SCIENTIFIC JOURNAL OF SPORT AND PERFORMANCE

ORIGINAL ARTICLE

Anthropometry and athletic performance with Zybek sports in elite American taekwondo athletes

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ABSTRACT

Introduction: The relationship between anthropometric characteristics and athletic performance in taekwondo athletes is a topic of growing interest in the field of sports science and physical preparation. Objective: To determine the relationship between athletic performance in Zybek Sport tests and anthropometry in elite American taekwondo athletes. Methodology: A quantitative, descriptive, and correlational quasi-experimental cross-sectional study was conducted on a sample of (n = 470) taekwondo athletes. Anthropometric measurements included height, weight, and BMI. Athletic performance was assessed using Zybek Sports Performance Standardized Athletic Testing (SAT®). Results: Negative and statistically significant relationships were identified between the 10 and 20-yard sprints and height ($p < .000$) and ($p < .000$), weight ($p < .000$) and ($p < .000$), and BMI ($p < .016$) and ($p < .000$). The pro Agility test only showed a significant negative relationship with weight ($p < .000$) and height ($p < .000$). As for the 40-yard dash, horizontal jump, and vertical jump, which showed positive and significant relationships, it was identified that performance in these tests is influenced by greater height ($p < .000$), ($p < .000$), ($p < .000$), weight ($p < .000$), ($p < .000$), ($p < .000$), and BMI ($p < .000$), ($p < .003$) respectively. Except for the vertical jump, which did not show a significant correlation with BMI ($p < .542$). Conclusion: In conclusion, despite the heterogeneity of the relationships, lower weight, height, and BMI were found to improve performance in the 10 and 20-yard sprints as well as in the pro agility test. In the case of the 40-yard dash, horizontal jump, and vertical jump, greater weight, height, and BMI were related to better performance in these tests, with the exception of the vertical jump, which did not show a significant correlation with BMI.

Keywords: Performance analysis, Physical tests, Physical performance, Body composition, Taekwondo.

Cite this article as:
Laurin, L. L. (2024). Anthropometry and athletic performance with Zybek sports in elite American taekwondo athletes. *Scientific Journal of Sport and Performance*, *3*(2), 282-290. https://doi.org/10.55860/XQKJ6685

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Submitted for publication February 12, 2024.
Accepted for publication March 12, 2024.
Published March 14, 2024.
Scientific Journal of Sport and Performance. ISSN 2794-0586.

doi: https://doi.org/10.55860/XQKJ6685

INTRODUCTION

The relationship between anthropometric characteristics and athletic performance in taekwondo practitioners is a topic of growing interest in the field of sports science and physical preparation (Formalioni, A., Antunez, et al. 2020; Arazi et al. 2016; Wheeler, Nolan et al. 2012). Taekwondo, as a sport discipline, demands a unique combination of physical skills, including strength, speed, agility, balance, and flexibility, making it a highly specialized sport (Vargas, Vargas et al. 2010; Bridge, Ferreira et al. 2014; Pieter, 2009). Additionally, anthropometric characteristics, encompassing body composition, muscle mass, height, limb length, and other factors related to body structure, play a fundamental role in the performance of taekwondo athletes (Villalba, Morocho et al. 2018; Ojeda, Azocar et al. 2020).

Success in taekwondo relies on athletes' ability to execute kicks and defence techniques quickly and accurately, requiring a unique combination of muscular power and agility (Vargas, Vargas et al. 2010; Bridge, Ferreira et al. 2014; Pieter, 2009). Variability in anthropometric characteristics, such as the ratio of lean mass to body fat, can influence a taekwondo practitioner's ability to generate explosive force and move skilfully on the tatami (Villalba, Morocho et al. 2018; Ojeda, Azocar et al. 2020; Campos, Morine et al. 2009; Peña, Mieles et al. 2022). Limb length, in particular, plays a critical role in executing precise jumps and kicks, as well as in maintaining balance during competitions (Morine et al. 2009; Peña, Mieles et al. 2022).

The relationship between anthropometric characteristics and athletic performance in taekwondo athletes has garnered increasing scientific interest. Researchers and sports professionals have conducted numerous studies to better understand how these characteristics influence performance and how they can be used to optimize athlete training and assessment. These studies have highlighted the importance of designing specific training programs that take into account the individuality of taekwondo practitioners, considering their unique physical and anthropometric characteristics (Formalioni, A., Antunez, et al. 2020; Arazi et al. 2016; Wheeler, Nolan et al. 2012).

