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Physical Fitness Parameters of Chinese Elite Taekwondo Athletes

Parámetros de Aptitud Física de Taekwondistas de Élite Chinos

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SUMMARY: This study aimed to analyze the physical fitness parameters and their characteristics of Chinese elite taekwondo athletes and to propose corresponding training strategies. Twenty-seven Chinese national team taekwondo athletes were selected as the study subjects, including the 2024 Paris Olympic Games participants and the 2022 and 2023 World Taekwondo Championship medalists, totaling nine elite athletes. The test indexes included height, weight, BMI, the absolute strength of deep squat and bench press, 400 meters, 3000 meters, back up, V-up, hexagonal jump, standing long jump, and flexibility score. Compared to the ordinary athlete, Chinese male, and female elite taekwondo athletes did not show consistent characteristics in terms of height, weight, BMI, and other body morphology parameters, reflecting the fact that body morphology parameters are not a determining factor in the competitive performance of taekwondo athletes. Chinese female elite athletes with better performance in international competitions such as the Olympic Games showed better lower limb explosive power, back muscle strength endurance, aerobic and anaerobic endurance, agility, and hip flexibility.

KEY WORDS: Taekwondo; Elite athletes; Body shape; Physical quality; Olympic Games.

INTRODUCTION

Taekwondo is a combat sport in which a variety of competitive ability factors such as physical fitness, technique, tactics, and psychology influence athletes' competitive performance. In January 2023, the World Taekwondo Federation (WTF) revised the rules for taekwondo competitions, and the new rules were adjusted in terms of the competition system, foul behavior, and standards for technical movements (World Taekwondo Federation, 2024). The original three-game point system has been changed to a two-out-of-three-game system, with each game being scored and penalized independently. If there are five penalty points in a single game, the opponent will win the game, and if the difference in the score of a single game reaches 12 points, the leader will win the game. Under the new rules, the competition is more intense, and the ordinary number of technical and tactical applications and points scored by the athletes per set has increased significantly, which puts higher demands on the athletes' physical fitness and technical and tactical application ability.

With the increasing level of competition confrontation, physical fitness plays an increasingly important role in the competitive performance of elite taekwondo athletes (Fortes *et al*., 2017). International studies on physical fitness parameters and the characteristics of elite taekwondo athletes have focused on body morphology, physiological functions, and motor qualities. Among them, studies on the body morphology of elite taekwondo athletes are relatively abundant, mainly analyzing anthropometric parameters such as height, weight, limb length, body fat percentage, BMI, and their characteristics. For example, Agopyan *et al*. (2022), compared the body morphometric parameters of winning and non-winning athletes at the European Taekwondo Championships and found that the winning athletes were taller [(1.79±0.06) m vs. (1.77±0.07)m], had lower body fat percentage [(10.83±1.61) % vs. (11.43±2.04) %], and defatted weights was greater [(54.67±5.37) kg vs. (53.85±8.44) kg].

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There are also different opinions on the analysis of height characteristics; for example, Cular *et al*. (2011), found that the ordinary height of non-winning athletes in the four categories of the women's event in the Olympic taekwondo competition was higher than that of medal-winning athletes [(171.72±6.18) cm *vs*. (169.41±7.86) cm]. Da Silva Santos *et al*. (2018), also came to the same conclusion, suggesting that taller athletes are disadvantaged in timing their attacks due to longer lower limbs, increased kicking swing cycles, and slower movements. Noh *et al*. (2014) stated that elite taekwondo athletes had a lower BMI when compared to the ordinary athlete [(22.4±0.3) kg/cm^2 *vs*. (23.0±0.4)kg/cm^2]. In addition, body fat percentage measured by different testing methods differed, with the range of mean values of body fat percentage in male and female elite taekwondo athletes in the available studies being 7.27 %–13.28 % and 11.19 % - 22.54 %, respectively, and elite athletes had lower body fat percentage (Reale *et al*., 2020; Agopyan *et al*., 2022).

