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ORIGINAL RESEARCH

Comparative analysis of isokinetic muscle function, anaerobic power, and physical fitness in male Taekwondo players based on body mass index standards

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Abstract

Background: Body mass index (BMI) significantly affects athletic performance among Taekwondo athletes. This study assessed the impact of BMI on isokinetic muscle function, anaerobic power and physical fitness among Taekwondo athletes. **Methods**: Forty-five Taekwondo athletes were divided equally into three BMI groups: normal weight (NWG), overweight (OWG) and obese (OG). Measurements were analyzed using one-way Analysis of Variance (ANOVA) with Scheffe's *post-hoc* test for group comparisons. **Results**: Isokinetic assessments revealed that OWG and OG demonstrated significantly higher right ($F = 7.517$, $p < 0.01$) and left ($F = 9.664$, $p < 0.001$) extensor strength compared to NWG. Additionally, OG showed greater right flexor strength ($F = 4.644$, $p < 0.05$) than NWG, while NWG exhibited higher right flexor strength per body weight ($F = 4.050$, $p < 0.05$) than OWG. Anaerobic power measures indicated that OWG and OG outperformed NWG in peak power ($F = 31.679$, $p < 0.001$), average power ($F = 31.977$, $p < 0.001$) and total energy ($F = 29.936$, $p < 0.001$); notably, OWG achieved the highest peak power relative to body weight ($F = 6.775$, $p < 0.01$) and demonstrated a more significant peak drop ($F = 3.614$, $p < 0.05$). In physical fitness tests, OWG and OG showed superior back strength ($F = 13.171$, $p < 0.001$), while NWG outperformed OG in sit-ups ($F = 7.275$, $p < 0.01$) and recorded faster reaction times in whole-body reaction tests to both sound ($F = 6.289$, $p < 0.01$) and light ($F = 3.825$, $p < 0.05$). **Conclusions**: BMI influences strength and power in Taekwondo athletes, but its limitations must be considered, as it does not reflect muscle mass. Athletes categorized as overweight based on BMI may possess greater muscle-related strength but reduced speed and endurance. Therefore, balanced conditioning and body composition analysis are essential for effective training.

Keywords

Taekwondo; Isokinetic muscle strength; Physical fitness; Anaerobic power; Body mass index

1. Introduction

In sports, maintaining good health and physical fitness is crucial to improving athletic performance. Body composition, particularly body mass index (BMI), serves as an essential indicator in designing effective training programs [1, 2]. In Taekwondo, optimal BMI management can significantly impact explosive power, speed and endurance. Importantly, this study uses BMI classifications specific to Asian populations, recognising that BMI thresholds vary across ethnic groups [3]. However, research focusing on the role of BMI in athletic performance, particularly within Asian cohorts, remains limited. Most previous studies have examined general physical characteristics or isolated variables such as anaerobic power or muscle strength, but have not systematically compared these factors across different BMI categories among Taekwondo athletes [4–6].

Lower extremity muscle strength is a key determinant of Taekwondo performance and is commonly assessed using isokinetic muscle joint measurement equipment [7]. The knee joint, which is essential for taekwondo kicks and defensive movements, requires balanced development of extensor and flexor muscle strength for efficient performance [8, 9]. Training programs targeting knee joint strength have been shown to significantly enhance performance over 12 weeks [7]. In addition, fast and repetitive movements require activation of the hamstring muscles to stabilize posture [10, 11]. This suggests that, for injury prevention, the activation of the hamstring muscles should not only focus on simple strength training but also emphasize efficient activation and coordination during dynamic, repetitive movements [12]. Despite the recognized importance of maintaining an optimal balance between body weight and performance, the specific interrelationships among BMI, neuromuscular strength, and anaerobic capacity in Taekwondo remain underexplored. This gap is particularly pronounced in Asian populations, where differences in body composition and BMI thresholds may lead to distinct performance outcomes compared to Western cohorts. Given the dual demands of generating explosive power while sustaining agility and endurance, it is critical to understand how variations in BMI influence these key performance parameters. Such insights are essential for designing tailored training programs and strategies that optimize the power-to-weight ratio while minimizing the potential negative impacts of weight management on athletic performance.

