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Physical Fitness Parameters of Chinese Elite Paralympic Badminton Players

Parámetros de Aptitud Física de los Jugadores de Bádminton Paralímpicos de Elite Chinos

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SUMMARY: The physical fitness parameters and characteristics of elite Paralympic badminton players remain understudied on an international level. This study aims to analyze physical fitness parameters and traits specifically among Chinese elite Paralympic badminton players to propose tailored training strategies. The research focused on twenty-four Chinese national team players, categorized into three groups: eight wheelchair athletes (four male, four female), nine male standing athletes, and seven female standing athletes, among who nine were Paralympic gold medalists. The following parameters were measured: sitting height/height, arm and forearm circumferences, chest circumference, body fat percentage, absolute strength in bench press, bench pull, and badminton throw far, along with 12 minutes of wheelchair push/run, and multi-directional movement abilities. Notably, compared with the average Chinese team athlete, the elite players had taller sitting height/height, lower body fat percentages, superior aerobic endurance, and enhanced agility.

KEY WORDS: Paralympic badminton; Elite athletes; Body shape; Physical fitness; Paralympics.

INTRODUCTION

Paralympic badminton has evolved from traditional badminton, marking its inception with the inaugural World Paralympic Badminton Championships held in the Netherlands in 1998. Since June 2011, the Badminton World Federation (BWF) has assumed the mantle as the principal governing authority overseeing Paralympic badminton. First introduced as a competitive discipline at the 2020 Tokyo Paralympic competitions, Paralympic badminton witnessed the Chinese team triumphantly amassing 5 gold, 3 silver, and 2 bronze medals, significantly bolstering China's medal tally in this event. Remarkably, the 2020 Tokyo Paralympics witnessed the inaugural inclusion of Paralympic badminton as a competitive sport, and China emerged victorious at the top of the medal tally. Subsequently, at the 2024 Paris Paralympic competitions, the Chinese Paralympic badminton team solidified its international dominance by claiming 9 gold, 2 silver, and 1 bronze medal.

Prior to engaging in international competitions, Paralympic badminton athletes are subject to rigorous assessments of their physical and technical abilities by the classification panel from the World Badminton Federation. This evaluation process determines their eligibility for competition and assigns them to the appropriate classification of competition based on their degree of disability. As illustrated in Table 1, the Paralympic badminton competition spectrum encompasses six distinct classifications: two for wheelchair (WH1, WH2), two for standing lower limb (SL3, SL4), one for standing upper limb (SU5), and one for short height (SH6).

Paralympic badminton competition rules are basically adopted by the non-disabled badminton competition rules, only the courts of some classifications are different. The competition method is single round-robin and single elimination, with three competitions and two wins. The first person to score 21 points in a game wins the competition (except for the following cases: after 20 draws, the one who is ahead by 2 points wins the competition; after 29 draws, the first person to score 30 points wins). Wheelchair and SL3 athletes use half-court singles courts, while all other standing competitions use standard courts for non-disabled singles or doubles.

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Table 1. Classifications of Paralympic Badminton Competitions (Validated by China Badminton Association, 2023).

Groups	Classifications	Disability and motor ability
Wheelchair	WH1	Usually bilateral lower limb disability with impaired trunk function and more significant motor function impairment
Wheelchair	WH2	Disability of one or both lower limbs, with slight or no damage to the trunk and relatively good motor skills
Standing lower limb	SL3	Athletes who compete standing but have a disability of one or both lower limbs and poor walking or running balance
Standing lower limb	SL4	Athletes competing standing but with lower limb disability less severe than SL3, with single or double lower limb disability, and with minor impairment of walking or running balance
Standing upper limb	SU5	Athletes who are non-disabled and flexible in both lower limbs and unilaterally disabled in the upper limbs
Short height	SH6	Dwarf with "pygmyism" or "dwarfism"

Purnama & Doewes (2022), analyzed the technical parameters of a forehand snap by an excellent SU5 athlete. They found that the athlete's legs jumped at a height of 0.43m, the ball hit the ground at a height of 2.95m, the knee flexion angle was 101.6°, the knee extension angle was 177.9°, and the force generated was 302.94N with a power of 342.63J/s and a kinetic energy of 0.62J. The speed of the snap was 15.07m/s, with the ball landing angle of 15.4°; this speed is accomplished by a shoulder angle of 164.6°, an elbow extension angle of 148.3° for the striking arm, and an angular velocity of 10.8 rad/s for forward spin. It is pointed out that when frontal spike, attention should be paid to the shoulder angle of the striking arm, elbow extension angle, elbow forward rotation angular velocity, striking force and its momentum transfer, as well as the knee flexion and extension angle and strength at the time of jumping.