Similarly, it is crucial to conduct periodic measurements with reliable assessments to comprehensively track improvement in relevant variables. Various methods exist to identify these profiles through reliable and validated tests. In this context, we have utilized the Zybek Sport SAT test battery. It is important to note that, while this battery is not specifically designed for the taekwondo population, its reliability has been demonstrated in other disciplines, such as National Football League (NFL) American football, due to its movement patterns and evaluation conditions. Taekwondo, characterized by short and intense efforts with rapid and constant changes, finds a connection with the SAT battery tests. Although there are more specific tests to evaluate the physical abilities required in taekwondo, the SAT can be considered a reliable tool in this population. The discipline itself demands agile movements, efficient changes of direction, as well as leg power and explosiveness to execute techniques quickly and accurately. Specifically, speed and agility tests, such as the 10, 20, and 40-yard dashes, along with the Pro Agility 5-10-5, provide valuable insights into a taekwondo practitioner's ability to move quickly and change direction effectively. Vertical and horizontal jumps, on the other hand, measure the power and explosiveness of the legs, fundamental skills in taekwondo, where movements and techniques require a rapid extension of the lower limbs. Furthermore, speed tests, especially short-distance ones like the 10 and 20-yard dashes, assess anaerobic capacity, essential in sports involving intense and brief bursts of activity, as seen in taekwondo bouts (Laurin, 2021; Guillen, Shoemaker et al. 2019; Leutzinger et al. 2018). Given all the aforementioned, the objective of this study was to determine the relationship between athletic performance in Zybek Sport tests and anthropometry in elite American taekwondo practitioners.

METHODOLOGY

Design

A quantitative, descriptive, correlational, quasi-experimental, and cross-sectional study was conducted among a population of elite American taekwondo practitioners.

Population and sample

The study included 470 participants from various classifications, conveniently selected by researchers through a non-random sampling method. Inclusion requirements specified that participants had to be volunteers affiliated with USA Taekwondo (USAT) and have completed all phases of the study. Informed consent was obtained, and permission for participants under the age of majority was secured through relevant signatures.

Instruments, techniques, and procedures

Anthropometric measurements, including weight (kg), height (m), and Body Mass Index (BMI, kg/m²), were assessed as follows: Taekwondo athletes' weight was measured using a TANITA® BC-585F scale. Measurements were taken in the morning, while fasting, in loose clothing, and barefoot. Three measurements were taken per athlete, and the last one was selected for confirmation. For height, the ISAK standardized Zybek Sport stadiometer was used, with the athlete standing upright and barefoot. BMI was calculated using the formula Weight (kg) / (Height (m) * Height (m)) (Norton, 2018).

Athletic performance assessment utilized the Zybek Sports Performance Standardized Athletic Testing (SAT®) battery. Measurements were taken in the morning, and athletes underwent tests in the same order as anthropometric evaluations.

SAT® main tests included the 10, 20, and 40-yard sprints, the Pro Agility 5-10-5 test, vertical jump, and horizontal jump, measured in seconds and centimetres, respectively. Automated timing systems with digital laser beams provided by Zybek Sports (Fully Automated Timing Systems, Broomfield, CO) were used for the 40-yard sprint and Pro Agility tests. In the 40-yard sprint and Pro Agility tests, taekwondo athletes started from a three-point stance, similar to that used in track and field, with intervals recorded at 10 and 20 yards to assess acceleration throughout the test. It is noteworthy that the 10, 20, and 40-yard sprints measure straight-line speed, while agility tests evaluate the ability to perform bidirectional and multidirectional movements (Guillen, Shoemaker et al. 2019; Leutzinger et al. 2018).

Vertical jump height was measured as the difference between standing reach height and the maximum jump height using a standard testing device (Power Jump; Zybek Sports, Broomfield, CO), providing a measure of vertical power (Guillen, Shoemaker et al. 2019; Leutzinger et al. 2018).

Horizontal jump (BJ) was also measured in centimetres, determining the total distance from the starting line to the nearest part of the athlete's body at the time of landing, typically corresponding to the heel for most athletes. The best score achieved in each test was used as the representative score (Guillen, Shoemaker et al. 2019; Leutzinger et al. 2018).

Ethical considerations

Throughout this research, strict adherence to the guidelines set by the 1974 Protection of Human Subjects Act, also known as the Biomedical Research Act, was maintained. Respect for fundamental rights, as per the 2013 Declaration of Helsinki by the World Medical Association, was ensured.

Detailed information about the research purpose, procedures involved, voluntary nature of participation, and complete confidentiality of personal data was provided to all participants. Informed consent, signed by each participant, was obtained to fully comply with these standards. The practice of assigning codes instead of using participants' names directly in the database was employed to maximize privacy.