The relationship between body composition and anaerobic power has been well documented in other sports, with increased lean body mass correlating with increased power output [13–15]. In Taekwondo, agility, flexibility and anaerobic capacity are vital as athletes rely on short, explosive movements powered by the adenosine triphosphate-phosphocreatine (ATP-PC) energy system [16, 17]. Despite this, studies directly comparing how BMI affects anaerobic performance and physical fitness in Asian Taekwondo athletes remain scarce. In addition, weight management through weight class categorisation may have a negative impact on power, requiring athletes and coaches to implement strategies that effectively balance weight control with the maintenance of muscular strength and explosive performance. This necessitates a comprehensive approach to training and nutrition, ensuring that weight reduction efforts do not compromise the essential physical attributes needed for optimal Taekwondo performance [18].

The objective of this study is to evaluate isokinetic muscle function, anaerobic power, and physical fitness across different BMI categories among Taekwondo players. To this end, BMI classifications appropriate for Asian populations were utilised, since BMI classifications tailored for Western populations may not accurately reflect body composition characteristics in Asian cohorts. Previous studies have suggested the necessity of adopting region-specific criteria [19]. This study, therefore, applies BMI classifications specifically designed for Asian populations to ensure more accurate assessments of body composition in Taekwondo athletes. The World Health Organization (WHO) Expert Consultation has highlighted that conventional BMI thresholds may not adequately reflect obesity-related health risks in Asian populations, as research indicates that adverse health effects occur at lower BMI levels compared to Western populations [3]. Consequently, the WHO has proposed adjusted BMI cut-off points for Asians, defining overweight as BMI 23–24.9 kg/m^2 and obesity as BMI $\geq$25 kg/m^2 to better assess health risks in this population. Identifying BMI-related differences in physical performance could contribute to the development of systematic training programs tailored to individual body composition and support more effective injury prevention strategies.

2. Materials and methods

2.1 Sample and procedure

The study participants comprised 45 male Taekwondo athletes, each with over five years of training experience. Participants were classified into three groups based on the Asian criteria proposed by the World Health Organization (WHO): a normal weight group (NWG, BMI: 18.5–22.9 kg/m^2), an overweight group (OWG, BMI: 23–24.9 kg/m^2) and an obesity group (OG, BMI: 25–29.9 kg/m^2), with 15 participants in each group. Participants were recruited through a public announcement made by the D Sports Science Center, followed by voluntary participation. Eligibility was determined based on training experience, health status and consent to participate. Physical fitness assessments were conducted at the D Sports Science Center between November and December 2023. The study was approved by the Institutional Review Board (Approval No K UIRB-2023-0295-0). The physical characteristics of the participants are presented in Table 1.

2.2 Measurement of physical characteristics

The assessments of the participants' physical characteristics were performed as follows. The height and weight of all participants were measured using a stadiometer, and their BMI and muscle mass were assessed using an InBody 770 analyzer (InBody, Seoul, South Korea).

2.3 Isokinetic muscle function test

The HUMAC NORM isokinetic dynamometer system (HUMAC NORM 2015, Computer Sports Medicine, Inc., Stoughton, MA, USA) was used to measure the isokinetic muscle strength and power of the knee joint. Following the standardized measurement procedures outlined by the HUMAC NORM testing and rehabilitation system, the equipment evaluated the function of the knee joint extensors and flexors at angular velocities of 60°/s and 180°/s. Before testing, participants performed a 5-minute warm-up consisting of light cycling on a stationary ergometer at moderate intensity to increase muscle temperature and prepare the lower limbs for exertion. After the warm-up, participants were securely

TABLE 1. Physical characteristics of the subjects.

