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Research article

Construction and validation of the Wingate index model for elite athletes

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ABSTRACT

Objective: The gold standard for measuring anaerobic fitness is the power cycle ergometer test, but this method is expensive and time-consuming, and it has negative effects on pre-competition performance. This study aims to utilize the strong correlation between accessible body composition indices and less accessible anaerobic power bicycle indices to establish and verify a Wingate Index Model.

Methods: A cohort of 993 male (age: 22.56 ± 3.30 years) and 450 female (age: 21.47 ± 2.70 years) athletes who participated in diverse sports were enrolled and completed the high-intensity power cycle test and body composition test, and the model formula was established based on these data. Totally, 283 participants were randomly selected to verify the formula using SPSS 22.0 and GraphPad Prism 9.4.1.

Results: There was no significant difference between the value derived from the confirmed formula and the measured value of the instrument among the elite athletes ($p > 0.05$). The probabilities that the values obtained by the formula would fall within the 95 % confidence interval were as follows: Mpower(mean power): 94.7 %, Mpower/W(mean power/weight): 96.8 %, total work: 94.7 %, Ppower(peak power): 94.7 %, Ppower/W(peak power/weight): 95.8 %, and fatigue index: 93.6 %.

Conclusion: By constructing and validating multiple regression equations for the anaerobic power cycle and body composition indices, this study showed that the probabilities of the values obtained from the equations falling within the 95 % confidence interval were 94.7 % for Mpower, 96.8 % for Mpower/W, 94.7 % for total work, 94.7 % for Ppower, 95.8 % for Ppower/W, and 93.6 % for fatigue index. Therefore, these equations may have some practical value in predicting the elite athlete population.

1. Introduction

Anaerobic capacity is the primary and pivotal athletic ability that requires development in various sporting disciplines, including sprinting, ball games, gymnastics, cycling, short track speed skating, and short burst events. A strong anaerobic capacity is also required at the onset and during the acceleration sprint phase of medium and long-distance events [1–6]. Anaerobic capacity is a critical determinant of exceptional athletic performance in both power and endurance events [7]. Consequently, the development of anaerobic capacity in training has gained increasing attention, with a focus on testing and evaluating this vital physiological function.

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Anaerobic capacity plays a crucial role in enhancing the merit of an athlete's performance in most sporting activities.

Body composition is an important factor for weight control, scientific and rational training arrangements, and maintenance of optimal athletic ability [8]. Different sports have different requirements for the body composition of athletes. With the rapid improvement in modern competitive sports, it has been recognized that an athlete's body composition is closely related to their athletic ability [9,10]. Researchers have identified a strong correlation between body composition ratio and athletic ability in high-level athletes in various sports [11–13]. Lean body mass is the weight that remains after removing body fat, and muscle is an important component of lean body mass. Muscle is the primary driver of an athlete's work during exercise, and studies have shown that lean body mass is strongly correlated with anaerobic capacity [14–16]. There is a moderate to strong correlation between muscle and peak power (Ppower), minimum power, and mean power (Mpower) in both male and female athletes. Similarly, the same moderate to strong correlation exists between body weight and Ppower, minimum power, and Mpower [16]. Another study reported that body fat is negatively correlated with exercise capacity and anaerobic power in athletes [17]. This suggests that anaerobic power cycling indices are also strongly correlated with body composition.

Scholars have used various testing methods to measure the anaerobic power and anaerobic capacity of athletes, such as the 20-m, 30-m, and 35-m repeated sprint run tests, suicide run test, Bosco test, and anaerobic power cycling test [18–21]. The Wingate Anaerobic Test (WAT) is a standard test used to determine anaerobic power and anaerobic capacity. It was proposed by the Sports Medicine Research Laboratory of the Wingate Institute of Physical Education in Israel in the early 1970s and further developed and refined by Ayalon et al., in 1974 [22]. This test has been an important method for evaluating anaerobic capacity in humans since the 1980s [22]. Numerous studies have shown that the WAT is useful for measuring the anaerobic power of athletes for sports selection, functional evaluation, and monitoring of training effects [22].

