

Physical Fitness Parameters of Chinese Outstanding Young Tennis Players

Parámetros de Aptitud Física de Jóvenes Tenistas Destacados Chinos

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SUMMARY: This study tested and analyzed the body morphology, sport quality parameters, and characteristics of Chinese outstanding young tennis players. Twenty Chinese outstanding young tennis players were used as the study subjects. Their body morphology parameters such as age, height, weight, body fat percentage, and BMI, and sport quality parameters such as bench press, squat absolute strength, grip strength, vertical jump, medicine ball side throw, Yo-Yo run, 10-meter sprint, spider run, hexagonal jump, and seated forward bending were tested and analyzed in comparison with international outstanding young tennis players of the same age group—comparative analysis. The results showed that outstanding Chinese young tennis players were slightly lower in height, slightly lighter in weight, and comparable in body fat percentage and BMI but had more years of training and had relatively better performance in deep squats and backhand side medicine ball throw. However, the performance of bench press, grip strength, forehand side throws medicine ball, spider run, hexagonal jump, vertical jump, seated forward bending, as well as the performance of men's 10-meter sprint and women's Yo-Yo run was lower than the international level of the same age.

KEY WORDS: Youth; Tennis; Body morphology; Strength and Conditioning; Physical qualities.

INTRODUCTION

Tennis is a network-blocking confrontation sport, and athletes' competitive performance is affected by various athletic ability factors such as physical fitness, technology, tactics, and psychology. With the continuous improvement of the competitive level of tennis in the world, the confrontational nature of tennis matches is getting stronger and stronger, and physical fitness plays an increasingly important role in athletes' competitive performance. International studies have mainly analyzed the physical fitness characteristics of tennis players from the perspectives of body morphology, physiological function, and sports quality parameters, and they have primarily focused on excellent athletes. However, few studies have been conducted on young tennis players' physical fitness parameters and characteristics.

Anthropometric parameters such as height, weight, body fat percentage, and BMI are commonly used to analyze athletes' physical morphometric characteristics. Hernández-Davó *et al.* (2021), found that compared to Chinese outstanding

young tennis players, international elite young tennis players were taller (male: 172.02 ± 9.12 m vs. 171.89 ± 8.49 m; female: 168.52 ± 5.12 m vs. 167.37 ± 4.92 m) and had lower body fat percentage (female: 18.51 ± 2.53 % vs. 18.86 ± 4.66 %), and lower BMI (male: 21.51 ± 2.33 kg/m² vs. 21.59 ± 2.73 kg/m²). These differences may be closely related to the athletes' training system, dietary management, and other factors. International elite young players focus more on high-intensity interval and strength training while strictly controlling their diets to maintain a lower body fat percentage and BMI.

In terms of physical function, according to Kovacs (2006), the maximal oxygen uptake (VO₂max/kg) of international elite male tennis players is usually in the range of 55-65 mL/kg/min, while that of international elite female tennis players is generally in the range of 50-60 mL/kg/min. Azad *et al.* (2011), stated that good cardiopulmonary function enhances adolescent athletes' physical adaptive capacity, enabling them to control the distribution of physical fitness

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during competition and reduce sports injuries caused by overexertion.

Existing studies have mainly used bench presses, deep squats, grip strength, and vertical jumps to test the essential strength qualities of elite young tennis players. Fernandez-Fernandez *et al.* (2023), found that most of the strength test values of international elite young tennis players were better than those of Chinese outstanding young tennis players, among which bench press (male: 60.23 ± 15.61 kg vs. 57.03 ± 16.02 kg; female: 40.06 ± 5.23 kg vs. 37.50 ± 6.77 kg) and grip strength (male: 48.64 ± 11.45 kg vs. 47.72 ± 10.96 kg) were significantly different. Vertical jump performance was comparable (male: 50.94 ± 5.46 cm vs. 50.56 ± 5.68 cm).