In terms of physical function, existing studies have mainly used VO_{2max} values to evaluate the aerobic capacity of elite taekwondo athletes, and heart rate, blood lactate, 30sWingate, 15-second continuous vertical jump, and kicking frequency to assess the anaerobic capacity of elite taekwondo athletes. For example, Kim & Nam (2021), stated that elite taekwondo athletes need to have excellent aerobic capacity to maintain continuous confrontation during competition and rapid recovery between matches and sets, and tested the top 10 % of Korean female taekwondo athletes with VO2max values ranging from 61.2 to 63.8 mL/kg/min. He & Tang (2013), tested the relative maximum power and average power of Chinese elite taekwondo athletes at 12.25 w/kg and 7.26 w/kg, respectively, which were significantly higher than those of ordinary athletes of 11.00 w/kg and 6.34 w/kg, indicating that elite athletes possessed a more substantial anaerobic work capacity. Santos *et al*. (2020), used the Frequency of Kick test (FSKT) to assess the anaerobic capacity of kicking in Taekwondo athletes found that elite Taekwondo athletes had a higher frequency of round house kick strikes and a more remarkable ability to execute high-intensity round house kicks continuously.

In terms of physical quality, existing studies have mainly used vertical jump, squat, bench press, isometric muscle strength, grip strength, and sit-up to test the essential strength qualities of elite taekwondo athletes. For example, Norjali Wazir *et al*. (2019), found that elite taekwondo athletes of the Belgian national team outperformed non-elite athletes in all strength test values, with turnaround vertical jump [(33.4±4.95) cm *vs*. 28.4±5.62) cm] and deep squat jump [(30.1±6.45) cm *vs*. (26.4±5.19) cm] showing significant differences ($p<0.05$). Sadowski *et al*. (2012) showed that Polish elite taekwondo athletes outperformed non-elite athletes in the 30m sprint [(5.07±0.39)s vs. (5.26±0.48)s]. The mean performance of the Illinois sensitive running test in Chinese elite male taekwondo athletes was 6.13±0.17s (Huang *et al*., 2009). Seated forward bending and forks are commonly used to evaluate the flexibility quality of elite taekwondo athletes. The male and female elite taekwondo athletes' seated forward bending scores were 36-36.9 cm and 35.2-56.6 cm, respectively (Bridge *et al*., 2014).

Internationally available studies have tested and analyzed the physical fitness parameters and their characteristics of elite taekwondo athletes, mainly from anthropometric, exercise physiology, and kinesiology perspectives. The previous studies have laid a solid foundation for subsequent research in terms of the selection of physical fitness testing indicators and physical fitness characterization of elite taekwondo athletes. Since taekwondo was established as an Olympic sport in 2000, the Chinese taekwondo team has won 7 gold, 2 silver, and 4 bronze medals in the past seven Olympic Games. However, studies on the physical fitness characteristics of Chinese elite taekwondo athletes are rare. Therefore, the present study analyzed the physical fitness parameters of Chinese elite taekwondo athletes and their attributes by using the test method and statistical analysis method, with the aim of providing the physical fitness parameters of Chinese elite taekwondo athletes for the coaches, athletes, researchers, and enthusiasts of taekwondo, as well as providing theoretical references for the selection of athletes for the sport and the training of the physical fitness of this sport.

MATERIAL AND METHOD

Participants and study design. Twenty-seven athletes (15 males and 12 females) from the Chinese National Taekwondo Team were used as study subjects, including the 2024 Paris Olympic Games participants and the 2022 and 2023 World Taekwondo Championships winners, totaling 9 as elite athletes (3 males and 6 females), and the remaining 18 athletes as ordinary athletes. All subjects signed an informed consent form for the test, and the study protocol was reviewed and approved by the Research Ethics Committee of Wuhan Sports University.

Data collection and instruments. Athletes' height and weight were measured using a height and weight measuring device. A multi-functional integrated strength trainer is used to test athletes' deep squat and bench press strength; athletes fully warm up, and an incremental load test is performed 3 times to get the best performance. Athletes will be tested on 400m and 3000m in a standard track and field stadium. The back up test requires athletes to lift their upper body and feet quickly within 1 minute in the prone position and record

the maximum number of times. The V-up test requires athletes to lie flat on the mat, complete the legs and arms at the same time within 1 minute, and record the maximum number of times. The Hexagonal Jump Test requires the design of a hexagon with a side length of 60 cm and an internal angle of 120°. The athlete is required to stand in the center of the hexagon, and when the whistle is heard, jump out and into the six edges in clockwise and counterclockwise directions, completing a total of 24 jumps and recording the time. Athletes are required to face the first side of the body at all times, remain upright, jump and land with both feet at the same time, test twice, and record the best performance. The standing long jump test requires the athlete to warm up sufficiently and then perform two jumps, taking the best score. Horizontal and vertical forks are used to test the quality of athletes' hip flexibility, with a score of 1-20 to evaluate the performance of athletes' flexibility, and the higher the score, the better the performance.