Bioimpedance analysis (BIA) is an emerging method for measuring body composition. As a health-related fitness evaluation index, it can be used to monitor nutritional status and body fluid balance; evaluate biological development, maturation, and aging; and contribute to the study of related diseases. Therefore, BIA is of great value for clinical and basic research, and it is thus receiving increasing research attention [23]. Research on body composition detection technology, including bioelectrical impedance, has developed rapidly. Inbody 3.0, Inbody 520, Inbody 720, and Inbody 770, which were produced by Biospace in Korea, are the most widely used human body composition analyzers and the most advanced instruments of their kind in the international arena [23]. They are suitable for use in the Chinese population, and they can be used to determine body composition quickly and accurately [9,23,24].

The Wingate Index Model is an algorithmic model that uses easily measurable body composition indicators to predict the Wingate test index. The bicycle test is a valid and reliable test of anaerobic power, and it is widely considered the gold standard in both domestic and international studies. However, according to relevant research, this method is limited because it is time-consuming and expensive due to its measurement method. In addition, the equipment is not portable, so it can be challenging to test the anaerobic exercise ability of athletes before a race [17,14]. Body composition analysis is more widely used than the power bicycle test as it has a shorter testing time [14]. Therefore, there are fewer concerns about the physical exertion of athletes before a race [1,14,17,19]. To overcome these shortcomings of the power bicycle test, this study aims to utilize the strong correlation between accessible body composition indices and less accessible anaerobic power bicycle indices to establish and verify a Wingate Index Model.

2. Methods

2.1. Participant selection

A cohort of 1000 male and 500 female athletes from several major sports academies in China were screened. The exclusion criteria were cardiovascular ailments and other illnesses that would prevent the athletes from undergoing strenuous, high-intensity power cycling tests. Some athletes were excluded, yielding a sample of 993 males and 450 females who completed the high-intensity power cycling test and body composition test to establish the formula model. Five nationwide sports schools and 60 participants from each school were randomly selected to obtain a total of 300 participants. Seventeen of the 300 participants were unable to participate in the tests due to competitions, so test data were available for 283 participants. These 283 participants were selected to verify the formula model using SPSS 22.0 and GraphPad Prism 9.4.1. All athletes provided voluntary written informed consent to participate in the study. The study was conducted after Medical Ethics Review by Hainan Medical College (Hnky2021-41), and the study protocol conformed to the principles outlined in the Declaration of Helsinki. The results of the body morphometric tests are shown in Tables 1 and 2.

2.2. Body composition measurement

Body composition parameters were each measured independently by one professional, and the relevant test methods and precautions were explained to the tester before each test. The body composition analyzer was calibrated by professional personnel. Height

Table 1
Body morphometric characteristics of the participants.

Sex	Age (years)	Height (cm)	Weight (kg)	BMI (kg/m^2)
Male (N = 993)	22.56 ± 3.30	174.90 ± 5.63	73.11 ± 10.19	23.84 ± 2.79
Female (N = 450)	21.47 ± 2.70	164.17 ± 6.17	59.59 ± 9.80	22.03 ± 2.70

Values are expressed as the mean ± standard deviation. BMI, body mass index.

Table 2
Body morphological characteristics of the participants.