Wang *et al*. (2023), constructed a specialized physical fitness evaluation index system for elite male wheelchair badminton athletes, in which the four level 1 indicators were, in order of weighting: sport-specific skills (0.4406), sports qualities (0.2928), cardiorespiratory function (0.1828) and body shape (0.0838). Oliveira *et al*. (2022), showed that SL3 badminton athletes' heart rate and oxygen uptake changed significantly during exercise tests and simulated matches. Cardiorespiratory training needs to be strengthened to improve the athletes' endurance level. Due to physical limitations, physical training tools for Paralympic badminton players are relatively complex and need to be personalized for different individuals.

Using "para-badminton" and "Paralympic badminton" as keywords, we searched 387 articles through Web of Science and Google Scholar. Among these, 5 specifically focused on the physical fitness of Paralympic badminton players. Taking "Paralympic badminton" and "Disabled Badminton Player" as the theme words, 37 articles were retrieved from China National Knowledge Infrastructure (CNKI), among which 3 articles were related to the physical fitness of Paralympic badminton players. International studies mainly analyze the technical, psychological, performance and injury rehabilitation of Paralympic badminton players, while Chinese studies include biographies, sports psychology, sports team development, injury rehabilitation, and characteristics of techniques and tactics of wheelchair group. Overall, there are few international studies on physical fitness parameters and their characteristics of elite Paralympic badminton players.

The competitive level of Chinese Paralympic badminton is in a leading position in the international arena. Analyzing the physical fitness parameters and their characteristics of Chinese elite Paralympic badminton athletes can provide important parameters of body morphology and athletic quality for coaches, athletes, scientific researchers and related enthusiasts of this sport and provide a basis for the selection of athletes and physical training of this sport. Consequently, this study employs testing methodologies and mathematical statistics to analyze the physical fitness parameters and characteristics of Chinese elite Paralympic badminton players, further proposing tailored training strategies that serve as theoretical guides for the practical implementation of physical fitness training for athletes in this discipline.

MATERIAL AND METHOD

Participants and study design. In this study, 24 Chinese National Paralympic Badminton Team players (including nine gold medalists of the Paris 2024 Paralympic Games) were selected as test subjects; among them, 4 Male wheelchair athletes (MWA), 4 Female wheelchair athletes (FWA), 9 Male standing athletes (MSA), 7 Female standing athletes (FSA). The highest-ranked athletes within the Chinese national team of the 2024 Paralympic Games Points Tournament at all levels of singles game or the 2024 World Paralympic Badminton Championships were considered elite

athletes, totaling 12 (including 9 The Paris Paralympic Games gold medalists), and the remaining 12 athletes were ordinary athletes. 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. Anthropometric measurements encompassing sitting height (for wheelchair groups) and height (for standing groups), arm and forearm circumferences, chest circumference, and body fat percentage were accurately assessed using a tape measure, a skin fold thickness gauge, and a soft ruler.

Physical fitness evaluations encompassed absolute strength of bench press and bench pull, Badminton throw far, 12 minutes of shuttle run/wheelchair push test, and Multi-directional movement assessments. Following a thorough warm-up, athletes engaged in a 1RM (one-repetition maximum) test utilizing bench press and bench pull equipment, with data analysis exclusively about athletes who participated in the two-handed barbell test. For the Badminton throw far, a new Victor brand ball was utilized. The 12 minutes of wheelchair push/shuttle run test was conducted on a badminton court, with a designated 20m straight line; and participants in SL3 and SL4 levels did not participate in this test. In the standing multi-directional movement test (Fig. 1., SL3: Fig. 1B), 5 badminton balls are placed in each of No. 1 to No. 4, and the right-handed racket holder repeats 5 times in the order of 0-1-2-3-4, and the left-handed racket holder repeats 5 times in the order of 0-3-4-1-2; in the wheelchair group multi-directional movement test (Fig. 1B), 5 badminton balls are placed in the outer circle of 20cm radius of each of the No. 1 and No. 3 points, and the athletes need to hold the racket to touch the badminton balls of No. 1 and No.3, and make a swinging gesture when the rear wheel arrives at point No. 2 and No. 4,the other requirements are the same as those of the standing group, and the staff starts timing from the start of the athlete until the end of touching the last badminton.