Statistical analysis

For statistical analysis, all collected data were entered into an Excel spreadsheet and then transferred to the SPSS Version 25 statistical analysis program. Categorical variables were described in terms of percentages and frequencies. The Kolmogorov-Smirnov test was applied to assess whether continuous variables followed a normal distribution for samples larger than 50. Continuous variables with a normal distribution were expressed using mean and standard deviation (SD), while those not meeting this criterion were represented using median and interquartile range (IQR). The correlation coefficient was used to establish the relationship between anthropometric measures and performance variables, with a significance level set at $p < .0005$.

RESULTS

The group of taekwondo athletes from the USAT in the United States that was analysed showed diversity in terms of categories, comprising (n = 153) cadet athletes, (n = 149) junior athletes, and (n = 168) senior athletes. Regarding gender, (n = 265) males and (n = 205) females were included in the study. The average age of the athletes was 15.2 ± 3.75 years.

Table 1. Sociodemographic and anthropometric characteristics of the population.

Characteristics	**N**	**%**
Athletes' Gender		
Male	265	56.38
Female	205	43.62
Total	470	100
Athletes' Category		
Cadet	153	32.55
Junior	149	31.7
Senior	168	35.74
Total	470	100
	M	**SD**
Age of athletes	15.28	±3.75

**Note: M = mean; SD = standard deviation.*

According to the data presented in Table 2, it is evident that the majority of the key variables in this study exhibited a non-normal distribution, as their significance level was below .005. Therefore, the null hypothesis (H0) is rejected, and the alternative hypothesis (H1) is accepted. On the other hand, the variables: Height, 10-yard sprint, and pro agility, showed a normal distribution, leading to the acceptance of the null hypothesis (H0).

According to the findings presented in Table 3, it was identified that the median height was 65.00 inches (IQR 62.00 – 68.00) and a weight of 125.60 pounds ± 28.03, resulting in a body mass index (BMI) of 20.75 (lb/in²), falling within normal values according to the classification of this instrument. For the 10, 20, and 40-yard sprint tests, results were obtained as 1.88 (IQR 1.78-1.98), 3.21 ± 0.33, and 5.85 ± 0.65, respectively. The

median time for the pro agility test was 5.20 (IQR 4.92 – 5.45). Finally, for the horizontal jump and vertical jump tests, measured in centimetres, mean values of 80.13 ± 12.10 and 21.97 ± 6.53 were obtained.

Table 2. Kolmogorov-Smirnov Test for fundamental variables.

Characteristics	N	Test Statistic	Significance
Height (in)	470	0.076	.011
Weight (lb)	470	0.048	.000
BMI (lb/in²)	470	0.085	.000
10-yard Sprint (s)	470	0.046	.021
20-yard Sprint (s)	470	0.073	.000
40-yard Sprint (s)	470	0.161	.000
Pro Agility (s)	470	0.021	.200
Horizontal Jump (in)	470	0.060	.000
Vertical Jump (in)	470	0.097	.000

Table 3. Measures of central tendency and dispersion of the fundamental variables.

Characteristics	N	M	SD	ME	IQR
Height (in)	470	64.86	±5.01	65.00	P25 = 62.00; P75 = 68.00
Weight (lb)	470	125.60	±28.03	123.00	P25 = 106.00; P75 = 142.00
BMI (lb/in²)	470	20.75	±3.58	20.37	P25 = 18.54; P75 = 22.45
10-yard Sprint (s)	470	1.89	±0.16	1.88	P25 = 1.78; P75 = 1.98
20-yard Sprint (s)	470	3.21	±0.33	3.24	P25 = 3.03; P75 = 3.42
40-yard Sprint (s)	470	5.85	±0.65	5.96	P25 = 5.53 P75 = 6.30
Pro Agility (s)	470	5.19	±0.37	5.20	P25 = 4.92; P75 = 5.45
Horizontal Jump (in)	470	80.13	±12.10	79.00	P25 = 72.00; P75 = 88.00
Vertical Jump (in)	470	21.97	±6.53	20.70	P25 = 17.2; P75 = 25.60

**Note: M = Mean; ME = median; SD = Standard Deviation; IQR = Interquartile Range; P25 = 25th percentile; P75 = 75th percentile.*

Table 4. Pearson correlation between the variables of interest.

