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Original Scientific Article

Evaluating Key Biomotor Abilities: A Comparison between National and International Elite Tennis Players

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Abstract

Background. Biomotor ability is essential for elite tennis players, as it significantly contributes to increased efficiency, responsiveness and overall performance on the court.

Objectives. This study aimed to assess and measure the biomotor abilities of elite tennis players, examining both national and international levels, and focusing on their physical and motor performance.

Materials and methods. The research involved a cross-sectional study of a total of 28 tennis players; among them, 15 were national players, and the remaining 13 were international players who served as subjects. The study focused on assessing eight key biomotor abilities: arm-shoulder strength and endurance, static muscular endurance, grip strength, power, speed, agility, and flexibility. Each test was conducted using appropriate equipment and standardized procedures, ensuring accurate score recording for analysis. The data was gathered at Super Shots Tennis Academy and Punjabi Bagh Club in Delhi, India. The statistical analysis involved calculating descriptive statistics (mean and standard deviation) and conducting an independent t-test to determine significance. The analysis was performed using SPSS Version 25, with a significance level of 0.05.

Results. The independent t-test comparing the biomotor abilities of international and national tennis players showed no significant differences in pull-ups, push-ups, speed, agility, or flexibility ($p > 0.05$). However, significant differences were found in wall squat hang, vertical jump, and hand grip strength ($p < 0.01$), with international players demonstrating superior performance.

Conclusions. In conclusion, the study reveals notable differences in certain biomotor abilities between international and national players, especially in static muscular endurance, explosive leg power, and hand grip strength. The findings suggest that national tennis players implementing targeted strength and power exercises, along with specialized endurance training, may exhibit enhanced overall biomotor abilities and improved on-court performance.

Keywords: biomotor abilities, strength and endurance, elite tennis player, motor performance.

Introduction

In the competitive world of tennis, an athlete's success depends not only on technical skill and strategy but also on key biomotor abilities. Tennis has evolved into a highly dynamic and explosive sport, characterized by its increasing physical demands and the speed of strokes and serves (Kovacs, 2007; Fernandez-Fernandez et al., 2009). This evolution has led to a significant shift in the focus of physical fitness training, which now aims to enhance physiological potential and develop biomotor skills essential for peak performance on the court (Radu, 2023). The intricate interplay of various biomotor qualities, particularly those related to strength is crucial for optimal performance in tennis, influencing critical aspects such as footwork and explosive strokes (Genevois, 2019; Dobos et al., 2021; Lambrich & Muehlbauer, 2022).

Central to understanding athletic performance in any sport is the concept of biomotor abilities—physical attributes that enable athletes to execute movements effectively. These abilities encompass strength, speed,

endurance, agility, flexibility, and coordination, each playing a pivotal role depending on the sport (Bompa & Haff, 2009). In tennis, strength and speed are particularly important, while endurance, agility, and coordination are equally critical for sustained high-level performance (Zatsiorsky & Kraemer, 2006). The assessment of these abilities is essential for evaluating an athlete's physical fitness, identifying areas for improvement, and determining effectiveness in sports competition (Baj-Korpak et al., 2022). Athletes' performance and well-being are heavily shaped by their physical fitness, with motor fitness playing a crucial role in the development of game-specific strategies and tactics (Reza et al., 2024).

Tennis, as a globally cherished sport, integrates skill, strategy, and athleticism, appealing to players and enthusiasts of all ages and abilities. Achieving excellence in tennis requires rigorous training regimens that include comprehensive assessments of both general and tennis-specific motor skills (Alexandru & Lorand, 2015; Reid et al., 2013). The growing field of sports science has become a crucial resource, offering evidence-based strategies to optimize athlete performance and minimize injury risks (Dewanti et al., 2019; Kovacs, 2007). Within this context, biomotor abilities such as strength, agility, endurance, and coordination are particularly significant (Junaidi, 2018; Fernandez-Fernandez et al., 2014). Understanding how these abilities influence tennis performance is crucial for enhancing player potential and guiding effective training methodologies (Yapıcı et al., 2018; Roetert & Ellenbecker, 2007). A comprehensive literature review revealed a significant relationship between physical motor abilities—such as muscle strength, endurance, speed, agility, and balance—and the enhancement of tennis performance skills (Nugroho et al., 2024).

