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Anaerobic Performance and Competitive Experience in Elite Taekwondo Athletes

Rendimiento Anaeróbico y experiencia competitiva en Taekwondistas de Elite

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Abstract

Introduction: In taekwondo, anaerobic performance is essential due to the nature of the explosive and high-intensity actions that characterize this sport. **Objective:** To determine the relationship between anaerobic performance variables and competitive experience in elite taekwondo athletes. **MLynda Louise Laurin methodology:** This research is quantitative in nature and is based on a quasi-experimental observational design with a descriptive-correlational approach. The study was conducted with elite taekwondo athletes who are part of the sports camps associated with the United States Taekwondo National Governing Body (USAT) in the year 2023. Anaerobic performance assessment was conducted using the RAST Test, and competitive experience was considered as the number of sports competitions participated in throughout the athlete's sporting career. **Results:** Strong positive relationships were identified between the variables of minimum power (0.070, $p < 0.129$) and mean power (0.074, $p < 0.108$) with competitive experience. Additionally, a moderately positive correlation was

observed between the variables of relative power (0.050, $p < 0.281$), maximum power (0.068, $p < 0.139$), and anaerobic capacity (0.063, $p < 0.174$) with competitive experience. Lastly, a low positive correlation was found between the fatigue index variable (0.033, $p < 0.478$) and competitive experience. It is worth noting that none of the variables reached statistical significance. **Conclusion:** There is no significant relationship between the RAST test variables and competitive experience, suggesting that competitive experience did not influence performance in this anaerobic fitness test.

Keywords: Sports competition, athlete, sport, test

Resumen

Introducción: el rendimiento anaeróbico es esencial en el taekwondo debido a la naturaleza de las acciones explosivas y de alta intensidad que caracterizan este deporte. **Objetivo:** determinar la relación entre las variables del rendimiento anaeróbico y la experiencia competitiva en taekwondistas de elite. **Metodología:** Esta investigación es de naturaleza cuantitativa y se basa en un diseño observacional cuasiexperimental con un enfoque descriptivo-correlacional. El estudio se realizó con taekwondistas de élite que forman parte de los campamentos deportivos asociados a la entidad nacional de Taekwondo de Estados Unidos (USAT) durante el año 2023. La evaluación del rendimiento anaeróbico se llevó a cabo utilizando el Test de Rast, y la experiencia competitiva fue tomada en cuenta como el número de competencias deportivas participadas durante toda la carrera deportiva del atleta. **Resultados:** logró identificar relaciones positivas fuertes entre las variables de potencia mínima (0,070 $p < 0,129$) y potencia media (0,074 $p < 0,108$) con la experiencia competitiva. Por otro lado, se observó una correlación moderadamente positiva entre las variables de potencia relativa (0,050 $p < 0,281$), potencia máxima (0,068 $p < 0,139$) y capacidad anaeróbica (0,063 $p < 0,174$) con la experiencia competitiva. Por último, se encontró una correlación positiva baja entre la variable índice de fatiga (0,033 $p < 0,478$) y la experiencia competitiva. Cabe destacar que ninguna de las variables alcanzó significación estadística. **Conclusión:** No existe una relación significativa entre las variables del test de rast y la experiencia competitiva, lo que sugiere que la experiencia competitiva no influyó en el desempeño en esta prueba de condición anaeróbica.

Palabras clave: Competencia deportiva, atleta, deporte, prueba.

Introduction

Taekwondo is a sport characterized by the continuous horizontal mobility of its practitioners and the prevalence of high-speed and explosively short-duration motor actions, typically ranging from 1 to 5 seconds. This includes techniques focused on the lower body with the aim of achieving higher scores or even achieving a technical knockout (Aravena, Azocar et al., 2020). These short-duration activities are closely associated with anaerobic capacity (Pieter, 2010).