Characteristics	Height (in)		Weight (lb)		BMI (lb/in²)	
	Spearman's Rho coefficient	*p*-value	Spearman's Rho coefficient	*p*-value	Spearman's Rho coefficient	*p*-value
10-yard Sprint (s)	-0.233	.000*	-0.224	.000*	-0.111	.016*
20-yard Sprint (s)	-0.332	.000*	-0.315	.000*	-0.187	.000*
40-yard Sprint (s)	0.580	.000*	0.692	.000*	0.516	.000*
Pro Agility (s)	-0.309	.000*	-0.222	.000*	-0.071	.126
Horizontal Jump (in)	0.454	.000*	0.355	.000*	0.137	.003*
Vertical Jump (in)	0.235	.000*	0.145	.000*	0.028	.542

According to the findings of the Spearman's Rho correlation coefficient expressed in Table 4, negative and statistically significant relationships can be identified between the 10 and 20-yard sprints with height (p < .000) and (p < .000), weight (p < .000) and (p < .000), and BMI (p < .016) and (p < .000) respectively. This suggests that lower height, weight, and BMI will increase performance in these tests, and vice versa. The pro agility test only showed a significant negative relationship with weight (p < .000) and height (p < .000). Regarding the 40-yard sprint, horizontal jump, and vertical jump, which showed positive and significant relationships, it was identified that performance in these tests is influenced by greater height (p < .000) (p <

.000) (p < .000), weight (p < .000) (p < .000) (p < .000), and BMI (p < .000) (p < .003) respectively. Except for the vertical jump, which did not show a significant relationship with BMI (p < .542).

DISCUSSION

The aim of this study was to determine the relationship between anthropometric variables and performance in Zybek Sport tests (SAT). The results of this study revealed several significant findings. Firstly, it was found that the weight of athletes showed a negative relationship with performance in the 10 and 20-yard sprints, as well as the pro-agility test, with a p-value < .000. This indicates that, overall, heavier athletes tend to have lower performance in these speed tests. This negative relationship may be attributed to the influence of weight on athletes' acceleration and speed capabilities. Another significant finding was the negative relationship between the height of athletes and their performance in the same tests, with a p-value < .000. This suggests that taller athletes tend to have lower performance in the 10 and 20-yard sprints, as well as the pro-agility test. The explanation for this relationship could be related to biomechanics and stride strength, as height may influence running technique. (Borba, Ferreira, 2016; Toro, Siquier et al. 2021) Additionally, a negative relationship was observed between the Body Mass Index (BMI) of athletes and performance in Zybek Sport tests, with a p-value < .016. BMI combines height and weight, and this negative relationship could indicate that athletes with a higher BMI have less outstanding performance in these speed and agility tests. (Borba, Ferreira, 2016; Toro, Siquier et al. 2021).

On the other hand, the 40-yard sprint, horizontal jump, and vertical jump, which showed positive and significant relationships, identified that performance in these tests is influenced by greater height, weight, and BMI. Except for the vertical jump, which did not show a significant correlation with BMI. In contrast to the 10 and 20-yard sprints and Zybek Sport tests, which demonstrated negative relationships with anthropometric variables, the results revealed a different scenario in the case of the 40-yard sprint, horizontal jump, and vertical jump. In these cases, positive and significant relationships were found between performance in these tests and certain anthropometric variables. (Borba, Ferreira, 2016; Toro, Siquier et al. 2021; Benavides, Salazar et al. 2021; Junior, Ascanio et al. 2020).

Firstly, the 40-yard sprint showed a positive and significant relationship with height, weight, and BMI. This indicates that taller, heavier athletes with a higher BMI tend to perform better in this speed test. The explanation behind this relationship may be related to the need for greater strength and power to accelerate and maintain high speed over a longer distance. (Borba, Ferreira, 2016; Toro, Siquier et al. 2021).

The horizontal jump also revealed a positive and significant relationship with height, weight, and BMI. This means that athletes with greater height, weight, and BMI tend to have better performance in this test, which assesses power and horizontal jumping ability. The influence of these anthropometric variables may be related to the strength and ability to generate thrust in the jump. (Benavides, Salazar et al. 2021; Junior, Ascanio et al. 2020).

However, it is important to note that, in the case of the vertical jump, although a positive relationship was found with height and weight, no significant relationship was identified with BMI. This suggests that, unlike the other mentioned tests, BMI does not seem to significantly influence vertical jump performance. Vertical jump is based on explosive leg strength, and this selective relationship with anthropometric variables may be related to the technique and biomechanics of the test. (Benavides, Salazar et al. 2021; Junior, Ascanio et al. 2020).