Statistical analyses. SPSS (version 25.0, IBM Corp Armonk, NY, USA) was used to analyze descriptive statistics (anthropometric and physical parameters), and data were expressed as mean ± standard deviation (SD). Independent samples t-tests were performed on the physical parameters of elite and ordinary Chinese taekwondo athletes. Statistical significance was set at $p \leq 0.05$.

RESULTS

As shown in Table I, Figure 1(A-C), male elite taekwondo athletes were taller (193±5.20 *vs.* 190±9.77 cm), heavier (85.2±15.08 *vs.* 77.79±10.38 kg), and had comparable BMIs (21.73±3.52 *vs*. 21.55±1.61) compared to the ordinary athletes; female elite athletes were shorter (177.67±6.95 *vs*.183±8.29 cm), lighter (62±7.97 *vs*. 70.38±14.54 kg), and had a slightly lower BMI (19.58±1.27 *vs*. 20.8±2.56).

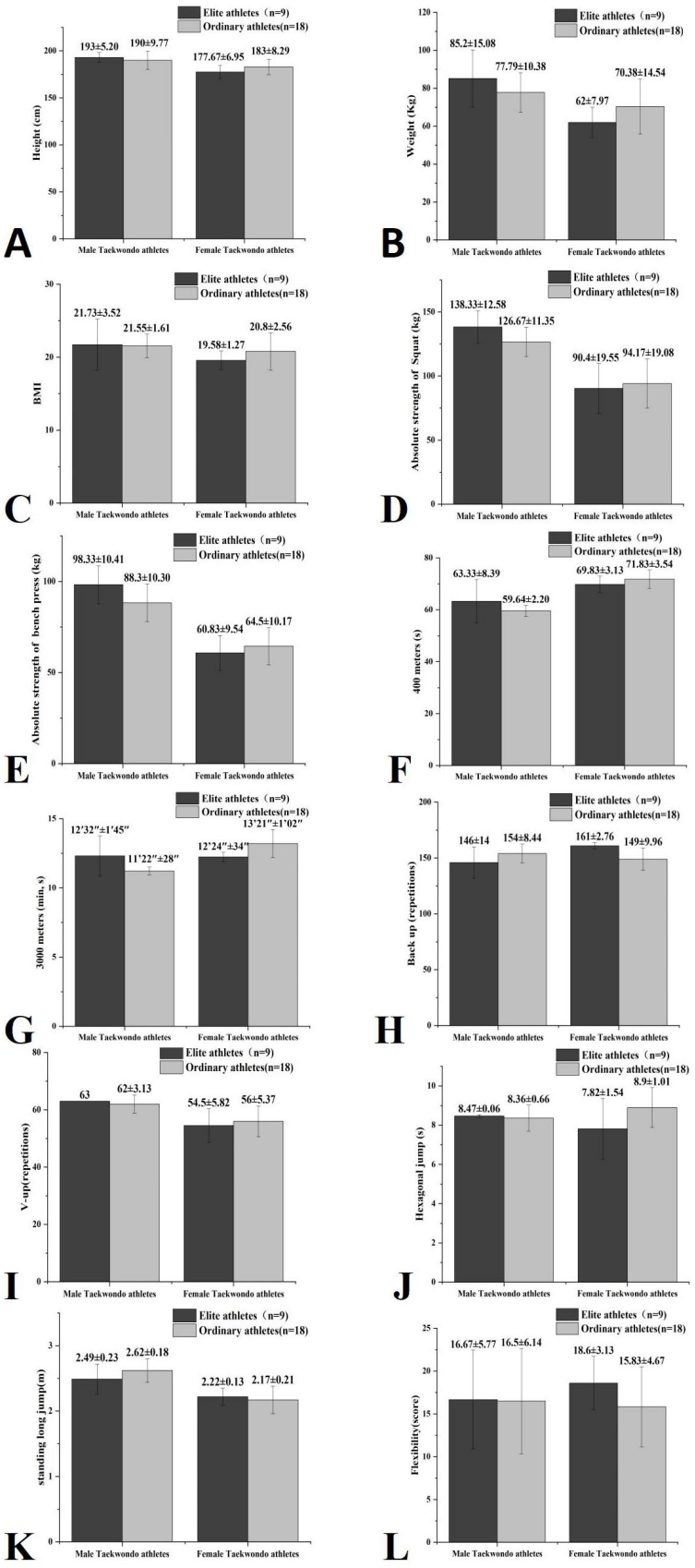
As shown in Table I, Figure 1(D-E) (H-K), compared to the ordinary athlete, elite male athletes had greater strength in a deep squat (138.33±12.58 *vs*. 126.67±11.35 kg), bench press (98.33±10.41 *vs*. 88.3±10.30 kg), slightly fewer back up (146±14 *vs*. 154±8.44 rep). The number of V-up was comparable (63 *vs.* 62±3.13 rep), and the standing long jump was poorer (2.49±0.23 vs. 2.62±0.18m); female elite athletes squatted (90.4±19.55 *vs*. 94.17±19.08kg) and bench pressed (60.83±9.54 *vs*. 64.5±10.17 kg) with less strength, the number of back up was higher and significantly different (161±2.76 *vs.* 149±9.96 rep; p=0.031), the number of V-up was comparable (54.5±5.82 *vs*. 56±5.37 rep), and the standing jump was slightly farther (2.22±0.13 *vs*. 2.17±0.21m).