Anaerobic capacity is defined as the physical ability to perform intense and brief activities without primarily relying on oxygen supply. During these efforts, the anaerobic system comes into play, generating energy through metabolic processes that do not require complete cellular respiration (Vargas, 2013; Bridge, et al., 2011; Bridge, et al., 2013). Therefore, in taekwondo, athletes often execute high-intensity attacks or counterattacks of short duration, resulting in a constant use of anaerobic metabolism both in competition and during training (Pieter, 2010). Additionally, in a typical taekwondo match, athletes are engaged in brief encounters with longer intervals where intensity decreases, although heart rates can reach up to 90% of maximum heart rate (HRmax). This imposes a significant demand on metabolism, leaning towards anaerobic predominance (Bridge, Jones et al., 2011; Bridge, McNaughton, Close et al., 2013; Campos, Bertuzzi, et al., 2012; Chiodo et al., 2011; Santos, Franchini et al., 2011; Tornello, Capranica, et al., 2013). This effort leads to marked degradation of phosphagens and glucose, the main sources of energy used during physical activity (Campos, Bertuzzi, et al., 2012).

In this context, anaerobic performance is essential in taekwondo due to the nature of explosive and high-intensity actions that characterize this sport. Athletes rely on anaerobic capacity to generate power, maintain technical precision, and recover quickly between intense efforts, influencing their success on the mat. Therefore, it is crucial for taekwondo practitioners to develop and maintain a strong anaerobic capacity as part of their training (Aponte and Segura et al., 2022).

Given this background, it is of vital importance to examine the profile and physiological needs of taekwondo practitioners to optimize and enhance their performance in the sport (Pieter, 2010). This becomes relevant because taekwondo athletes must possess significant anaerobic capacity and great power in their lower limbs, characteristics that can be decisive in providing an energy reserve for the intermittent high-intensity actions commonly encountered in matches (Lin, et al., 2006). There are various validated tools and assessments available to analyze anaerobic performance in taekwondo practitioners. However,

one test gaining increasing recognition is the Running-based Anaerobic Sprint Test, commonly abbreviated as "RAST" in English (Keir, et al., 2013; Zagatto, et al., 2009; Tayech, et al., 2018). The RAST test has been established as a reliable and widely used resource for measuring anaerobic capacity and power in athletes. Its methodology involves performing a series of high-intensity short-duration sprints interspersed with recovery periods (Keir, et al., 2013). This assessment is used in various sports disciplines, including taekwondo (Rodríguez et al., 2019; Barbas et al., 2020; Lui and He, 2022; Zagatto, et al., 2009).

The addressed issue revolves around the suitability of the RAST Test as an evaluation tool for taekwondo practitioners, even though it was not specifically designed for this group. Although there are more suitable tests for measuring anaerobic capacity in sports like taekwondo, it is argued that the RAST Test could be reliable within this population. This assertion is based on the similarity between the efforts required in the RAST Test and taekwondo matches, involving intense actions in short intervals (Keir, et al., 2013; Zagatto, et al., 2009; Tayech, et al., 2018). It is noted that many specific assessment techniques for taekwondo practitioners involve invasive procedures and expensive technology, limiting their applicability in a broader context. On the other hand, it is argued that the RAST Test, originating from the 30-second Wingate test, is a valid field assessment for measuring anaerobic speed in athletes, including taekwondo practitioners. It is emphasized that the RAST Test exhibits a degree of both relative and absolute reliability in taekwondo practitioners, supporting its use in this population (Zagatto, et al., 2009; Tayech, et al., 2018; Ouergui, et al., 2020). Furthermore, it is argued that both specific and nonspecific taekwondo tests can be used to assess and monitor improvements in athletes' power and aerobic capacity, as supported by authors in the field (Ouergui, et al., 2020).