Group	Age (yr)		Height (cm)		Weight (kg)		BMI (kg/m^2)		Muscle mass (kg)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
NWG (n = 15)	18.8	1.47	176.4	1.99	64.0	3.83	20.6	1.19	53.7	3.18
OWG (n = 15)	19.3	1.63	181.1	2.94	78.1	3.27	23.8	0.54	63.7	3.17
OG (n = 15)	19.1	1.25	181.8	5.91	88.8	8.40	26.8	1.78	67.4	6.94

BMI: Body mass index; NWG: Normal Weight Group; OWG: Overweight Group; OG: Obesity Group; SD: Standard Deviation.

positioned against the backrest, with the upper body and hips stabilized using the device's restraint belts. Following three familiarization trials, participants performed the knee extensor and flexor strengths of both legs at angular velocities of 60°/s and 180°/s, respectively. The isokinetic muscle strength was measured by having the participants perform knee extension and flexion movements of the dominant leg at an angular velocity of 60°/s. Measurements were taken in triplicate, followed by a 1-minute rest period; the same procedure was then applied to the opposite leg. Isokinetic muscle power was similarly assessed at an angular velocity of 180°/s, where participants performed knee extension and flexion movements of the dominant leg five times consecutively, followed by the same measurements on the opposite leg after a 1-minute rest period. At an angular velocity of 60°/sec, muscle strength was measured and expressed in Nm, indicating the absolute torque generated, and in % Body Weight (BW), representing muscle strength relative to the participant's body weight. At an angular velocity of 180°/sec, mean muscle power was measured and expressed in Watts, indicating the absolute power output, and in %BW, representing power relative to the participant's body weight. The procedure for measuring isokinetic muscle function is illustrated in Fig. 1.

2.4 Anaerobic exercise ability test

Anaerobic exercise capacity was assessed using the Wingate test performed on a Monark 894E ergometer (Monark, Varberg, Sweden). The saddle height was adjusted such that the knee was extended to approximately 10° at maximum extension. Participants performed a 5-minute warm-up by cycling at a moderate pace. A resistance load of 7.5% of their body weight was applied using weighted calibration. The test began with a start signal, at which point the participants pedaled at maximum revolutions per minute (RPM). The Wingate test lasted 30 seconds, during which the participants maintained a fixed posture and pedaled at maximum speed, while receiving verbal encouragement to sustain performance. Upon completion, participants performed a 2–3 minutes cooldown at a moderate pace to minimize physiological strain and facilitate recovery. Watts and Watts per kilogram (W/kg) are used to express absolute and relative power output, respectively; Joules (J) represent total energy expenditure; and peak power drop (%) indicates the rate of power decline due to fatigue during anaerobic exercise.

2.5 Physical fitness test

The following parameters were measured [20]:

Strength was assessed by measuring back strength using a digital dynamometer (ST-5402D, Seedtech, Bucheon, Korea). Participants performed a maximal isometric pull for 3 seconds in a semi-flexed position. Results were recorded in kg (0.1 kg units), and the higher value from the two trials was used for analysis.

Muscular endurance was assessed by sit-ups and repeated jumps. Sit-ups were performed on a sit-up bench (FAS-5370, Korea) for 1 minute, with proper form maintained throughout. The total number of completed repetitions was recorded. Repeated jumps were measured using a jump device (FAS-5310, Faskorea, Incheon, Korea), where the bar was set 30 cm above the participant's maximum reach, and the number of successful touches within 30 seconds was recorded.

Power was assessed using two tests: the standing long jump and the Sargent jump. For the standing long jump (FT-7700, Seedtech, Bucheon, Korea), participants performed two trials after a warm-up, and the longest jump distance was recorded. For the Sargent jump, participants used a jump device (ST-150, Seedtech, Bucheon, Korea) after a practice session; two trials were performed, and the highest vertical jump height (in cm) was recorded.

Whole-body reaction time was measured using a reaction test device (ST-140, Seedtech, Bucheon, Korea). After preparation, participants responded to an auditory stimulus, with the test repeated three times. The average reaction time was used for analysis.

Agility was measured using a sidestep test device (ST-110, Seedtech, Bucheon, Korea). After assuming the starting position, participants moved laterally left, right, and across a center line in sequence, and the number of completed steps within 20 seconds was recorded.

Flexibility was measured using forward and backward bend tests with specialized devices. For the forward bend, participants sat on a device (DHT-5412, Takei, Tokyo, Japan) with legs fully extended and reached forward with both hands, with the maximum reach distance measured in cm. For the backward bend, participants lay prone on a device (TKK-5404, Takei, Tokyo, Japan), fixed their lower body, and extended the upper body upward, measuring the chin height in cm. Both tests were performed twice, and the highest value was recorded.