Reid & Schneiker (2008), showed that the aerobic system supply accounted for about 60-70 % and the anaerobic system supply accounted for about 30-40 % in tennis, and the training should pay attention to the development of aerobic and anaerobic endurance of the athletes. Madruga-Parera *et al.* (2020), found that the Yo-Yo run results of young male and female tennis players were, respectively, 1500.36 ± 100.65 m and 1200.63 ± 100.46 m, and concluded that the aerobic endurance qualities were better in international elite young tennis players. In addition, Smekal *et al.* (2001), stated that athletes' heart rate is usually maintained at 70-90 % of maximum heart rate and blood lactate values at 4-8 mmol/L during tennis matches, suggesting that athletes need to have a good anaerobic capacity to cope with high-intensity confrontation.

The speed of a tennis player includes not only straight sprint speed but also reaction speed, acceleration, Multi-directional movement speed. Hagemann *et al.* (2006), pointed out that the reaction time of elite tennis players is usually 0.15-0.25 seconds, and they can react to the opponent's shots in a very short time, especially in the reception of serves and the interception in front of the net. Reid & Schneiker (2008), found that elite athletes typically serve at speeds of 180-220 km/h (male) and 150-180 km/h (female), while forehand and backhand stroke speeds typically range from 120-160 km/h. Fernandez-Fernandez *et al.* (2023), tested that the 10-meter sprint performance of the international outstanding young male tennis players (1.826 ± 0.13 s vs. 1.817 ± 0.072 s) was superior to that of Chinese outstanding young tennis players.

Agility is the basis of tennis players' quick reactions, flexible movement, and accurate strokes in the match. Fernandez-Fernandez *et al.* (2023), indicated that the hexagonal jump performance of international elite young tennis players was superior to that of Chinese outstanding young tennis players (male: 14.623 ± 1.245 s vs. $8.309 \pm$

0.212 s; female: 15.515 ± 1.564 s vs. 8.685 ± 0.337 s). Madruga-Parera *et al.* (2020), demonstrated that the spider run performance of international elite young tennis players was superior to that of Chinese outstanding young athletes (male: 18.563 ± 0.436 s vs. 18.338 ± 0.401 s; female: 19.203 ± 0.569 s vs. 19.108 ± 0.607 s). Seated forward bending were also superior to those of Chinese outstanding young athletes (male: 15.26 ± 2.13 cm vs. 14.80 ± 1.40 cm; female: 18.76 ± 2.56 cm vs. 18.42 ± 4.51 cm).

In recent years, the rapid development of tennis in China, especially female athletes have won the Grand Slam, the Olympic Games, and other major tournaments, which also led to the vigorous development of Chinese young tennis, a large number of young athletes in the world's young tennis tournaments, and make a positive contribution to promoting the development of the world's tennis. However, in contrast to the practice's rapid growth, little research has been conducted on the physical fitness parameters and the characteristics of outstanding young tennis players. Therefore, this study analyzed the physical fitness parameters and the characteristics of outstanding young Chinese tennis players by using the test method and statistical analysis method, aiming to provide theoretical references for the practice of talent identification and physical training of young athletes in this sport.

MATERIAL AND METHOD

Participants and study design. This paper's subjects were 20 outstanding Chinese athletes (10 males and 10 females) participating in national and international junior competitions. The mean age was 14.8 ± 1.40 for males and 14.5 ± 1.72 for females. All subjects signed an informed consent form, and the study protocol was reviewed and approved by the Scientific Research Ethics Committee of Wuhan Sports University.

Data collection and instruments. Athletes' height and weight were measured using a height and weight measuring instrument. A multifunctional comprehensive strength trainer was used to test the athletes' squat, bench press, and grip strength; the athletes were fully warmed up, and the incremental load was tested 3 times to take the best performance as the test result. Test athletes' 10m sprint and Yo-Yo run on the track and field, and test athletes' spider run on the tennis court. The hexagonal jump test requires a hexagon design with a side length of 60 cm and an internal angle of 120° . Athletes must stand in the center of the hexagon and jump out and into the six edges according to the clockwise and counterclockwise directions after hearing the whistle, completing a total of 24 jumps, and recording the time. Athletes are always required to face the first edge,

keep upright, jump, land with both feet simultaneously, test twice, and record the best performance. The vertical jump test requires athletes to warm up thoroughly, perform two jumps, and get the best performance as the test result. Seated forward bending test: To test athletes' hip flexibility quality. Side Throwing Medicine Ball (Forehand/Backhand) requires athletes to stand in the designated position, throw the medicine ball sideways with forehand and backhand, respectively, and measure the throwing distance of the medicine ball.