One key aspect of tennis-specific training is the emphasis on early strength development, which plays a vital role in shaping musculoskeletal health. This holistic approach underscores the importance of balancing joint flexibility and muscular strength, especially in a sport that involves repetitive, high-intensity movements (Tsao et al., 2022; Cools et al., 2014; Ellenbecker & Roetert, 2003). A well-rounded fitness and flexibility training program enhances muscle strength, flexibility, and coordination, which not only lowers the risk of injury during training or competition but also increases range of motion (Rebecca, 2020; Rahman & Islam, 2020). For instance, the shoulder's range of motion is a critical factor in both performance and injury prevention in tennis (Chang & Qiu, 2022; Kibler & Safran, 2005). Additionally, to enhance hamstring strength and prevent injury, the hamstring curl is among the most effective exercises for increasing hamstring flexibility (Islam et al., 2024). Consequently, in-depth research into tennis-specific biomotor abilities aims to uncover the intricate relationship between physical fitness and on-court proficiency, providing valuable insights for tailored training interventions (Yapıcı et al., 2018; Reid et al., 2010).

Despite extensive research on general biomotor attributes like strength, agility, and endurance, there is a notable gap in assessing and comparing these abilities between national and international tennis players. The specific differences between players at varying competitive levels remain underexplored. This study aims to evaluate and compare the key biomotor abilities of national and international tennis players, identifying areas where national players may lag or excel. The findings will offer insights for targeted training interventions, ultimately enhancing player development and elevating tennis standards through evidence-based strategies.

Material and Methods

Subjects

Twenty-eight (n = 28) elite tennis players who have competed professionally were selected as subjects for the study. Among them, 13 were international players, and the remaining 15 were national players. Data collection was carried out at two selected sports academies or clubs in Delhi, India: R. K. Khanna Tennis Stadium and Super Shots Tennis Academy, Punjabi Bagh Club. The following Table 1 indicates (Mean ± SD) that the international and national players are relatively close in terms of mean values across all variables, with no statistically significant differences.

Variables and Criterion Measures

The study selected the following eight essential biomotor variables for assessment: strength, strength endurance, grip strength, power, speed, agility, and flexibility. Each test was conducted with proper equipment and standardized

Table 1. Characteristics of the subjects

Variables	Groups	n	Mean	Std. Deviation	Sig.
Age (yr)	International	13	20.85	3.31	0.25
	National	15	19.23	3.92	
Height (cm)	International	13	172.50	14.88	0.55
	National	15	169.46	11.12	
Weight (kg)	International	13	73.54	6.65	0.01
	National	15	66.40	7.35	
Body mass index (kg/m^2)	International	13	25.15	4.42	0.29
	National	15	23.40	4.06	
Training experience (yr)	International	13	10.38	2.60	0.16
	National	15	8.73	3.43	

Table 2. Variables and criterion measures

Variables	Test items	Unit of measure
Arm Strength	Pull up	Number (n)
Arm Strength and Endurance	Push up	Number (n)
Static Muscular Endurance	Wall Squat Hang	Second (s)
Leg Power	Vertical Jump	Centimeter (cm)
Hand Grip Strength	Hand Grip Dynamometer	Kilogram (kg)
Speed	20 m Sprint	Second (s)
Agility	T-Drill	Second (s)
Flexibility	Sit and Reach	Centimeter (cm)

procedures, with scores accurately recorded for analysis. This approach aimed to ensure a systematic and scientific assessment of biomotor abilities in elite tennis players.