Sex	Age (years)	Height (cm)	Weight (kg)	BMI (kg/m^2)
Male (N = 187)	22.44 ± 2.89	174.65 ± 5.79	73.03 ± 9.69	23.92 ± 2.74
Female (N = 96)	21.32 ± 2.87	164.23 ± 5.99	59.26 ± 9.86	21.93 ± 2.82

Values are expressed as the mean ± standard deviation. BMI, body mass index.

and weight were measured and used to calculate body mass index (BMI). Body composition was measured by bioresistance using a body composition meter (Inbody 720, Korea). Before the test, the participants were instructed to remove their shoes, socks, and excess items from the body, and the tare weight of the clothes and other items on the participant's body was preset. The participants were instructed to align their heels with the electrode plate, stay quiet, look ahead, pick up the electrode handle once the weight value had stabilized, ensure no contact between the arms and the sides of the body or between the inner legs, and maintain this position for 1–2 min. The built-in software of the instrument automatically recorded the body composition-related parameters, including fat mass (FM), fat-free mass (FFM), and body fat percentage (BFP).

2.3. Power cycling test

The power cycling test was independently conducted by two professionals, and the relevant test methods and precautions were explained to each tester beforehand. The power bicycle was calibrated by a professional. A power bicycle (Lode, The Netherlands) was used with an optimal load factor of 0.075 kp/kg body mass, i.e., body weight (kg) × factor = power bike resistance (N). The participants were prepared for 2–4 min at a speed of 60 Watts/minute and rested for 3–5 min after the formal test. After completing the prescribed load for 30 s, the participants were required to relax and pedal for 2–3 min. The power output during the load process was used as an index of anaerobic capacity, and the following anaerobic power indicators were recorded: Mpower, Ppower, and fatigue index (FI).

2.4. Data analysis

The data were entered and checked by two professionals. For missing data, the average value was used if the missing data equated to less than one-third of the overall data, and the data were omitted if the missing data equated to more than one-third of the overall data. The data were collated using Microsoft Excel, and data analysis was performed using SPSS 22.0 and GraphPad Prism 9.4.1 software. Categorical data are described as frequencies and percentages, and normally distributed quantitative data are expressed as the mean ± standard deviation. Pearson's correlation was used to measure the correlation between each index of body composition and anaerobic power for the 1443 study participants. The multivariate linear regression analysis was used to model the quantitative relationship between body composition and anaerobic power cycling indices. Before conducting the paired-samples *t*-test, normality and homogeneity of variance checks were performed on the data of 283 participants. The paired-samples *t*-test, probability statistics, and Bland–Altman graphs were used to verify the body composition of the 283 participants within the model, to determine the difference between the anaerobic power index values and the directly measured index values, and to assess the validity of the model formula. A p value of <0.05 was considered statistically significant.

3. Results

Results of the correlation and multivariate linear regression analyses between anaerobic power cycling indices and body composition indices.

Table 3 shows that the anaerobic power cycle index (Mpower) of elite athletes was strongly correlated with sex ($r = -0.754$, $p < 0.001$) and height ($r = -0.721$, $p < 0.001$), and moderately correlated with skeletal muscle mass ($r = 0.546$, $p < 0.001$), BMI ($r = 0.506$, $p < 0.001$), body fat percentage ($r = -0.412$, $p < 0.001$), and waist–hip ratio ($r = -0.506$, $p < 0.001$).

The results of the predicted equation between Mpower and the body composition index of elite athletes are shown in Table 4. Sex ($t = -14.143$, $p < 0.001$), body fat percentage ($t = -10.633$, $p < 0.001$), skeletal muscle mass ($t = -6.290$, $p < 0.001$), height ($t = 16.143$, $p < 0.001$), BMI ($t = 16.102$, $p < 0.001$), and waist–hip ratio ($t = -2.601$, $p < 0.001$) all significantly influenced Mpower. The multivariate linear regression model for Mpower in elite athletes was Mpower = −626.888 − 132.304 × sex −5.452 × BFP −1.952 × muscle mass +6.892 × height +26.002 × BMI −362.623. The multifactorial linear regression equations for Mpower per kg body weight (Mpower/W) and total work in 30 s (total work) were derived as Mpower/W = (−626.888 − 132.304 × gender − 5.452 × BFP − 1.952 × muscle mass + 6.892 × height + 26.002 × BMI − 362.623 × waist–hip ratio)/body weight and total work = 30 ×

Table 3
Correlation analysis between Mpower and the body composition indices of elite athletes.