As shown in Table I, Figure 1(F-L), compared with the ordinary athletes, the elite male athletes had worse performance in 3000m (12′32″±1′45″ vs. 11′22″±28″), 400m (63.33±8.39 *vs*. 59.64±2.20s), hexagonal jump (8.47±0.06 *vs.* 8.36±0.66s), and forks (16.67±5.77 *vs*. 16.5±6.14scores) were comparable; women's 3000m (12′24″±34″ *vs*. 13′21″±1′02″), 400m (69.83±3.13 *vs*. 71.83±3.54s), hexagonal jump (7.82±1.54 *vs*. 8.9±1.01s), forks (18.6 ±3.13 *vs.* 15.83±4.67scores) were better.

Table I Physical fitness parameters of Chinese elite and ordinary taekwondo athletes.

	Male Taekwondo athletes			Female Taekwondo athletes		
	Elite (n = 3)	Ordinary (n = 12)	p	Elite (n = 6)	Ordinary (n = 6)	p
Height (cm)	193±5.20	190±9.77	0.622	177.67±6.95	183±8.29	0.255
Weight (kg)	85.2±15.08	77.79±10.38	0.326	62±7.97	70.38±14.54	0.248
BMI	21.73±3.52	21.55±1.61	0.086	19.58±1.27	20.8±2.56	0.321
Absolute strength of deep squat (kg)	138.33±12.58	126.67±11.35	0.142	90.4±19.55	94.17±19.08	0.755
Absolute strength of bench press (kg)	98.33±10.41	88.3±10.30	0.157	60.83±9.54	64.5±10.17	0.534
400 meters (s)	63.33±8.39	59.64±2.20	0.526	69.83±3.13	71.83±3.54	0.324
3000 meters (min, s)	12′32″±1′45″	11′22″±28″	0.052	12′24″±34″	13′21″±1′02″	0.079
Back up (repetitions)	146±14	154±8.44	0.215	161±2.76	149±9.96	0.031*
V-up (repetitions)	63	62±3.13	0.293	54.5±5.82	56±5.37	0.653
Hexagonal jump (s)	8.47±0.06	8.36±0.66	0.787	7.82±1.54	8.9±1.01	0.18
Standing long jump (m)	2.49±0.23	2.62±0.18	0.338	2.22±0.13	2.17±0.21	0.658
Flexibility (score)	16.67±5.77	16.5±6.14	0.967	18.6±3.13	15.83±4.67	0.289

**, P≤0.01, Very significant difference; *, P≤0.05, Significant difference.



DISCUSSION

According to Agopyan *et al*. (2022), higher height and leg length advantage extends the attacking and defending distance and hitting range, and lighter body weight enhances movement speed and reduces energy consumption. Table I, Figure 1 (A-C) shows that male elite athletes are taller, heavier, and have comparable BMI compared to the ordinary athlete. Female elite athletes were shorter, lighter, and had a slightly lower BMI. Although height and weight are essential indicators of the competitive performance of taekwondo athletes, they are not decisive factors. The same conclusion was reached in the study of Cular *et al*. (2011). The elite female athletes of the Chinese team did not have height and weight advantages, but their overall performance was better relative to the male athletes, which may be related to the more vigorous technical and tactical application of the female athletes. Studies have shown that taekwondo athletes in the same weight category who are taller, have greater defatted body weight, and have a lower body fat percentage are more likely to produce superior results (Kazemi *et al*., 2009; Da Silva Santos *et al*., 2018; Górski & Orysiak, 2019). If these physical shape parameters are not advantageous, there is a greater need to strengthen the athlete's physical fitness and technical and tactical application to compensate for their physical conditioning deficiencies.