Test Procedure

The upper body strength endurance test evaluates the endurance of the triceps, pectoral, and deltoid muscles through push-ups. Players perform as many push-ups as possible in one minute, maintaining proper form, with the score being the total number of correct push-ups (Hashim et al., 2018; Adams et al., 2022). In the pull-up test, participants begin with arms fully extended and shoulders flexed for 2 seconds. A valid rep requires the upper jawline to pass above the bar, returning to the starting position without swinging or kipping (Bartolini, 2022; Coyne et al., 2015). The wall squat test measures quadriceps endurance. Players slide into a 90° sitting position against a wall, lifting one foot 5 cm off the ground and holding it as long as possible. The score is the time each foot remains elevated (Mackenzie, 2005; Fukuda, 2019). Grip strength is tested using a dynamometer. Players squeeze it as tightly as possible while moving their arm through a 90° arc, with the best score out of three attempts recorded for each hand (Lupton-Smith et al., 2022; Rahman & Sharma, 2023). The agility T-test assesses a player's ability to change direction quickly through a T-shaped course, recording the best time out of three trials (Pauole et al., 2000; Miller et al., 2006; Sassi et al., 2009). The sit-and-reach test measures lower back and hamstring flexibility. Players reach forward from a seated position, with the distance reached beyond the toes recorded as the best of three trials (Wells & Dillon, 1952; Holt et al., 1999; Baltaci et al., 2003). The vertical jump test measures leg power by having players jump and mark the highest point they reach on a wall (Whitmer et al., 2015; Klavora, 2000). Finally, the 20-meter sprint test measures speed and acceleration, with the best time out of three attempts recorded (Liu et al., 1992; Alikhajeh et al., 2012). The researchers and their assistants conducted all tests, ensuring both consistency and accuracy throughout the study.

Statistical Analysis

The collected data were analyzed using both descriptive and inferential statistical methods. Descriptive statistics, such as the mean and standard deviation (SD), were used, and inferential analysis included conducting an independent sample t-test to assess significance levels. The Shapiro-Wilk test confirmed normal distribution, and Levene's test equality of variances. The study utilized SPSS Version 25 for analysis, with a significance threshold set at 0.05.

Results

The following Table 3 presents the descriptive statistics (mean and SD) of biomotor abilities, while Figure 1 shows that, on average, international tennis players have higher mean values compared to national tennis players.

Table 4 presents the results of independent sample t-tests comparing the biomotor abilities of international and national tennis players. For the pull-up, push-up, speed,

Table 3. Descriptive statistics of bio-motor abilities

Variables	Groups	n	Mean	Std. Deviation	Std. Error Mean
Pull up	International	13	6.69	4.25	1.18
	National	15	5.67	4.08	1.05
Push up	International	13	26.23	8.06	2.24
	National	15	23.67	11.15	2.88
Wall Squat Hang	International	13	44.23	11.38	3.16
	National	15	14.67	7.48	1.93
Vertical Jump	International	13	19.30	2.42	0.67
	National	15	16.08	3.73	0.96
Hand Grip Strength	International	13	31.38	6.42	1.78
	National	15	15.44	5.25	1.35
Speed	International	13	3.45	0.35	0.10
	National	15	3.62	0.56	0.15
Agility	International	13	11.48	0.58	0.16
	National	15	12.16	1.41	0.36
Flexibility	International	13	6.18	2.35	0.65
	National	15	4.65	2.49	0.64

Table 4. Independent sample t-test of biomotor abilities

Items	Groups	Mean difference	Std. error difference	t	df	Sig. (2-tailed)
Pull up	International National	1.03	1.58	0.65	25	0.52
Push up	International National	2.56	3.64	0.70	25	0.49
Wall Squat Hang	International National	29.56	3.70	7.99	20	0.00*
Vertical Jump	International National	3.22	1.18	2.74	24	0.01*
Hand Grip Strength	International National	15.94	2.24	7.13	23	0.00*
Speed	International National	0.67	0.40	0.98	24	0.34
Agility	International National	0.67	0.40	1.70	19	0.11
Flexibility	International National	1.53	0.92	1.67	26	0.11