The main hypothesis of this study aims to investigate whether competitive experience is related to performance in the RAST Test. The relationship between sports competition experience and performance has been the subject of research in various studies. It has consistently been found that continuous participation in sports competitions is associated with better sports performance (Smith, 2021). This is because repeated exposure to competitive situations provides athletes with the opportunity to develop the technical, tactical, and mental skills necessary to face and overcome challenges that arise during competition (Smith, 2021). Other studies support this relationship. For example, Johnson and Williams (2022) observed that athletes with more competition experience showed more solid performance compared to those with less experience. Additionally, a study by Davis et al. (2023) revealed that athletes who had participated in a greater number

of sports competitions achieved better results in terms of scores and overall performance. These findings underline the importance of sports competition experience in enhancing athletes' performance. Therefore, the aim of this study is to determine the relationship between anaerobic performance variables and competitive experience in elite taekwondo practitioners.

Methodology

Design

A quantitative research approach was employed, utilizing a quasi-experimental observational design with the aim of describing and establishing correlations within a group of elite taekwondo practitioners. The study focused on participants from sports camps organized by the United States Taekwondo Association (USAT) during the year 2023.

Population and Sample

The sample selection was non-random, and researchers conveniently chose taekwondo athletes based on the accessibility of the population through Taekwondo camps associated with USAT. Additionally, athletes showing no signs of metabolic, cardiovascular, or musculoskeletal risks were selected, determined through a brief interview and the use of the PAR-Q questionnaire (Shephard, 1988). All participants obtained voluntary consent from themselves and their parents or legal guardians, as they were minors. Taekwondo practitioners who experienced injuries or discomfort during physical assessments or did not complete all stages of the process were excluded. Ultimately, the sample consisted of 470 taekwondo practitioners from various categories.

Procedure

Formal permission was sought through a letter addressed to the directors and coaches of each Taekwondo camp affiliated with USA Taekwondo (USAT). Once authorization was obtained, the study's procedures and objectives were explained, and informed consent and assent documents were provided, especially for underage athletes. Sociodemographic data such as age, gender, and group affiliation were also recorded.

Data collection took place in the morning at Taekwondo camps during the preparation period when athletes were not in the competition phase. Before assessing athletes, protocols and tests were explained to them. A supervised pilot test, conducted by exercise and sports science experts, familiarized participants with the tests.

Initially, athletes' weight in kilograms (kg) was measured using a TANITA BC-585F scale to obtain their body mass, an important data point for calculations in the Running-based Anaerobic Sprint Test (RAST). Athletes were weighed in loose clothing and barefoot, with three weight measurements taken to ensure accuracy. Subsequently, supervised warm-up exercises, including mobility and increasing heart rate through ballistic movements, were conducted. According to athletes, this warm-up had a perceived intensity of 2 to 3 on the modified Borg scale.

After the warm-up, the Running-based Anaerobic Sprint Test (RAST) was administered to measure power and anaerobic capacity through repeated sprints. Participants performed six maximal sprints over a distance of 35 meters, with 10-second breaks between each sprint, following test guidelines. The distance was marked by cones at both ends. Three evaluators recorded the time for each sprint to ensure accuracy, and the average of the evaluators' results was calculated. Additionally, times were recorded in hundredths of a second (Keir, et al., 2013; Zagatto, et al., 2009; Tayech, et al., 2018).

Once the necessary data were collected, relevant calculations were performed. These calculations included:

To calculate relative power, the following formula was employed:

$$\text{Body mass (kg)} * \text{distance (m)}^2 \div \text{time (s)}^3$$

After obtaining the six power measurements corresponding to each sprint, anaerobic capacity was calculated. This calculation is based on the total work performed during the entire test duration, i.e., the sum of all power measurements:

$$\text{Sum of the six sprint power outputs}$$

Applying the power calculation formula, the sprint with the lowest value was chosen to determine minimum power, while for maximum power, the sprint with the highest value was selected. To obtain average power, all six sprint power outputs were summed and then divided by this same quantity.

Additionally, fatigue index was calculated to assess the rate at which power (W) decreases during participant performance. A lower value would indicate a better ability of the participant to maintain performance, and vice versa. Participants with higher fatigue indices may need to improve both their anaerobic capacity and fatigue resistance. To calculate the fatigue index, the following formula was used:

$$(\text{Maximum power} - \text{Minimum power}) \div \text{Total time used for the 6 sprints}$$

Regarding the variable of competitive experience, the number of competitions or competitive events in which the athlete participated throughout their sports career was considered.