Pearson's correlation		Sex	SMM	BMI	BFP	WHR	Height
Mpower	r	−0.754**	0.546**	0.506**	−0.412**	0.506**	0.721**

SMM: skeletal muscle mass; BMI: body mass index; BFP: body fat percentage; WHR; waist–hip ratio; Mpower: mean power. **p < 0.001.

Table 4
Multivariate linear regression analysis between Mpower and the body composition indices of elite athletes.

Variate	Non-standardized coefficient		Standard coefficient	t	Sig.	Collinear statistics		Adjusted R^2
	B	Standard error	Trial version			Tolerance	VIF	
(Constant)	−626.888	141.688		−4.424	0.000			0.753
Sex	−132.304	9.355	−0.390	−14.143	0.000	0.225	4.440	
BFP	−5.452	0.513	−0.204	−10.633	0.000	0.464	2.155	
SMM	−1.952	0.310	−0.120	−6.290	0.000	0.473	2.115	
Height	6.892	0.427	0.335	16.143	0.000	0.398	2.513	
BMI	26.002	1.615	0.477	16.102	0.000	0.195	5.123	
WHR	−362.623	139.392	−0.081	−2.601	0.000	0.175	5.700	

Dependent variable: Mean power; Sex: male = 1, female = 2; SMM: skeletal muscle mass; BMI: body mass index; BFP: body fat percentage; WHR: waist–hip ratio; Mpower: mean power; B: beta coefficient; t: T-value; VIF: variance inflation factor; Sig: significant.

(−626.888 − 132.304 × sex − 5.452 × BFP − 1.952 × muscle mass + 6.892 × height + (26.002 × BMI − 362.623 × waist–hip ratio).

As shown in Table 5, the anaerobic power cycling index (Ppower) of excellent athletes was strongly correlated with sex ($r = -0.675$, $p < 0.001$), height ($r = 0.678$, $p < 0.001$), and weight ($r = 0.708$, $p < 0.001$); moderately correlated with skeletal muscle mass ($r = 0.502$, $p < 0.001$), BMI ($r = 0.518$, $p < 0.001$), and waist–hip ratio ($r = 0.488$, $p < 0.001$); and weakly correlated with BFP ($r = -0.351$, $p < 0.001$).

The results of the predictive model between Ppower and body composition in elite athletes are shown in Table 6. Sex ($t = -9.962$, $p < 0.001$), BFP ($t = -9.027$, $p < 0.001$), skeletal muscle mass ($t = -7.190$, $p < 0.001$), height ($t = 14.551$, $p < 0.001$), BMI ($t = 15.883$, $p < 0.001$), and waist–hip ratio ($t = -2.882$, $p < 0.001$) all had significant effects on Ppower. The multivariate linear regression equation for Ppower in elite athletes was Ppower = −1455.892 − 209.918 × sex −10.426 × BFP −5.027 × skeletal muscle mass +13.994 × height +57.775 × BMI −905.104 × waist–hip ratio. The multivariate linear regression equation for Ppower per kg body weight (Ppower/W) was derived as Ppower/W = (−1455.892 − 209.918 × sex − 10.426 × BFP − 5.027 × skeletal muscle mass + 13.994 × height + 57.775 × BMI − 905.104 × waist–hip ratio) ÷ weight.

As shown in Table 7, the anaerobic power cycling index (FI) of excellent athletes was moderately correlated with sex ($r = -0.579$, $p < 0.001$), height ($r = 0.553$, $p < 0.001$), skeletal muscle mass ($r = 0.483$, $p < 0.001$), BMI ($r = 0.478$, $p < 0.001$), and waist–hip ratio ($r = 0.431$, $p < 0.001$). FI was very weakly correlated with age ($r = 0.112$, $p < 0.001$) and weakly correlated with BFP ($r = -0.267$, $p < 0.001$).