2.6 Statistical analysis

IBM SPSS software (version 22.0; IBM, Armonk, NY, USA) was used to calculate the mean and standard deviation of all measured variables. Before analyzing variance, Levene's Test for Equality of Error Variances was performed to verify the assumption of homogeneity of variances. To compare and analyze differences in isokinetic muscle function, anaerobic power, and physical fitness among the study groups, one-way analysis of variance (ANOVA) was performed, followed by Scheffé's *post-hoc* test for multiple comparisons. The

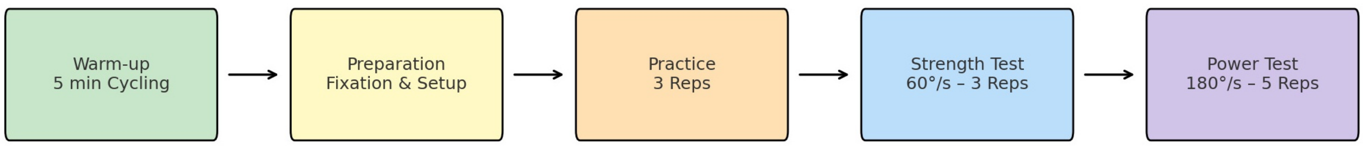

FIGURE 1. Isokinetic muscle function test measurement procedure.

statistical significance level for all results was set at $\alpha = 0.05$.

3. Results

3.1 Results of the isokinetic muscle function test

The results of isokinetic knee strength are summarized in Tables 2 and 3. Athletes in the OWG and OG showed significantly higher right and left extensor strength compared to those in the NWG. Similarly, OG athletes exhibited greater right flexor strength than NWG athletes. In contrast, NWG athletes demonstrated higher right flexor strength relative to body weight than those in the OWG. For isokinetic muscle power, OWG and OG athletes recorded significantly higher right and left extensor power compared to NWG athletes.

3.2 Results of the anaerobic exercise ability test

As shown in Table 4, athletes in OWG and OG exhibited significantly higher peak power, average power, and total energy output than athletes in NWG. Notably, OWG athletes achieved the highest peak power per body weight, outperforming both OG and NWG athletes. Additionally, OWG athletes showed a greater peak power drop compared to NWG athletes.

3.3 Results of the physical fitness test

Table 5 presents the results of the physical fitness assessments. Athletes in OWG and OG demonstrated significantly greater back strength than NWG. In contrast, NWG athletes performed better in sit-ups compared to OG athletes. In the Sargent jump, OWG athletes outperformed OG athletes, indicating superior lower-body power. Regarding whole-body reaction time, NWG athletes responded significantly faster to both auditory and visual stimuli compared to athletes in OWG and OG.

4. Discussion

This study utilized BMI classifications tailored to Asian populations to evaluate the isokinetic muscle function, anaerobic power, and physical fitness of Taekwondo athletes across different BMI categories, aiming to identify functional characteristics and examine their impact on performance.

The findings revealed that athletes in the overweight group (OWG) and obese group (OG) exhibited significantly higher absolute isokinetic knee extensor strength compared to those in the normal weight group (NWG). Specifically, OWG and OG athletes demonstrated higher right and left extensor strength, and OG athletes showed greater right flexor strength than NWG athletes. These results are consistent with previous studies indicating that individuals with higher BMI often possess greater absolute strength due to increased lean mass [21, 22]. However, when considering relative strength per body weight, NWG athletes outperformed OWG athletes in right flexor strength. This suggests that, while increased body weight contributes to higher absolute strength, it may not translate to advantages in relative strength, which is crucial for movements requiring speed and agility like in Taekwondo [22]. Furthermore, a recent literature review underscored that athletes with lower BMI values tend to exhibit superior speed and agility, implying that higher body weight could potentially hinder performance in sports demanding explosive and agile movements [23]. These findings imply that although heavier athletes may generate more total force, their force output per unit of body weight is lower. In sports like Taekwondo, where movements are highly dynamic and rely on rapid acceleration and agility, relative strength can be more indicative of performance efficiency than absolute strength alone. Therefore, training strategies should consider not only increasing strength but also optimizing body composition to enhance the power-to-weight ratio, which is essential for functional performance in Taekwondo.