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

RESULTS

As shown in Table II, Fig. 2 (C-N), the results of the physical fitness test for elite athletes and ordinary athletes were as follows: Age (MWA:29±8.49 *vs*. 24±0 years; FWA:21±1.41 *vs.* 22.5±4.95 years; MSA:26.25±4.19 *vs*. 36.2±6.26 years; FSA:28.75±2.5 *vs*. 25.33±4.73 years), Training Age (MWA:15.5±6.36 *vs*. 8.5±0.71 years; FWA:9±1.41 *vs*. 8.5±3.54 years; MSA:9±3.60 *vs*. 13.8±5.89 years; FSA:11.75±3.59 *vs*. 9.33±2.31 years), and Sitting height/height (MWA:92.75±1.77 *vs*. 90±5.66 cm; FWA:86.25±8.84 *vs*. 86±4.24 cm; MSA:164±16.27 *vs*. 161.6±16.65 cm; FSA:154.75±13.4 *vs*. 150.33±16.5 cm), Body fat percentage (MWA:15.25±1.09 *vs*. 21.97±4.67 %; FWA:19.40±0.01 *vs*. 21.88±2.12 %; MSA:12.79±2.12 *vs*. 17.23±3.93 %; FSA:22.10±3.01 *vs*. 26.04±8.85 %), and upper explosive strength (MWA:7.68±0.51 *vs*. 7.16±0.91 m; FWA:5.92±0.45 *vs*. 6.13±0.21 m; MSA:8.02±0.44 *vs*. 7.08±0.79 m; FSA:6.43±0.46 *vs*. 6.26±0.28 m), endurance qualities (MWA:2355.10±69.47 *vs*. 2304.96±130.48 m; FWA: 1981.81±26.41 *vs*. 1949.84±70.66 m; MSA:2308.25±322.79 *vs*. 2037.49±533.85 m; FSA:2104.5±321.73 *vs*. 1998.97±9.02 m), agilty qualities (MWA:46.68±1.48 *vs*. 48.64±1.97 s; FWA:52.36±9.26 *vs*. 62.40±9.21 s; MSA:36.52±1.75 *vs*. 41.79±2.45 s; FSA:40.87±4.80 *vs*. 45.33±7.19 s) demonstrate a strong correlation with competitive level, whereas the link between arm and forearm circumference, chest circumference, and upper limb absolute strength, and competitive level is comparatively weaker.

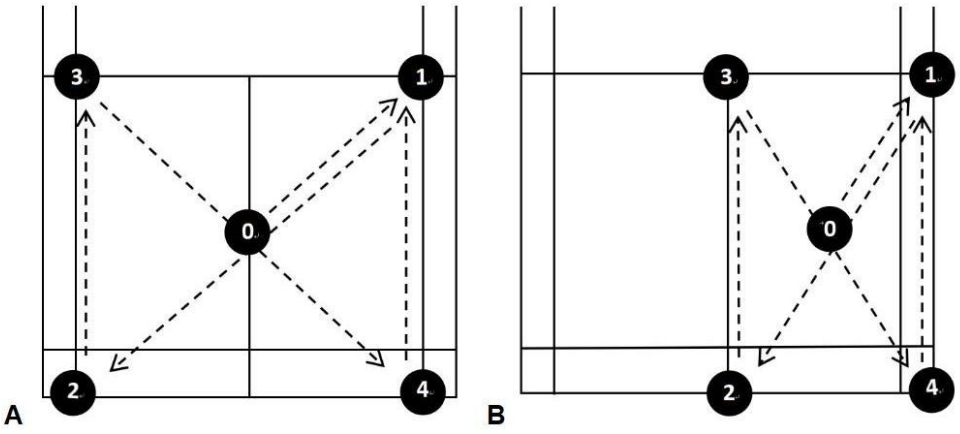

Fig. 1. A. SL4, SU5, SH6 multi-directional movement test routes. B. WH1, WH2, SL3 multi-directional movement test routes