The results of the index anaerobic power decrement rate (FI) and body composition index predictive equations in elite athletes are shown in Table 8. Sex ($t = -9.064$, $p < 0.001$), BFP ($t = -4.158$, $p < 0.001$), height ($t = 5.855$, $p < 0.001$), BMI ($t = 12.989$, $p < 0.001$), and waist–hip ratio ($t = -4.283$, $p < 0.001$) all had significant effects on the FI. The multivariate linear regression equation for FI in elite athletes was as follows: FI = 1.783 − 7.963 × sex +1.849 × BMI +0.231 × height −56.300 × waist–hip ratio −0.203 × BFP.

Comparison of the instrument-measured values of anaerobic power indices and the values obtained from the equation model.

As shown in Table 9, there were no significant differences between the formula-derived and instrument-measured values for the anaerobic power indices in elite athletes ($p > 0.05$).

Fig. 1shows the results of the Bland–Altman analysis. The 95 % confidence interval values for the difference between the formula-derived and instrument-measured values for each index of anaerobic power were as follows: Mpower: −122, 136.3; Mpower/W: −1.992, 1.862; total work: −3661, 4088; Ppower: −312.1, 332.3; Ppower/W: −4.456, 4.859; and FI: −13.71, 13.49. The probabilities that the values obtained from the formula would fall within the 95 % confidence interval were 94.7 % for Mpower, 96.8 % for Mpower/W, 94.7 % for total work, 94.7 % for Ppower, 95.8 % for Ppower/W, and 93.6 % for FI (see Fig. 3) (see Fig. 4) (see Fig. 5) (see Fig. 6) (see Fig. 2).

4. Discussion

The importance of anaerobic capacity in sports is evidenced by its impact on performance in both power and endurance events [25].

Therefore, determining anaerobic capacity quickly and effectively is important for objectively evaluating athletes, adjusting their training programs, and achieving excellent performance. There is a strong correlation between anaerobic capacity and body composition in Taekwondo athletes undergoing rapid weight loss ($p < 0.001$) [25]. Lean body mass refers to the weight remaining after removal of body fat, and muscle is an important component of lean body mass and the driving force of an athlete's work during exercise. Several studies have shown a strong correlation between BFP and anaerobic and aerobic capacity ($p < 0.001$) [26–28,9,29,30], and some studies have suggested a negative correlation between BFP and an athlete's anaerobic capacity ($p < 0.001$) [29]. In this

Table 5
Correlation analysis between Ppower and the body composition indices of elite athletes.

Pearson's correlation		Sex	Height	Weight	SMM	BMI	BFP	WHR
Ppower	r	−0.675**	0.678**	0.708**	0.502**	0.518**	−0.351**	0.488**

SMM: skeletal muscle mass; BMI: body mass index; BFP: body fat percentage; WHR: waist–hip ratio; Ppower: peak power; **$p < 0.001$.

Table 6
Multivariate linear regression analysis between Mpower and the body composition indices of elite athletes.

Variate	Non-standardized coefficient		Standard coefficient	t	Sig.	Collinear statistics		Adjusted R^2
	B	Standard error	Trial version			Tolerance	VIF	
(Constant)	−1455.892	319.174		−4.561	0.000			0.671
Sex	−209.918	21.073	−0.317	−9.962	0.000	0.225	4.440	
BFP	−10.426	1.155	−0.200	−9.027	0.000	0.464	2.155	
SMM	−5.027	0.699	−0.158	−7.190	0.000	0.473	2.115	
Height	13.994	0.962	0.349	14.551	0.000	0.398	2.513	
BMI	57.775	3.638	0.543	15.883	0.000	0.195	5.123	
WHR	−905.104	314.003	−0.104	−2.882	0.000	0.175	5.700	

Dependent variable: Peak power; Sex: male = 1, female = 2; SMM: skeletal muscle mass; BMI: body mass index; BFP: body fat percentage; WHR: waist–hip ratio; Ppower: peak power; B: beta coefficient; t: T-value; VIF: variance inflation factor; Sig: significance.