*. Significant at 0.05 level

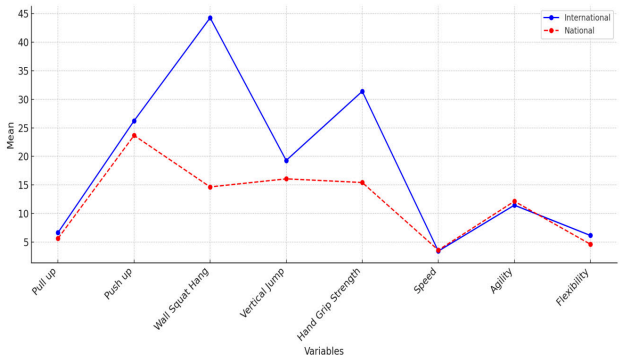

Fig. 1. Comparison of mean biomotor abilities

agility, and flexibility tests, no significant differences were found between groups: $t_{(25)} = 0.65$, $p = 0.52$; $t_{(25)} = 0.70$, $p = 0.49$; $t_{(24)} = 0.98$, $p = 0.34$; $t_{(19)} = 1.70$, $p = 0.11$; and $t_{(26)} = 1.67$, $p = 0.11$, respectively. However, significant differences were observed in the wall squat hang, $t_{(20)} = 7.99$, $p = 0.00$; vertical jump, $t_{(24)} = 2.74$, $p = 0.01$; and hand grip strength, $t_{(23)} = 7.13$, $p = 0.00$, indicating superior performance by the international players. The results indicate significant differences in specific biomotor abilities between international and national players, particularly in wall squat hang, vertical jump, and hand grip strength, at a significance level of 0.05.

Discussion

In the present study, as indicated in Table 4, significant differences were observed in hand grip strength, wall squat hang, and vertical jump. However, no significant differences were found in other strength variables, speed, agility, and flexibility. This finding is consistent with existing research, which presents a mixed view regarding differences in fitness abilities across various sports. For instance, research highlights that elite international male tennis players tend to exhibit superior leg power compared to their national counterparts. National level male tennis players average a vertical jump height of approximately 54 cm, while elite players typically achieve higher jump heights. This demonstrates enhanced explosive strength and power in their lower limbs (Farrow, 2013). In a study comparing international and national female tennis players, significant differences in functional asymmetries, particularly in lower extremity tests, were found. Nationally ranked players displayed greater asymmetry, whereas international players exhibited better symmetry and balance in their lower body strength. This is crucial for optimal performance in the dynamic and reactive environment of tennis (Chapelle et al., 2022). These findings align with previous studies, such as those by Kovacs (2007) and Fernandez-Fernandez et al. (2009), which emphasize the increasing physical demands of tennis, particularly the need for enhanced strength and explosiveness.

Additionally, a study by Ulbricht et al. (2016) compared young tennis players at different performance levels (regional vs. national teams), revealing significant differences in grip strength and 20-meter sprint times. Similarly, research on tennis players in the U12, U14, and U16 age groups found statistically significant differences in motor skills, particularly in tests like the 20-meter shuttle run, countermovement jump, and squat jump. These abilities tend to improve progressively with age, reflecting the increasing competitive demands at each performance stage (Barbaros et al., 2023). Moreover, Tamara et al. (2013) highlighted differences in motor abilities among Serbian national female tennis players in various age categories. Players aged up to 16 excelled in power and speed tests, while those up to 12 performed best in coordination-related tasks, influenced by their growth and training levels.