DISCUSSION

Table II and Figure 2 (C-D) show that the elite athletes in the male wheelchair and female standing groups of the Chinese Paralympic badminton team are older and have longer training years; the elite athletes in the female wheelchair group are younger but have slightly longer training years, and the elite athletes in the male standing group are younger and have shorter training years, indicating that Paralympic badminton athletes should increase their training years to accumulate competition experience, except for the male standing group athletes, who may be relatively low in overall competitive level in this category. Regarding body shape, the elite athletes of the Chinese Paralympic badminton team have a higher sitting height/height and a lower body fat rate. In this study, due to the limitations of the sample size and the special physical conditions of Paralympic badminton athletes, the grading of the sport and the overall competitive level of the sport, the relationship between body morphology indicators, such as the athletes' arm circumference, forearm circumference and chest circumference, and the level of competitiveness did not show consistent characteristics. Weight was not included in the test due to differences in disability.

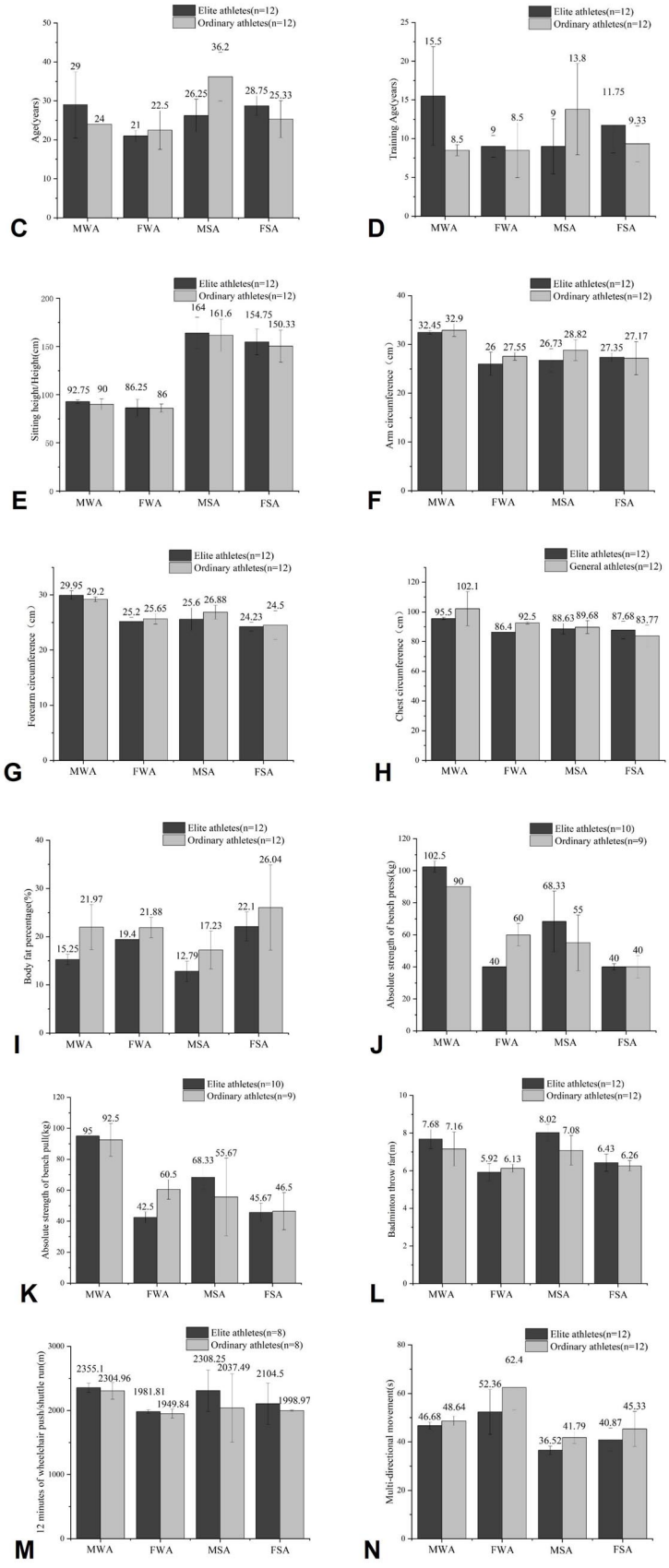

Fig. 2. C. Comparison of age between Chinese elite and ordinary Paralympic badminton players. D. Comparison of training age between Chinese elite and ordinary Paralympic badminton players. E. Comparison of sitting height/height between Chinese elite and ordinary Paralympic badminton players. F. Comparison of arm circumference between Chinese elite and ordinary Paralympic badminton players. G. Comparison of forearm circumference between Chinese elite and ordinary Paralympic badminton players. H. Comparison of chest circumference between Chinese elite and ordinary Paralympic badminton players.I. Comparison of body fat percentage between Chinese elite and ordinary Paralympic badminton players. J. Comparison of absolute strength of bench press between Chinese elite and ordinary Paralympic badminton players. K. Comparison of the absolute strength of bench pull between Chinese elite and ordinary Paralympic badminton players. L. Comparison of badminton throw far between Chinese elite and ordinary Paralympic badminton players. M. Comparison of 12-minute of wheelchair push/shuttle between Chinese elite and ordinary Paralympic badminton players. N. Comparison of multi-directional movement between Chinese elite and ordinary Paralympic badminton players.