Table 7
Correlation analysis between fatigue index and the body composition indices of elite athletes.

Pearson's correlation		Sex	Age	Height	SMM	BMI	BFP	WHR
Fatigue index	r	−0.579**	0.112**	0.553**	0.483**	0.478**	−0.267**	0.431**

SMM: skeletal muscle mass; BMI: body mass index; BFP: body fat percentage; WHR: waist–hip ratio; **$p < 0.001$.

Table 8
Multivariate linear regression analysis between fatigue index and the body composition indices of elite athletes.

Variate	Non-standardized coefficient		Standard coefficient	t	Sig.	Collinear statistics		Adjusted R^2
	B	Standard error	Trial version			Tolerance	VIF	
(Constant)	1.783	13.528		0.132	0.895			0.490
Sex	−7.963	0.879	−0.354	−9.064	0.000	0.233	4.296	
BMI	1.849	0.142	0.511	12.989	0.000	0.229	4.365	
Height	0.231	0.039	0.169	5.855	0.000	0.425	2.351	
WHR	−56.300	13.144	−0.190	−4.283	0.000	0.180	5.560	
BFP	−0.203	0.049	−0.115	−4.158	0.000	0.467	2.141	

Dependent variable: fatigue index; Sex: male = 1, female = 2; BMI: body mass index; WHR: waist–hip ratio; BFP: body fat percentage; B: beta coefficient; t: T-value.
VIF: variance inflation factor; Sig: significance.

Table 9
Analysis of the variability between the instrumental-measured and formula-derived values of anaerobic power in elite athletes.

(N = 283)		Mean ± standard deviation	T	p
Mpower (W)	A	520.82 ± 152.95	1.816	0.071
	B	513.70 ± 136.93		
Mpower/W (W/kg)	A	7.36 ± 1.56	−1.111	0.267
	B	7.43 ± 1.30		
Total work (W)	A	15624.46 ± 4588.64	1.816	0.071
	B	15411.10 ± 4107.88		
Ppower (W/kg)	A	899.79 ± 295.58	1.030	0.304
	B	889.73 ± 250.39		
Ppower/W (W/kg)	A	13.02 ± 3.30	1.426	0.155
	B	12.81 ± 2.36		
Fatigue index (%)	A	23.51 ± 9.98	−0.271	0.786
	B	23.63 ± 7.33		

A: instrument-measured values; B: formula-derived values; Mpower: mean power; Mpower/W: mean power/weight; Ppower: peak power; Ppower/W: peak power/weight.

study, Mpower, Ppower, and FI were strongly correlated ($p < 0.001$) with sex, skeletal muscle mass, BMI, BFP, waist–hip ratio, and height in elite athletes, which is consistent with previous findings [25]. Therefore, we conclude that indices of anaerobic power and body composition are strongly correlated, providing a strong theoretical basis for the construction of a model of anaerobic power cycling and body composition indices in elite athletes.

In previous studies, the linear regression equation R^2 between Ppower and body mass was 0.44, and the R^2 between Ppower and lean body mass was 0.57 [31,32]. This is lower than the R^2 values of 0.753, 0.671, and 0.490 for the predicted equation between the Mpower, Ppower, FI, and body composition index of elite athletes in the present study. The reason for this discrepancy may be related