In terms of anaerobic power, OWG and OG athletes demonstrated significantly higher peak power, average power, and

TABLE 2. Results of isokinetic muscle function at an angular velocity of 60°/sec.

Measurement factor	Group						F	p	Effect Size (η^2)
	NWG		OWG		OG				
	Mean	SD	Mean	SD	Mean	SD			
Right extensor muscle strength (%BW)	276.47	44.33	263.47	37.74	247.87	33.62	2.041	0.143	0.089
Left extensor muscle strength (%BW)	253.60	38.13	258.80	47.98	231.87	29.51	1.985	0.150	0.086
Right extensor muscle strength (Nm)	177.53	30.42	205.47	27.97	219.60	32.18	7.517	0.002**	0.264
Left extensor muscle strength (Nm)	162.53	25.44	201.80	35.48	205.60	27.22	9.664	<0.001***	0.315
Right flexor muscle strength (%BW)	152.20	32.40	129.20	22.87	131.60	14.26	4.050	0.025*	0.162
Left flexor muscle strength (%BW)	143.60	28.31	133.40	23.35	122.20	17.10	3.145	0.053	0.130
Right flexor muscle strength (Nm)	97.33	20.53	101.27	17.73	117.20	18.34	4.644	0.015*	0.181
Left flexor muscle strength (Nm)	92.86	20.43	104.33	19.01	108.73	17.50	2.783	0.073	0.117

$^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.
NWG: Normal Weight Group; OWG: Overweight Group; OG: Obesity Group; SD: Standard Deviation; BW: Body Weight; Nm: Newton-meters.

TABLE 3. Results of Isokinetic muscle function at an angular velocity of 180°/sec.

Measurement factor	Group						F	p	Effect Size (η^2)
	NWG		OWG		OG				
	Mean	SD	Mean	SD	Mean	SD			
Mean power of right extensor muscle (%BW)	276.47	44.33	263.47	37.74	247.87	33.62	2.041	0.143	0.082
Mean power of left extensor muscle (%BW)	253.60	38.13	258.80	47.98	231.87	29.51	1.985	0.150	0.104
Mean power of right extensor muscle (Watts)	177.53	30.42	205.47	27.97	219.60	32.18	7.517	0.002**	0.415
Mean power of left extensor muscle (Watts)	162.53	25.44	201.80	35.48	205.60	27.22	9.664	<0.001***	0.296
Mean power of right flexor muscle (%BW)	152.20	32.40	129.20	22.87	131.60	14.26	4.050	0.025*	0.106
Mean power of left flexor muscle (%BW)	143.60	28.31	133.40	23.35	122.20	17.10	3.145	0.053	0.097
Mean power of right flexor muscle (Watts)	97.33	20.53	101.27	17.73	117.20	18.34	4.644	0.015*	0.070
Mean power of left flexor muscle (Watts)	92.86	20.43	104.33	19.01	108.73	17.50	2.783	0.073	0.107

**$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.*
NWG: Normal Weight Group; OWG: Overweight Group; OG: Obesity Group; SD: Standard Deviation; BW: Body Weight.

TABLE 4. Result of anaerobic exercise ability.

Measurement factor	Group						F	p	Effect Size (η^2)
	NWG		OWG		OG				
	Mean	SD	Mean	SD	Mean	SD			
Maximum anaerobic power (Watts)	496.13	62.77	677.76	60.47	687.49	94.37	31.679	<0.001***	0.601
Maximum anaerobic power (Watts/kg)	7.76	0.77	8.69	0.73	7.70	0.95	6.775	0.003**	0.244
Mean of anaerobic power (Watts)	383.79	41.97	508.32	36.11	506.19	63.92	31.977	<0.001***	0.604
Total energy (J)	11,093.40	1185.95	14,405.13	1069.68	14,360.53	1694.65	29.936	<0.001***	0.588
peak drop (%)	48.98	5.94	55.59	8.29	53.95	6.57	3.614	0.036*	0.147