Table II. Physical fitness parameters of elite and ordinary Paralympic badminton players in China.

	Male wheelchair athletes		Female wheelchair athletes		Male standing athletes		Female standing athletes	
	Elite n=2)	Ordinary (n=2)	Elite (n=2)	Ordinary (n=2)	Elite (n=4)	Ordinary (n=5)	Elite (n=4)	Ordinary (n=3)
Age (years)	29±8.49	24±0	21±1.41	22.5±4.95	26.25±4.19	36.2±6.26	28.75±2.5	25.33±4.73
Training Age (years)	15.5±6.36	8.5±0.71	9±1.41	8.5±3.54	9±3.60	13.8±5.89	11.75±3.59	9.33±2.31
Sitting height/height (cm)	92.75±1.77	90±5.66	86.25±8.84	86±4.24	164±16.27	161.6±16.65	154.75±13.43	150.33±16.5
Arm circumference (cm)	32.45±0.35	32.9±1.27	26±2.40	27.55±0.78	26.73±2.38	28.82±2.14	27.35±0.87	27.17±3.39
Forearm circumference (cm)	29.95±0.78	29.2±0.42	25.2±0.71	25.65±0.92	25.6±2.04	26.88±1.27	24.23±0.80	24.5±2.62
Chest circumference (cm)	95.5±0.71	102.1±11.46	86.4±0	92.5±0.71	88.63±3.54	89.68±4.33	87.68±5.80	83.77±7.26
Body fat percentage (%)	15.25±1.09	21.97±4.67	19.40±0.01	21.88±2.12	12.79±2.12	17.23±3.93	22.10±3.01	26.04±8.85
Absolute strength of bench press (kg)	102.5±3.54	90±0	40	60±7.07	68.33±18.93	55±17.32	40±2	40±7.07
Absolute strength of bench pull (kg)	95±0	92.5±10.61	42.5±3.54	60.5±6.36	68.33±7.64	55.67±25.03	45.67±6.03	46.5±12.02
Badminton throw far (m)	7.68±0.51	7.16±0.91	5.92±0.45	6.13±0.21	8.02±0.44	7.08±0.79	6.43±0.46	6.26±0.28
12 minutes of shuttle run/wheelchair push (m)	2355.10±69.47	2304.96±130.48	1981.81±26.41	1949.84±70.66	2308.25±322.79	2037.49±533.85	2104.5±321.73	1998.97±9.02
Multi-directional movement (s)	46.68±1.48	48.64±1.97	52.36±9.26	62.40±9.21	36.52±1.75	41.79±2.45	40.87±4.80	45.33±7.19

In terms of strength, as shown in Figure 2 (J-L), the absolute strength of bench press and bench pull of male wheelchair group athletes was significantly higher than that of the standing group. The absolute upper body strength and explosive power of elite male wheelchair and standing athletes were superior to those of ordinary athletes. This indicates that absolute upper body strength and explosive powerpositively correlate with male athletes' competitive performance. Compared with the ordinary athletes, the elite athletes in the female wheelchair and standing groups had significantly lower absolute upper limb strength but similar or slightly superior explosive power, indicating that explosive power of the upper limb is more important for the competitive performance of women athletes. As shown in Figure 2(L), compared with the wheelchair group, athletes in the standing group could conduct power transfer through the lower limbs and generally had better upper limb explosive strength.