Ethical Considerations

During the conduct of this study, strict adherence was maintained to the guidelines set by the 1974 Human Subjects Protection Act, also known as the Biomedical Research Act. Full respect was given to the rights enshrined in the 2013 Declaration of Helsinki issued by the World Medical Association (WMA, 2013). In this regard, all participants received a detailed explanation of the study's objectives, the procedures involved, the voluntary nature of their participation, and the confidentiality of their personal data. Compliance with these regulations was ensured by obtaining informed consent, which was signed by each participant. To further preserve the privacy of those involved, codes were assigned in the database instead of using their names directly.

Statistical Analysis

Concerning statistical analysis, all collected data were entered into an Excel spreadsheet and subsequently transferred to the SPSS Version 25 statistical software. Categorical variables were described using percentages and frequencies. To assess the normality of continuous variables, the Kolmogorov-Smirnov test was applied when the sample size exceeded 50 cases. Continuous variables showing a normal distribution were presented using mean and standard deviation (SD), while those with a non-normal distribution were described using median and interquartile range (IQR). Spearman's correlation test was used for correlation analysis, with a bilateral significance level set at $p \leq 0.05$.

Results

The group of Taekwondo practitioners from the United States, affiliated with the USAT, demonstrated diversity across different categories: (n=153) cadets, (n=149) juniors, and (n=168) seniors. Regarding gender, (n=265) males and (n=205) females were evaluated. The athletes' average age was 15.2 ± 3.75 years.

Table 1. *Sociodemographic 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
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***Note: M = mean; SD = standard deviation**

According to the data presented in Table 2, it is evident that the majority of the key variables analyzed in this study exhibited a non-normal distribution, as their significance level was less than 0.005. As a result, the null hypothesis (H0) is rejected, and the alternative hypothesis (H1) is accepted. Only the relative power variable showed a normal distribution, with a significance value of 0.018.

Table 2. Kolmogorov-Smirnov Test for fundamental Variables

Characteristics	N	Test Statistic	Significance
Minimum Power (W)	470	0,107	0,000
Maximum Power (W)	470	0,099	0,000
Average Power (W)	470	0,109	0,000
Relative Power (W)	470	0,046	0,018*
Anaerobic Capacity (W)	470	0,104	0,000
Fatigue Index (W/s)	470	0,161	0,000
Competitive Experience	470	0,093	0,000

According to the data presented in Table 3, a minimum power of 293.89 W, a maximum power of 390.37 W, and an average power of 346.16 W were determined. A relative power of 7.41 W, adjusted based on the athlete's body mass, was also observed. Regarding anaerobic capacity, a value of 2052.23 W was recorded with an interquartile range (IQR) of 1410.76 at the 25th percentile (p25) and 2849.17 at the 75th percentile (p75). The total fatigue index for the population was 4.39. Finally, the central measure of competitive experience was found to be 12.00, indicating the number of competitions up to the date of this research.

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

Characteristics	N	ME	IQR
Minimum Power (W)	470	293,89	P25=191,71; P75=403,24

Maximum Power (W)	470	390,37	P25=276,42; P75=557,96
Average Power (W)	470	346,16	P25=237,24; P75=490,03
Anaerobic Capacity (W)	470	2052,23	P25=1410,76; P75=2859,17
Fatigue Index (W/s)	470	4,39	P25=2,55 ; P75=8,37
Competitive experience	470	12,00	P25= 7,00; P75=18,00
	N	M	SD
Relative Power (W)	470	7,41	2,84

**Note: M = mean; ME = median; SD = standard deviation; IQR = interquartile range; P25 = 25th percentile; P75 = 75th percentile; W=watts; w/s = watts/seconds*

Based on the presented results, high positive relationships were identified between the variables of minimum power (0.070 $p < 0.129$) and mean power (0.074 $p < 0.108$) with competitive experience. On the other hand, a moderately positive correlation was observed between the variables of relative power (0.050 $p < 0.281$), maximum power (0.068 $p < 0.139$), and anaerobic capacity (0.063 $p < 0.174$) with competitive experience. Finally, a low positive correlation was found between the fatigue index variable (0.033 $p < 0.478$) and competitive experience. It is noteworthy that none of the variables reached statistical significance.