Training interventions like plyometric exercises can improve leg power and vertical jump performance (Thomas et al., 2009; Singh et al., 2024), while resistance training enhances grip strength (Thomas et al., 2008). Endurance exercises, such as wall squat hangs, effectively build both

upper and lower body strength and improve muscular endurance (Goldberg et al., 1994; Cho, 2013). Developing these biomotor skills not only boosts performance but also reduces injury risks from inadequate strength or endurance (Tsao et al., 2022; Ellenbecker & Roetert, 2003). Additionally, exercises like foot taps, jumping squats, lunges, and chin-ups significantly enhance agility, strength, and sport-specific skills (Fenta & Mola, 2023).

In summary, these studies highlight the critical role of physical conditioning in elite tennis, emphasizing how strength, endurance, power, speed, agility, and coordination progressively develop and distinguish players across different performance levels

Conclusions

In conclusion, the study found that international tennis players outperformed national players in static muscular endurance, explosive leg power, and hand grip strength. No significant differences were observed in pull-ups, push-ups, speed, agility, or flexibility. Targeted training in these key areas can help national players improve their biomotor abilities and overall performance, consequently enabling them to become elite international tennis players. Further research is needed to determine how these variables relate to performance success in elite tennis.

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Conflicts of Interest

The authors declare no conflicts of interest.

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Оцінка ключових показників біомоторних здібностей: Порівняльний аналіз між елітними тенісистами національного та міжнародного рівнів

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

Реферат. Стаття: 8 с., 4 табл., 1 рис., 56 джерел.

Історія питання. Біомоторна здібність має важливе значення для тенісистів високої кваліфікації, оскільки зазначений чинник суттєво сприяє підвищенню ефективності, швидкості реакції та загальній результативності на корті.

Мета дослідження. Мета цього дослідження полягала в оцінці та вимірюванні показників біомоторних здібностей елітних тенісистів як на національному, так і на міжнародному рівнях, з акцентом на фізичну та рухову результативність гравців.

Матеріали та методи. Представлена наукова праця передбачала проведення поперечного дослідження за участю 28 тенісистів, серед яких 15 були гравцями національного рівня, а решта 13 — міжнародними гравцями, які виступали в якості випробовуваних осіб. Дослідження було зосереджено на оцінці восьми ключових показників біомоторних здібностей: сили та витривалості рук і плечей, статичної м'язової витривалості, сили хвату, потужності, швидкості, спритності та гнучкості. Кожен тест проводився з використанням відповідного обладнання та стандартизованих процедур, забезпечуючи точну фіксацію результатів з метою подальшого аналізу. Збирання даних проводилося в тенісній академії "Super Shots Tennis Academy" та клубі "Punjabi Bagh" у місті Делі, Індія. Статистичний аналіз включав розрахунок описової статистики (середнє значення та стандартне відхилення) та проведення методики застосування t-критерію для незалежних вибірок з метою визначення значущості. Аналіз проводився за допомогою програмного забезпечення SPSS версії 25 з рівнем значущості 0,05.

Результати. Т-критерій для незалежних вибірок, за яким порівнювали біомоторні здібності тенісистів міжнародного та національного рівнів, не виявив достовірних відмінностей у наступних показниках: підтягування, віджимання,

швидкість, спритність та гнучкість ($p > 0,05$). Однак спостерігалися значні відмінності у виконанні присідань з опорою на стіну, вертикальному стрибку та силі кистьового хвату ($p < 0,01$), де міжнародні гравці продемонстрували кращу результативність.

Висновки. Отже, проведене дослідження виявило помітні відмінності у певних біомоторних здібностях між гравцями міжнародного та національного рівнів, особливо у показниках статичної м'язової витривалості, вибухової сили ніг та сили кистьового хвату. Отримані дані свідчать про те, що тенісисти національного рівня, які виконують цілеспрямовані силові вправи в поєднанні зі спеціалізованими тренуваннями на витривалість, можуть продемонструвати поліпшення загальних показників біомоторних здібностей, а також підвищення рівня результативності на корті.

Ключові слова: біомоторні здібності, сила і витривалість, елітний тенісист, рухова результативність.

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