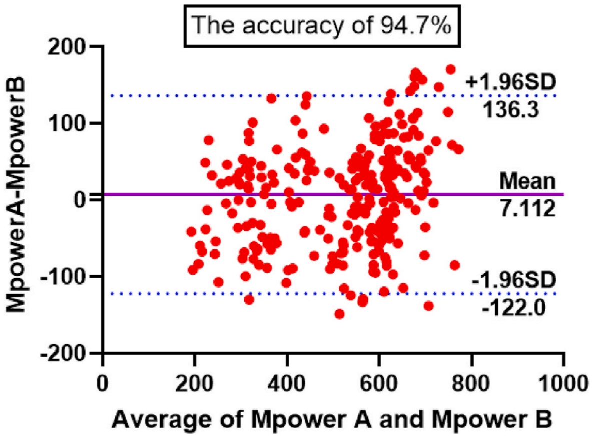

Fig. 1. Bland–Altman analysis of the instrument- and formula-derived values of Mpower.

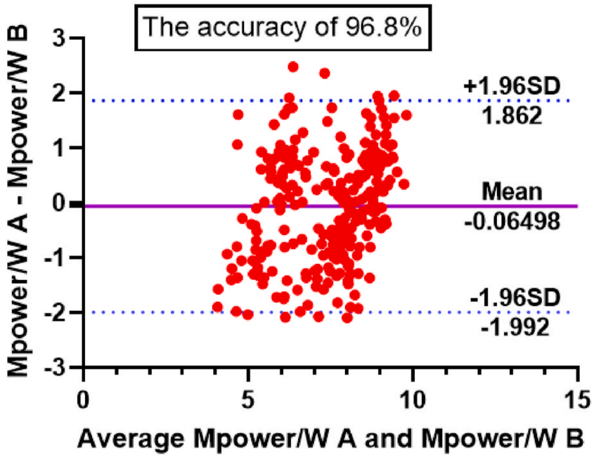

Fig. 2. Bland–Altman analysis of the instrument- and formula-derived values of Mpower/W.

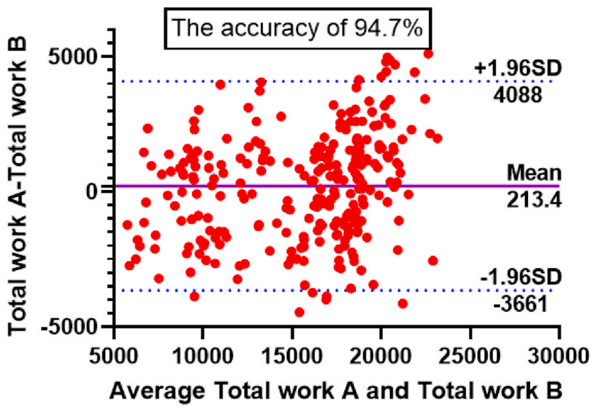

Fig. 3. Bland–Altman analysis of the instrument- and formula-derived values of Total work.

to the sample size [24,31]. Previous studies had small sample sizes and did not validate the accuracy of the related regression equations [24,32]. In contrast, the present study validated the related equations and obtained better results, which may have practical value for predicting specific groups within a certain range.

Having an alternative measure of anaerobic power is valuable, given the limitations of the power cycling test. Therefore, this study

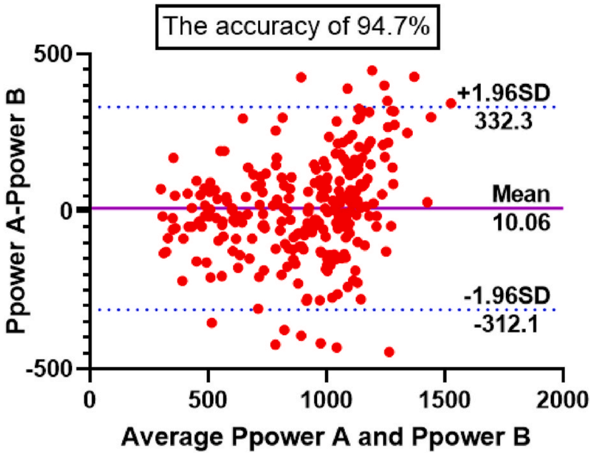

Fig. 4. Bland–Altman analysis of the instrument- and formula-derived values of Ppower.