Statistical analyses. SPSS (version 25.0, Armonk, NY, IBM Corp.) was used to analyze descriptive statistics (anthropometric, physiological, and physical parameters), and data were expressed as means \pm standard deviation (means \pm SD).

RESULTS

As shown in Table I, compared with international young tennis players of the same age, Chinese young tennis players were slightly lower in height (male: 171.89 ± 8.49 cm vs. 172.02 ± 9.12 cm; female: 167.37 ± 4.92 cm vs. 168.52 ± 5.12 cm). Weight was slightly lower (male: 64.34 ± 13.01 kg vs. 65.12 ± 12.02 kg; female: 56.80 ± 7.76 kg vs. 57.63 ± 6.26 kg). Body fat percentage was comparable (male: 13.02 ± 2.83 % vs. 13.14 ± 1.83 %; female: 18.86 ± 4.66 % vs. 18.51 ± 2.53 %). BMI was comparable (male: 21.59 ± 2.73 kg/m² vs. 21.51 ± 2.33 kg/m²; female: 20.27 ± 2.46 kg/m² vs. 20.70 ± 2.13 kg/m²). Longer years of training (male: 7.7 ± 0.82 years vs. 6.23 ± 1.86 years; female: 7.22 ± 1.14 years vs. 5.92 ± 1.65 years).

Table I. Indicators of physical fitness test for young tennis players.

Indicators	Chinese athletes		International athletes	
	Male athletes (n=10)	Female Athletes (n=10)	Male Athletes Mean \pm SD	Female athletes Mean \pm SD
Age (years)	14.80 \pm 1.40	14.50 \pm 1.72	14.61 \pm 1.31 (Hernández-Davó <i>et al.</i> , 2021)	14.42 \pm 1.21 (Hernández-Davó <i>et al.</i> , 2021)
Height (cm)	171.89 \pm 8.49	167.37 \pm 4.92	172.02 \pm 9.12 (Hernández-Davó <i>et al.</i> , 2021)	168.52 \pm 5.12 (Hernández-Davó <i>et al.</i> , 2021)
Body weight (kg)	64.34 \pm 13.01	56.80 \pm 7.76	65.12 \pm 12.02 (Hernández-Davó <i>et al.</i> , 2021)	57.63 \pm 6.26 (Hernández-Davó <i>et al.</i> , 2021)
Body fat percentage (%)	13.02 \pm 2.83	18.86 \pm 4.66	13.14 \pm 1.83 (Hernández-Davó <i>et al.</i> , 2021)	18.51 \pm 2.53 (Hernández-Davó <i>et al.</i> , 2021)
BMI (kg/m ²)	21.59 \pm 2.73	20.27 \pm 2.46	21.51 \pm 2.33 (Hernández-Davó <i>et al.</i> , 2021)	20.70 \pm 2.13 (Hernández-Davó <i>et al.</i> , 2021)