Fig. 1. A. Comparison of height between Chinese elite and ordinary taekwondo athletes. B. Comparison of body weights of Chinese elite and ordinary taekwondo athletes. C. Comparison of BMI between Chinese elite and ordinary taekwondo athletes. D. Comparison of absolute strength of squat between elite Chinese and ordinary taekwondo athletes. E. Comparison of absolute bench press strength between elite Chinese and ordinary taekwondo athletes. F. Comparison of 400 meters between elite Chinese and ordinary taekwondo athletes. G. Comparison of 3000 meters between elite Chinese and ordinary taekwondo athletes. H. Comparison of Back up between elite Chinese and ordinary taekwondo athletes. I. Comparison of V-up between elite Chinese and ordinary taekwondo athletes. J. Comparison of hexagonal jumps between Chinese elite and ordinary taekwondo athletes. K. Comparison of standing long jump between Chinese elite and ordinary taekwondo athletes. L. Comparison of flexibility between Chinese elite and ordinary taekwondo athletes.

Taekwondo is a combat sport that involves confrontation through kicks and punches. Athletes' absolute lower limb strength and explosive power have an essential effect on kicking movements and their application, and absolute upper limb strength also plays a vital role in the impact of punching. Table I, Figure 1(D-E)(K) shows that the male elite athletes of the Chinese taekwondo team had better deep squat and bench press absolute strength than the ordinary athletes, but the standing long jump results were slightly worse, indicating that the male elite athletes had insufficient lower limb explosive power. Although the absolute strength of deep squats and bench presses of female elite athletes is relatively lower, their standing long jump performance is better. Female elite athletes include Olympic silver medalists and World Taekwondo Championship champions, whose competitive level indicates that although absolute strength affects the competitive performance of elite taekwondo athletes, it is not a decisive factor. At the same time, lower limb explosive force is a key quality necessary for elite taekwondo athletes. The better the explosive power, the more conducive to the athlete's rapid start, kicking, and movement, and thus better recognize, capture, and respond to the timing of the attack to enhance athletic performance.

Table I, Figure 1(H-I) shows that there is no advantage of abdominal and back strength endurance in male elite athletes compared to ordinary athletes, but back strength endurance in female elite athletes is better and significantly different. Trunk strength not only plays the role of power chain transmission in Taekwondo technical confrontation but also is an essential guarantee for adjusting body posture, controlling the distance between attack and defense, maintaining the balance of the center of gravity, and improving the effect of strikes. Anwarudin *et al*. (2020), pointed out that abdominal and back muscle strength, flexibility, and suppleness are crucial for the explosive power of the lower limbs and the quality of kicks in Taekwondo athletes. With the changes in taekwondo competition rules, the number of techniques applied per unit of time by elite athletes in competition has significantly increased, and the role played by the lumbar and abdominal muscles in the process of technical strikes has become more and more critical. Therefore, elite taekwondo athletes, especially Chinese male elite athletes, need to strengthen the development of trunk strength, endurance, and explosive power.

Taekwondo competitions are based on a two out of three rounds system, with a two-minute round and a one-minute break between rounds. The competition of the same category is fought in one day, and the finalists need to complete 4-5 matches in one day. This shows that elite Taekwondo athletes need to have outstanding anaerobic endurance to complete each round of high-intensity confrontation, as well as good aerobic endurance to maintain physical fitness for multiple consecutive matches and the ability to recover quickly between matches and rounds. Zhou & Wang (2017) pointed out that athletes in taekwondo competitions are mainly supplied by ATP-CP and glycolytic energy supply system, supplemented by aerobic metabolic energy supply system, and that improving the body's ATP-CP reserve and its ability to recover quickly and accelerating the removal of lactic acid is essential for the enhancement of taekwondo athletes' physical fitness. The Chinese taekwondo team tested athletes' aerobic endurance and anaerobic endurance using 3000-meter and 400-meter runs, respectively. Table I and Figure 1(F-G) show that compared with ordinary athletes, male elite athletes have relatively poor aerobic and anaerobic endurance. In contrast, female elite athletes are significantly better, which is consistent with the better overall competitive level of female elite athletes in the current Chinese team, indicating that elite taekwondo athletes need to strengthen aerobic and anaerobic endurance training.