**$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.*
NWG: Normal Weight Group; OWG: Overweight Group; OG: Obesity Group; SD: Standard Deviation; J: Joules; kg: kilograms.

total energy output compared to NWG athletes. Notably, OWG athletes exhibited higher peak power per body weight, suggesting that increased body mass may enhance anaerobic power output, possibly due to greater muscle mass [24, 25]. Nonetheless, excessive body weight could negatively impact performance in activities requiring quickness and endurance. In Taekwondo, where agility, flexibility, and anaerobic capacity are vital due to the reliance on short, explosive movements powered by the adenosine triphosphate-phosphocreatine (ATP-PC) energy system [16, 17], the potential drawbacks of excessive body weight must also be carefully considered. Although increased body mass may contribute to absolute anaerobic power through greater muscle mass, the associated reduction in relative strength may impair the quickness and endurance required in Taekwondo. Therefore, it is crucial for training programs to optimize the power-to-weight ratio, ensuring that athletes not only develop sufficient anaerobic capacity but also maintain the agility and rapid acceleration necessary for peak performance.

Physical fitness tests revealed that athletes with higher BMI scored significantly higher in back strength tests, reflecting greater absolute strength [24, 26]. Conversely, NWG athletes outperformed OG athletes in the sit-up test, indicating superior muscular endurance [27]. This finding aligns with a study

TABLE 5. Result of physical fitness measurement.

Measurement factor	Group						F	p	Effect Size (η^2)
	NWG		OWG		OG				
	Mean	SD	Mean	SD	Mean	SD			
Back muscle strength (kg)	122.03	15.84	145.50	12.62	149.90	18.89	13.171	<0.001***	0.385
Sit-up (trial)	58.87	8.40	52.47	10.13	46.93	6.89	7.275	0.002**	0.257
Repeated jump (trial/30sec)	53.87	3.27	53.80	4.92	53.40	2.87	0.066	0.936	0.003
Standing long jump (cm)	231.55	17.83	232.68	14.58	219.77	21.75	2.290	0.114	0.098
Sargent jump (cm)	52.00	4.61	54.13	3.54	49.67	5.73	3.370	0.044*	0.138
Full-body reaction-sound (sec)	0.227	0.022	0.257	0.028	0.258	0.030	6.289	0.004**	0.230
Full-body reaction-light (sec)	0.247	0.025	0.273	0.033	0.275	0.034	3.825	0.030*	0.154
Side-step (trial/20sec)	50.67	4.53	51.53	5.89	49.00	4.81	0.952	0.394	0.043
Trunk forward flexion with sitting (cm)	18.79	6.31	18.14	7.37	16.97	5.21	0.316	0.731	0.015
Trunk backward flexion (cm)	58.49	5.89	62.28	7.55	58.55	7.78	1.393	0.260	0.062

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
NWG: Normal Weight Group; OWG: Overweight Group; OG: Obesity Group; SD: Standard Deviation; sec: seconds; cm: centimeters; kg: kilograms.

on athletes aged 13 to 21, which categorized BMI based on WHO standards and investigated the relationship between BMI and physical fitness performance [28]. Additionally, NWG athletes exhibited faster reaction times in whole-body reaction tests compared to OWG and OG athletes, suggesting that lower body weight may facilitate better coordination and agility [29, 30].

In the Sargent jump test, OWG athletes scored higher than OG athletes, implying that excessive body weight may hinder explosive movements like jumping [31, 32]. These observations are underpinned by exercise physiology theories that emphasize the importance of the power-to-weight ratio and neuromuscular efficiency. While a higher BMI is typically associated with greater muscle mass and enhanced absolute strength, it also contributes to a greater inertial load, which can reduce the relative strength necessary for rapid, explosive movements. According to the force-velocity relationship, increases in muscle mass that are not accompanied by proportional enhancement in neuromuscular activation may lead to a decline in maximal contraction velocity, thereby impairing performance in activities requiring quickness and endurance. Consequently, maintaining an optimal balance between muscle mass and overall body weight is essential. This balance ensures that athletes not only benefit from high absolute strength but also preserve the relative strength and agility needed for explosive, dynamic movements, which are key performance determinants in Taekwondo.