Training Age (years)	7.7 \pm 0.82	7.22 \pm 1.14	6.23 \pm 1.86 (Hernández-Davó <i>et al.</i> , 2021)	5.92 \pm 1.65 (Hernández-Davó <i>et al.</i> , 2021)
Bench press (kg)	57.03 \pm 16.02	37.50 \pm 6.77	60.23 \pm 15.61 (Fernandez-Fernandez <i>et al.</i> , 2023)	40.06 \pm 5.23 (Fekih <i>et al.</i> , 2020)
Deep Squat (kg)	99.51 \pm 23.74	73.13 \pm 10.06	95.63 \pm 20.23 (Fernandez-Fernandez <i>et al.</i> , 2023)	70.64 \pm 10.35 (Fekih <i>et al.</i> , 2020)
Grip strength (kg)	47.72 \pm 10.96	37.02 \pm 5.18	48.64 \pm 11.45 (Fernandez-Fernandez <i>et al.</i> , 2023)	37.76 \pm 5.49 (Fekih <i>et al.</i> , 2020)
Vertical jump (cm)	50.56 \pm 5.68	39.57 \pm 4.27	50.94 \pm 5.46 (Fernandez-Fernandez <i>et al.</i> , 2023)	40.67 \pm 4.98 (Fekih <i>et al.</i> , 2020)
Forehand side throw medicine ball (m)	10.18 \pm 2.00	7.74 \pm 0.68	10.96 \pm 2.79 (Madruga-Parera <i>et al.</i> , 2020)	8.81 \pm 1.43 (Fekih <i>et al.</i> , 2020)
Backhand side throw medicine ball (m)	9.11 \pm 1.90	6.80 \pm 0.80	7.26 \pm 1.06 (Madruga-Parera <i>et al.</i> , 2020)	6.53 \pm 0.74 (Fekih <i>et al.</i> , 2020)
Yo-Yo run (m)	1504.00 \pm 78.20	1100.00 \pm 164.65	1500.36 \pm 100.65 (Madruga-Parera <i>et al.</i> , 2020)	1200.63 \pm 100.46 (Fekih <i>et al.</i> , 2020)
10-meter sprint (s)	1.817 \pm 0.072	1.985 \pm 0.052	1.826 \pm 0.132 (Fernandez-Fernandez <i>et al.</i> , 2023)	1.963 \pm 0.192 (Berral-Aguilar <i>et al.</i> , 2022)
Spider run(s)	18.338 \pm 0.401	19.108 \pm 0.607	18.563 \pm 0.436 (Madruga-Parera <i>et al.</i> , 2020)	19.203 \pm 0.569 (Berral-Aguilar <i>et al.</i> , 2022)
Hexagonal jump (s)	8.309 \pm 0.212	8.685 \pm 0.337	14.623 \pm 1.245 (Fernandez-Fernandez <i>et al.</i> , 2023)	15.515 \pm 1.564 (Berral-Aguilar <i>et al.</i> , 2022)
Seated forward bending (cm)	14.80 \pm 1.40	18.42 \pm 4.51	15.26 \pm 2.13 (Madruga-Parera <i>et al.</i> , 2020)	18.76 \pm 2.56 (Berral-Aguilar <i>et al.</i> , 2022)