In badminton competitions, a better level of explosive power is beneficial for athletes to complete critical techniques such as smash technique. The Chinese Paralympic badminton team mainly adopts stretch-shortening-cycle (SSC) to develop athletes' lower limb explosive power, such as deep jump and squat jump. The standing group specializes in organizing eccentric strength training for the athletes' hamstrings to strengthen their braking and changing direction speed performance. It also uses elastic bands to combine exercises with techniques such as dealing with the opponent' smash and drop shot techniques to improve their strength. In addition, exercises such as fast push-ups with barbells or dumbbells and medicine ball throws are used to develop the athletes' upper body explosiveness. Repeated bench press and bench pull training with different loads and intensities are used to develop the athletes' upper body absolute strength and strength endurance, and unilateral strength training is used to help improve the athletes' left-right muscle imbalances.

As shown in Figure 2(M), Chinese elite Paralympic badminton players at all levels had better results in the 12 minutes of shuttle run/wheelchair push test compared with ordinary athletes in terms of endurance. The duration of high-level badminton matches is 19-80 min, and the closer the competitive level of both sides, the longer the match time and the higher the requirement for aerobic endurance. Wang *et al*. (2019), showed that the aerobic energy supply in badminton simulation matches accounted for 87.5%~95.4%. The Chinese Paralympic badminton

team attaches great importance to athletes' aerobic endurance training. It mainly adopts continuous training (20 min pushing wheelchair/cycling/rowing boat) to develop athletes' aerobic endurance.

Li *et al*. (2013), showed that peak oxygen uptake(VO2peak), lactate threshold, and aerobic metabolism were significantly increased in competitive wheelchair athletes after six weeks of plateau training. The Chinese Paralympic badminton team transferred to Guizhou Province for four weeks of sub-altitude training before the Paris Paralympic Games to improve athletes' aerobic endurance. The anaerobic endurance of Paralympic badminton players is mainly manifested in continuous rapid movement and multi-shot strokes during the competition. This type of ability is primarily developed through multi-directional intermittent sprint training (40~60s uniform speed followed by 20s sprinting in a 20-minute cycle), strength endurance training, specialized technical and tactical training, and actual combat. Goosey-Tolfrey *et al*. (2003), stated that wheelchair basketball and racing athletes with more excellent trunk stability and balance had on average 11% higher peak oxygen uptake(VO2peak)values and endurance performance in the competition after controlling for the influences of athlete age, weight, and body fat percentage. The Chinese Paralympic badminton team mainly uses trunk strength training such as anti-rotation, anti-lateral flexion, and anti-flexion to develop athletes' body stability, balance, and energy economy during rapid movement and changes in direction. This optimizes the transmission of the trunk power chain during hitting, gaining more incredible movement speed and hitting explosiveness, delaying exercise fatigue, and ensuring the quality of the application of skills and tactics throughout the competition.

Agility is one of the most crucial motor qualities for Paralympic badminton players. As shown in Figure 2(N), the results of the multi-directional movement test of Chinese elite Paralympic badminton players were faster than ordinary players. The agility of athletes in badminton competitions is reflected in reaction time, quick starts, changes of direction, sudden stops, the speed of linear and multi-directional movement, and tactical adaptability. The Chinese Paralympic badminton team mainly uses multi-directional movement, multi-ball training that combines tactics, and wheelchair teams that specifically organize secondary starts and sudden stops for wheelchair pushing (e.g., one whistle for forward, two whistles for backward) to develop the agility of athletes.