These results underscore the importance of maintaining an optimal body weight that balances absolute and relative strength to enhance overall athletic performance in Taekwondo [33, 34]. Athletes with lower body weight may benefit from improved agility and endurance, while those with higher body weight may have advantages in absolute strength and power [35]. Optimal weight maintenance should be considered in the context of weight class requirements, as different training regimens and weight targets may apply depending on the athlete's competitive category. Therefore, individualized training programs that consider an athlete's BMI, particularly when using classifications appropriate for Asian populations, may provide more effective guidance for improving performance while minimizing the negative impacts of suboptimal body composition.

The findings of this study, which focuses on Taekwondo, a traditional Korean martial art, and includes Asian athletes as participants, provide valuable insights into the role of BMI in influencing isokinetic muscle strength, anaerobic power and physical fitness. These results suggest that training programs should be tailored to the specific needs of athletes based on their BMI category. Overweight and obese athletes demonstrated superior absolute isokinetic knee strength and anaerobic power, highlighting the need for conditioning programs that capitalize on their strength advantages while addressing potential agility limitations. Conversely, normal-weight athletes showed greater relative strength and agility, underscoring the importance of maintaining these attributes through targeted training strategies. Coaches and trainers should implement BMI-specific conditioning programs and systematic weight management strategies to achieve optimal balance between strength, agility and overall performance. Additionally, isokinetic muscle function assessments should be utilized as a supplementary tool for assessing strength, guiding training interventions and monitoring rehabilitation progress. The results also emphasize the importance of injury prevention strategies, particularly for overweight and obese athletes, to mitigate the risks associated with repetitive joint stress. Ultimately, the normative data provided by this study offer a valuable reference for designing evidence-based training and rehabilitation programs for Taekwondo athletes, particularly those of Asian descent, ensuring optimal performance and injury prevention. This study has several limitations. First, BMI was used as a primary criterion for body composition classification; however, it does not differentiate between lean mass and fat mass. Future studies should incorporate more precise measures of body composition, such as body fat percentage or dual-energy X-ray absorptiometry (DEXA). Second, the cross-sectional design of this study limits the ability to establish causality between BMI and physical performance outcomes. Longitudinal studies are recommended to assess performance changes over time and the impact of weight management interventions on performance metrics.

5. Conclusions

By applying BMI classifications tailored to Asian populations, this study underscores the influence of body weight on isokinetic muscle strength, anaerobic power and physical fitness among Taekwondo athletes. The results suggest that, while a higher BMI may contribute to greater absolute strength and power, a lower BMI is associated with superior relative strength, agility and endurance. These findings caution against overly simplistic interpretations of physical traits, as excessive focus on absolute strength without considering relative performance factors may lead to misleading conclusions about athletic potential. Therefore, training programs should aim to achieve a balanced development of strength and agility while acknowledging the diverse physical profiles of individual athletes. Future research should explore more precise indicators of body composition, such as body fat percentage, to provide deeper insight into how these factors affect performance and to help refine personalized training and conditioning strategies.

ABBREVIATIONS

BMI, Body mass index; BW, Body weight; Nm, Newton meter; WHO, World Health Organization; ATP-PC, Adenosine Triphosphate-Phosphocreatine; NWG, Normal Weight Group; OWG, Overweight Group; OG, Obesity Group; DEXA, Dual-Energy X-ray Absorptiometry; RPM, revolutions per minute; ANOVA, Analysis of Variance.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available, on request, from the corresponding author.

AUTHOR CONTRIBUTIONS

MP and SK—conceived and designed the study. MP—performed the experiments and analyzed the data; drafted the manuscript. SK—reviewed and edited the manuscript; and provided project management and supervision. YB—reviewed the manuscript and contributed to the study. All authors have read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

All subjects gave their informed consent for inclusion before participating in the study. The study was conducted in accordance with the Declaration of Helsinki, and the Research Ethics Review Board of the Korea university approved the protocol (No. KUIRB-2023-0295-0) on 03 April 2024. This IRB approval includes prior consent from all subjects or legal guardians.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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