Compared with international young athletes of the same age, Chinese young tennis players had less bench press strength (male: 57.03 ± 16.02 kg vs. 60.23 ± 15.61 kg; female: 37.50 ± 6.77 kg vs. 40.06 ± 5.23 kg). Deep squat strength was more powerful (male: 99.51 ± 23.74 kg vs. 95.63 ± 20.23 kg; female: 73.13 ± 10.06 kg vs. 70.64 ± 10.35 kg). Grip strength was slightly lower (male: 47.72 ± 10.96 kg vs. 48.64 ± 11.45 kg; female: 37.02 ± 5.18 kg vs. 37.76 ± 5.49 kg). Vertical jump was slightly lower than the international level (male: 50.56 ± 5.68 cm vs. 50.94 ± 5.46 cm; female: 39.57 ± 4.27 cm vs. 40.67 ± 4.98 cm). The forehand side throw medicine ball was slightly worse (male: 10.18 ± 2.00 m vs. 10.96 ± 2.79 m; female: 7.74 ± 0.68 m vs. 8.81 ± 1.43 m), and the backhand side throw medicine ball was better (male: 9.11 ± 1.90 m vs. 7.26 ± 1.06 m; female: 6.80 ± 0.80 m vs. 6.53 ± 0.74 m).

Compared with international young athletes of the same age, Chinese young tennis players had comparable 10-meter sprint times (male: 1.817 ± 0.072 s vs. 1.826 ± 0.132 s; female: 1.985 ± 0.052 s vs. 1.963 ± 0.192 s). The male's Yo-Yo run was slightly better than the international average (1504.00 ± 78.20 m vs. 1500.36 ± 100.65 m), while the female's was slightly worse (1100.00 ± 164.65 m vs. 1200.63 ± 100.46 m). Chinese young tennis players performed well in the hexagonal jump (male: 8.309 ± 0.212 s vs. 14.623 ± 1.245 s; female: 8.685 ± 0.337 s vs. 15.515 ± 1.564 s) and slightly better in the spider run (male: 18.338 ± 0.401 s vs. 18.563 ± 0.436 s; female: 19.108 ± 0.607 s vs. 19.203 ± 0.569 s) and slightly worse in seated forward bending (male: 14.80 ± 1.40 cm vs. 15.26 ± 2.13 cm; female: 18.42 ± 4.51 cm vs. 18.76 ± 2.56 cm).

DISCUSSION

As shown in Table I, young Chinese tennis players have significantly more years of sports experience than their international counterparts, suggesting that they began tennis-specific training earlier. However, this is not a global practice. Haugen *et al.* (2024), showed that although most Grand Slam champions are introduced to tennis at the age of 4-5 years, they also participate in other different sports during their childhood and do not focus on tennis training until the age of 12-15 years. This early multi-sport background contributes to developing young athletes' physical, mental, and motor skills while reducing the risk of sports injuries associated with early specialization.

Height and weight have a significant effect on the competitive performance of tennis players. Table I shows that the mean values of height and weight of young Chinese tennis players are slightly lower than those of the international level. Differences in growth and development, dietary habits, and athlete selection strategies may cause this

discrepancy. Although taller heights have advantages in serving and high-pressure shots, relatively shorter athletes have more movement speed and agility advantages. For the cultivation of young Chinese tennis players, on the one hand, the talent identification mechanism should be improved; on the other hand, combined with the law of the sensitive period of the development of physical fitness of young athletes, it is essential to optimize the dietary and nutritional plan of athletes to enhance their muscle mass and control their body fat percentage and BMI level, while strengthening the strength and aerobic training.

Table I shows that compared with international young tennis players of the same age, Chinese young tennis players' body fat percentage and BMI are comparable. Buchheit & Laursen (2013), showed that the world's top tennis players have lower body fat percentage (male: 8 %-12 %, female: 16 %-18 %), and the lower body fat percentage helps to improve athletes' agility and mobility and also helps to improve relative strength levels and reduce energy consumption during long matches. Hernández-Davó *et al.* (2021), also reached a consistent viewpoint for comparing body morphology parameters between Chinese and international outstanding young tennis players. It was suggested that Chinese tennis players should strengthen muscular strength and aerobic endurance training while strictly controlling their diet to maintain a low body fat percentage and BMI.

Tennis players need good strength qualities. Lower limb, trunk, and upper limb strength must be comprehensive and balanced to move faster, change direction, rotate, and whip the ball during the game. As shown in Table I, although Chinese young tennis players had better performance in a deep squat and backhand side throw, their strength parameters such as vertical jump, bench press, grip strength, and forehand side throw were slightly lower than the international level, suggesting that Chinese young tennis players should improve their lower limb explosive power, leg push-off power during forehand strokes as well as upper limb essential strength. Fernandez-Fernandez *et al.* (2023), also pointed out in a comparative study of the strength qualities of international outstanding young tennis players and Chinese outstanding young tennis players that they need to strengthen their upper limb strength training.

For the physical characteristics of young athletes, 30-45 % 1RM deep squats and half squats, as well as depth jump exercises to overcome self-weight, folding running, multi-directional speed exercises, and other exercises can be used to develop the lower limb explosive power and strength endurance of Chinese young tennis players. Core area strength training, right and left side throwing medicine balls,

and front and back throwing solid ball exercises were used to develop the athlete's trunk strength. Resistance exercises such as 60-80 % 1RM bench presses, dumbbell curls, and elastic bands were used to create the upper limb strength of the athletes; in addition, combined with the characteristics of tennis technical movements, body functional training, trunk flexion, and extension, stirrup, and turn strength training, as well as strength training for all kinds of stroking were used to develop the strength of Chinese young tennis players.