In relation to the univariate analysis, it was identified that the results in the 40-yard sprint in our study show similarities to those obtained by Leutzinger, Gillen, and others in 2018, who evaluated American football players, as in this study, the mean for the 40 yards was 5.85 ± 0.65 for taekwondo athletes and approximately 5.78 ± 0.50 for ages closest to our sample. However, significant differences are observed in the Pro Agility, where participants in our study recorded a higher time (5.20 seconds) compared to players who spent between 4.50 and 4.84 seconds. Additionally, our vertical jump of 55.80 cm turned out to be lower than the range of 57.6 compared to 66.5 cm obtained by Leutzinger, Gillen et al. in 2018. Regarding the horizontal jump, our results of 203.5302 cm are lower compared to the range of 209 to 258 cm of the players evaluated by Leutzinger, Gillen et al. in 2019. These disparities in results can be explained by several reasons. Firstly, the athletes evaluated in our study differed in age, with taekwondo athletes being younger compared to participants in the previous study, and they also had a higher height, ranging between 173 and 184 cm, and a greater weight, ranging between 73 and 119 kg. It is worth noting that the athletes in the previous study were American football players, which could influence the differences in the evaluated tests. It is important to mention that there are few studies that evaluate these types of tests in taekwondo athletes, if any. (Leutzinger, Gillen et al. in 2018).

In another study conducted by Gillen, Shoemaker et al. in 2019, involving high school students associated with American football, similar results were obtained in the 10-yard sprint, with 1.9 ± 0.2 seconds, compared to taekwondo athletes in our study who recorded 1.88 seconds (IQR 1.78 - 1.98). Likewise, Gillen's study obtained 3.1 seconds in the 20-yard sprint, a similar result to our study, which was 3.21 seconds. However, in the 40-yard sprint, our results were higher, with a time of 5.8 seconds, compared to Gillen's 5.3 seconds, indicating that our participants took more time in this test. Also, our results in the Pro Agility were lower, indicating that our participants spent less time compared to Gillen's study in 2019. Additionally, our vertical jump and horizontal jump were lower than the values of Gillen and others in 2019, with 64 cm and 203 cm, respectively, in contrast to the 273 cm in their study. (Gillen, Shoemaker et al. in 2019).

Limitations

It is evident that this study adopts a novel approach, as there is limited literature that has used the Zybek Sports Performance Standardized Athletic Testing (SAT), especially in sports other than American football. However, this novelty could pose certain limitations in discussions due to the limited availability of literature on this test. On the other hand, one notable strength of this study lies in the use of a sizable sample. Few studies can access large sample sizes for their research. However, it is important to highlight that the sample population was conveniently selected by researchers, which could restrict the scope of the study's findings and limit the applicability of the methodology in future research.

For a comprehensive understanding of the relationship between anthropometric characteristics and athletic performance, it is necessary to conduct research that examines causality. This involves determining whether anthropometric aspects effectively enhance athletic performance or if other factors come into play. Furthermore, longitudinal studies are recommended, which, by following athletes throughout their competitive trajectories, can provide a more holistic insight into how the relationship between these two constructs develops.

CONCLUSIONS

In conclusion, statistically significant relationships were established between anthropometric characteristics and athletic performance in the Zybek Sport test. Firstly, the 10 and 20-yard sprint tests showed a negative correlation with height, weight, and BMI, suggesting that shorter stature, lower body weight, and lower BMI

translate to better performance in these speed tests. This indicates that, overall, heavier athletes tend to have lower performance in these speed tests. This negative relationship could be explained by the influence of weight on athletes' acceleration and speed capabilities. Additionally, concerning height, taller athletes tend to achieve lower performance in the 10 and 20-yard sprints. This association could be related to biomechanics and running technique, as height may influence athletes' stride. Regarding the agility test, only a negative and significant correlation with height and weight was observed, aligning with the previously mentioned findings. Greater height and greater weight can also affect the biomechanics, speed, and acceleration of athletes. Lastly, concerning the 40-yard sprint, horizontal jump, and vertical jump, positive and significant correlations were found. It was identified that better performance in these tests is influenced by greater height, weight, and BMI, except for the vertical jump, which did not show a significant correlation with BMI. The explanation behind this relationship may be related to the need for greater strength and power to accelerate and maintain high speed over longer distances. Additionally, the influence of these anthropometric variables could be related to the strength and ability to generate thrust in the jump. All these findings suggest that anthropometric characteristics can influence biomechanically in performance variables in Zybek Sport.

SUPPORTING AGENCIES

No funding agencies were reported by the author.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the author.

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