Research has shown that agility is a key motor quality for combat counterpart athletes (Bridge *et al*., 2014; Chaabene *et al*., 2018). Although the agility of elite taekwondo athletes is influenced by many factors such as reaction speed, movement speed, timing awareness, technique application, and tactical strategy, body coordination, flexibility, and balance are the basis of agility. The hexagonal jump is often used to assess athletes' agility. Table I and Figure 1(J) show that compared with the ordinary athletes, male elite athletes performed slightly worse in the hexagonal jump, while female elite athletes performed better, which is also consistent with the better overall competitive level of female elite athletes in the current Chinese team. Therefore, elite taekwondo athletes need to pay attention to the development of agility, which can be strengthened by using body functional training, specific reaction speed training, moving footwork training, body coordination training, changing target position training, and actual combat confrontation training.

Taekwondo kicking movement is composed of four parts: preparation, knee lifting, kicking, and recovery. The mobility of the hip, knee, and ankle joints has an essential effect on the quality of kicking and striking. The hip joint is not only the starting point of knee lifting but also the key body part for outputting striking force and maintaining body balance. Therefore, hip joint flexibility is one of the essential physical qualities for elite taekwondo athletes. Table I, Figure 1(L) shows that both male and female elite taekwondo athletes have better performance in flexibility quality compared to ordinary athletes. In the physical fitness test, some athletes had poor results in the horizontal fork test, which was related to the fact that athletes used less technical movements similar to the horizontal fork movement in their daily training. The

horizontal fork is composed of hip flexion, abduction, and external rotation, which reflects the mobility of the hip, posterior thigh, and medial thigh muscle groups and is also affected by the muscle strength of the iliopsoas muscle, the tensor fasciae latae, the gluteus maximus muscle, and other active muscles. Therefore, to address the problem of lack of hip flexibility in elite taekwondo athletes, it is necessary to strengthen the muscle strength of the relevant active muscle groups on the one hand and the extension of the passive muscles on the other hand, so as to strengthen the multidirectional mobility of the hip joint.

CONCLUSION

Chinese men's and women's taekwondo athletes won a bronze and a silver medal, respectively, at the 2024 Paris Olympics, with women's taekwondo qualifying for and bettering all four Olympic categories. Although taekwondo athletes' technical and tactical application and mental ability play an important role in performance, the physical fitness level of elite taekwondo athletes is becoming increasingly important under the new rules. The study showed that Chinese male and female elite athletes did not show consistent characteristics of height, weight, BMI, and other physical morphology parameters. Chinese female elite athletes with better results in international competitions showed better lower limb explosive power, back muscle strength endurance, aerobic and anaerobic endurance, agility qualities, and hip flexibility qualities. From the perspective of physical training of elite taekwondo athletes, emphasis should be placed on the development of athletes' lower limb essential strength and explosive strength, trunk strength endurance, aerobic and anaerobic endurance, agility qualities, and hip flexibility qualities.

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RESUMEN: Este estudio tuvo como objetivo analizar los parámetros de aptitud física y sus características en taekwondistas de élite chinos y proponer estrategias de entrenamiento correspondientes. Se seleccionó a 27 taekwondistas de la selección nacional china, incluyendo a los participantes de los Juegos Olímpicos de París 2024 y a los medallistas del Campeonato Mundial de Taekwondo de 2022 y 2023, un total de nueve atletas de élite. Los índices de prueba incluyeron altura, peso, IMC, fuerza absoluta en sentadilla profunda y press de banca, 400 metros, 3000 metros, espalda, V-up, salto hexagonal, salto de longitud sin apoyo y flexibilidad. En comparación con el atleta promedio, los atletas chinos de élite de taekwondo, tanto hombres como mujeres, no mostraron características consistentes en cuanto a altura, peso, IMC y otros parámetros morfológicos corporales, lo que refleja que estos parámetros no son un factor determinante en el rendimiento competitivo de los atletas de taekwondo. Las atletas chinas de élite con mejor rendimiento en competiciones internacionales como los Juegos Olímpicos mostraron mayor potencia explosiva en los miembros inferiores, resistencia muscular de la espalda, resistencia aeróbica y anaeróbica, agilidad y flexibilidad de cadera.

PALABRAS CLAVE: Taekwondo; Atletas de élite; Forma corporal; Calidad física; Juegos Olímpicos.

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