The Yo-Yo run is primarily used to assess athletes' intermittent endurance and recovery capacity after high-intensity repeated sprints. As shown in Table I, Compared to international athletes of the same age, Chinese young tennis players exhibit less dominance in both aerobic and anaerobic endurance, especially female athletes. Therefore, it is recommended that Chinese young tennis players should enhance their training in these two areas. In a preparation training phase, gradually increasing the intensity of aerobic training can effectively develop aerobic endurance. Subsequently, high-intensity interval training can be incorporated to further develop the athlete's anaerobic endurance.

Lambrich & Muehlbauer (2023), showed that elite tennis players were significantly better at sprinting than sub-elite players. As shown in Table I, the 10-meter sprint performance of young Chinese tennis players is comparable to that of the international level. Multi-directional movement and body coordination are more critical for tennis players than straight-line movement speed. Bonato *et al.* (2020), states that the ability to move fast side-to-side, backward and forward, and multi-directional running is the key to improving competitiveness in tennis. Spider run and hexagonal jump tests can effectively assess tennis players' agility and coordination. As shown in Table I, young Chinese male and female tennis players excelled in both the hexagonal jump and spider run tests, surpassing the international level of the same age, and it is essential to continue to maintain this advantage in training.

Rotator cuff injuries and hip, knee, and ankle injuries are common sports injuries in tennis players. Among them, the flexibility of the hip joint directly affects the mobility of the athlete and the efficiency of force generation when hitting the ball. Insufficient hip joint flexibility may lead to overloading of the hip and knee, increasing the risk of injury. As shown in Table I, Chinese male and female athletes' performance in seated forward bending is lower than the level of international athletes of the same age, and static stretching, dynamic stretching, and core strength training can be used while focusing on correct posture and breathing control to enhance body flexibility and stability.

CONCLUSION

In this study, we compared the physical fitness indexes of Chinese outstanding young tennis players with their international counterparts and found that Chinese athletes were slightly lower in height, slightly lighter in weight, and had comparable body fat percentage and BMI but had more years of training. Chinese athletes performed relatively well in deep squats and backhand side throw medicine balls, but their performance in the bench press, grip strength, forehand side throw medicine ball, spider run, hexagonal jump, vertical jump, seated forward bending, men's 10m sprint, and women's Yo-Yo run was lower than that of their international counterparts. In order to cultivate more world-class outstanding young tennis players, attention should be paid to the balanced development of the physical qualities of Chinese young tennis players, especially the strengthening of athletes' upper limb strength, torso rotational strength, lower limb explosive strength, grip strength, aerobic endurance, sprinting speed, and flexibility training, and thus improve their overall physical fitness level.

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RESUMEN: Este estudio evaluó y analizó la morfología corporal, los parámetros de calidad deportiva y las características de jóvenes tenistas destacados chinos. Se evaluaron veinte tenistas jóvenes destacados chinos como sujetos de estudio. Sus parámetros de morfología corporal, como edad, altura, peso, porcentaje de grasa corporal e IMC, y parámetros de calidad deportiva, como press de banca, fuerza absoluta en sentadilla, fuerza de agarre, salto vertical, lanzamiento lateral con balón medicinal, carrera de yoyó, sprint de 10 metros, carrera de araña, salto hexagonal e inclinación hacia adelante sentado, se evaluaron y analizaron en comparación con jóvenes tenistas destacados internacionales del mismo grupo de edad (análisis comparativo). Los resultados mostraron que los jóvenes tenistas chinos destacados eran ligeramente más bajos en estatura y peso, y comparables en porcentaje de grasa corporal e IMC, pero contaban con más años de entrenamiento y un rendimiento relativamente mejor en sentadillas profundas y lanzamiento de balón medicinal lateral de revés. Sin embargo, el rendimiento en press de banca, fuerza de agarre, lanzamiento de balón medicinal lateral de derecha, carrera de araña, salto hexagonal, salto vertical, flexión hacia adelante sentado, así como en el sprint masculino de 10 metros y la carrera Yo-Yo femenina, fue inferior al nivel internacional de la misma edad.

PALABRAS CLAVE: Jóvenes; Tenis; Morfología corporal; Fuerza y acondicionamiento; Cualidades físicas.

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