Limitations. This study is the first to analyze the body morphology and athletic quality of elite Paralympic badminton athletes at all levels. Due to the limited sample size of athletes and the significant pathological differences in the body structure and function of athletes at different classifications, it is difficult to select the test indexes and their testing methods, and there are some limitations in analyzing the physical characteristics of elite athletes. In the future, we should further refine the testing indexes of body morphology and athletic quality of Paralympic badminton athletes of different classifications, and further expand the sample size of elite athletes from different countries, so as to collect anthropometric and kinematic parameters of athletes more scientifically and accurately, and to provide theoretical references for the practice of physical training in this sport.

CONCLUSION

Compared with general athletes, Chinese elite Paralympic badminton players are of moderate age, with longer training years, elite badminton players have higher sitting height/height and lower body fat percentage, male elite badminton players have better absolute strength in bench press and bench pull and better explosive power in badminton long throw, whereas female elite badminton players have less absolute strength but similar explosive power, and elite badminton players have better endurance and agility were better. From the perspective of athletes' long-term development and physical training, Paralympic badminton players should increase the number of years of training to accumulate training and competition experience. Elite Paralympic badminton players should pay attention to the basic strength and explosive power of the upper limbs and lower limbs (except wheelchair group) and the power endurance training of continuous hitting, and at the same time, develop the athletes' core strength, aerobic endurance and agility, and control their body fat rate at a low level.

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RESUMEN: A nivel internacional los parámetros y características de aptitud física de los jugadores de bádminton paralímpicos de élite siguen siendo poco estudiados. Este estudio tuvo como objetivo analizar los parámetros y rasgos de aptitud física, específicamente, entre los jugadores de bádminton paralímpicos de élite chinos para proponer estrategias de entrenamiento personalizadas. La investigación se centró en veinticuatro jugadores del equipo nacional chino, categorizados en tres grupos: ocho atletas en silla de ruedas (cuatro hombres, cuatro mujeres), nueve atletas de pie masculinos y siete atletas de

pie femeninas, entre los cuales nueve fueron medallistas de oro paralímpicos. Se midieron los siguientes parámetros: altura/altura sentada, circunferencias de brazos y antebrazos, circunferencia del pecho, porcentaje de grasa corporal, fuerza absoluta en press de banca, tirón de banca y lanzamiento de bádminton a larga distancia, junto con 12 minutos de empuje/carrera en silla de ruedas y habilidades de movimiento multidireccional. Cabe destacar que, en comparación con el atleta promedio del equipo chino, los jugadores de élite tenían una altura/altura sentada más alta, porcentajes de grasa corporal más bajos, resistencia aeróbica superior y agilidad mejorada.

PALABRAS CLAVE: Bádminton paralímpico; Atletas de élite; Forma corporal; Aptitud física; Juegos Paralímpicos.

REFERENCES

China Badminton Association. *Badminton competition rules 2023*. Beijing, People's Sports Press, 2023.

Goosey-Tolfrey, V. L.; Batterham, A. M. & Tolfrey, K. Scaling behavior of VO2peak in trained wheelchair athletes. *Med. Sci. Sports Exerc., 35(12)*:2106-11, 2003.

Li, L.; Li. H. & Wang, Y. Altitude training on aerobic capacity effect of wheelchair racing athletes. *J. Beijing Sport Univ., 36(5)*:74-7, 2013.

Oliveira, S. F. M.; Oliveira, J. I. V.; Haiachi, M. & Felder, H. Heart rate, oxygen uptake, and energy expenditure response of an SL3 class parabadminton athlete to a progressive test and simulated training session: a case study. *Appl. Physiol. Nutr. Metab., 47(8)*:883-7, 2022.

Purnama, S. K. & Doewes, R. I. Biomechanics analysis of badminton forehand smash in standing classification disability players. *J. Phys. Educ. Sport, 22(12)*:3183-8, 2022.

Wang, D.; Wang, S.; Hou, J. & Yin, M. Construction of a sport-specific strength and conditioning evaluation index system for elite male wheelchair badminton athletes by the Delphi method. *J. Men Health, 19(9)*:82-91, 2023.

Wang, X.; Li, B. & Li, X. Profile of energy contribution in simulated badminton match and multi-ball stroke drill. *China Sport Sci. Technol., 55(9)*:3-8, 2019.

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