, and manuscript preparation. MH contributed to the methodology, statistical analysis, and interpretation of results. MR assisted with data collection, the literature review, and manuscript revisions. All authors critically reviewed and approved the final manuscript and agree to be accountable for the integrity and accuracy of this work.

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