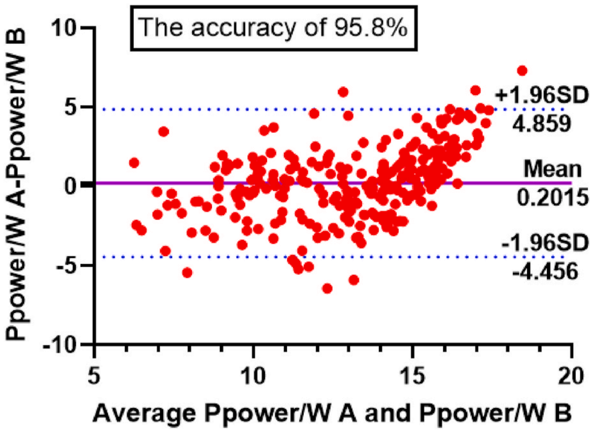

Fig. 5. Bland–Altman analysis of the instrument- and formula-derived values of Ppower/W.

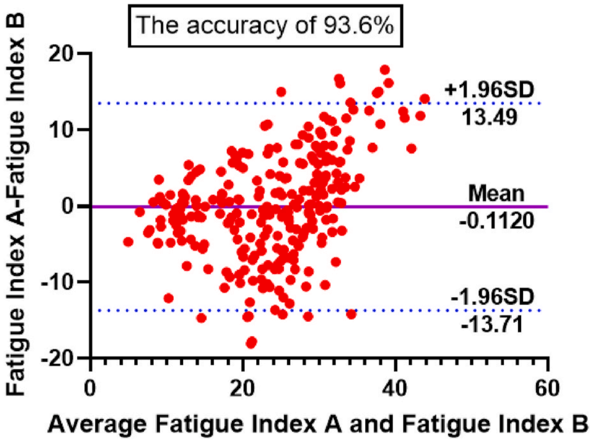

Fig. 6. Bland–Altman analysis of the instrument- and formula-derived values of Fatigue index.

established a quantitative model by testing body composition indices, which are accessible to athletes, and anaerobic power cycling indices, which are not easily accessible, to predict anaerobic power. This model can be used to quickly and effectively evaluate the anaerobic capacity of athletes based on the strong correlation between body composition and anaerobic power cycling indices using data from 993 male and 450 female elite athletes. After that, 283 elite athletes from various sports were randomly selected as experimental participants. There were no significant differences between the values obtained from the formula of each index of anaerobic power and the values measured by the instrument, demonstrating the accuracy of the formula. The Bland–Altman analysis showed that the prediction equations had high accuracy.

5. Limitations

This study has some limitations that should be considered. The participants were elite athletes, so the research model is not applicable to the general population. The model predicts power cycling indicators based on body composition testing indicators. The testing environment and conditions of the body composition testing instrument may have affected the results of the body composition indicators, thus also having an impact on the prediction of the power cycling indicators.

6. Conclusions

By constructing and validating multiple regression equations for anaerobic power cycling and body composition indices, this study showed that the probability of the value from the equation falling within the 95 % confidence interval was 94.7 % for Mpower, 96.8 % for Mpower/W, 94.7 % for total work, 94.7 % for Ppower, 95.8 % for Ppower/W, and 93.6 % for FI. These equations may thus have some practical value for predicting the elite athlete population.

Ethical approval

The Ethics Committee of Hainan Medical College approved this study (Approval No. Hnky2021-41), and all participants provided informed consent.

Consent to publish

Not applicable.

Availability of data and materials

All data generated or analyzed during this study are included in this published article.

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Data availability statement

Data included in article/supplementary material/referenced in article.

CRediT authorship contribution statement

Jiamang Wang: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Youzhi Zong:** Writing – review & editing, Writing – original draft, Methodology, Funding acquisition, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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