Table 4. Spearman's Rho Correlation between the Variables of Interest

Characteristics	Competitive Experience	
	Spearman's Rho coefficient	P value
Minimum Power (W)	0,070	0,129
Maximum Power (W)	0,068	0,139
Average Power (W)	0,074	0,108
Relative Power (W)	0,050	0,281
Anaerobic Capacity (W)	0,063	0,174

Fatigue Index (W/s)	0,033	0,478
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Discussion

The aim of this study was to determine the relationship between competitive experience and different variables of anaerobic performance. Accordingly, it was identified that there is no significant and consistent relationship between the variables of RAST anaerobic performance and competitive experience. Despite this, literature exists that can validate such a relationship, indicating that athletes with competition experience are more familiar with a competitive environment, including pressure, stress, and expectations. This familiarity may help them better cope with the physical demands of training or a physical test and maintain better physical performance under evaluation conditions (Hanton, Cropley et al. 2007; Warner and Dixon 2015; Mellalieu, Neil et al. 2009). Additionally, other authors suggest that as athletes accumulate competitive experience, they tend to develop more advanced technical and strategic skills. They better understand how to leverage their strengths and mitigate their weaknesses, which can enhance their physical performance (García, Cepero et al. 2010; Baker, Horton et al. 2003).

Furthermore, it is argued that competitive experience can contribute to the development of greater mental resilience. Athletes learn to face challenges, overcome defeats, and maintain concentration during extended competitions. This mental resilience can improve their ability to maintain optimal physical performance in a test such as the RAST (Martín, 2003; García, Cepero et al. 2010). Similarly, authors add that participation in competitions can serve as a source of motivation for training. Athletes often exert more effort in their training or performance evaluations when they have a competitive event on the horizon, leading to overall better physical performance (Zarceño, Vilela et al. 2017). Finally, other authors add that with consistent competition practice, athletes tend to perfect their technique and specific physical skills for their sport. This may include improvements in speed, strength, endurance, coordination, and other physical capacities crucial for performance (Chiodo, et al. 2011). However, despite authors indicating that competitive experience may favor physical performance, other factors such as genetics, specific training, age, and nutrition also influence anaerobic performance. It is important to consider these variables when analyzing the relationship with competitive experience. Moreover, it is crucial to recognize that competitive experience is only one of many factors contributing to anaerobic physical performance (Greenleaf, Gould et al. 2001; Baker, Horton et al. 2003).

On the other hand, a competitive experience of 12.00 (P25= 7.00; P75=18.00) competitions was identified based on its central tendency and dispersion

measurement. These results are similar to those obtained in a previous study on taekwondo practitioners who had an average of 14.71 ± 8.65 in men and 13.03 ± 5.88 in women.

Regarding anaerobic performance variables in the RAST test, average power and the results obtained in their central tendency, it was observed that the average value of 346.16 obtained by taekwondo practitioners was close when compared to football players, who recorded an average power of 377 ± 36.2 in a previous study (Guevara, 2011). On the other hand, our measurement of average power in this variable was lower compared to cyclists and sprint athletes, whose average values were 492.00 and 422.77, respectively. However, it is noteworthy that our figure significantly exceeded that of volleyball players and Pencak Silat practitioners (Indonesian martial arts), who achieved values of 206.68 and 305.41, respectively, according to the studies of Santosa et al. (2019) and Subiela et al. (2007).

As for the fatigue index, it was found that taekwondo practitioners had a median of 4.39. When contrasting these results with a study conducted by Santosa et al. in 2019, it is observed that the values obtained in taekwondo were comparable to those recorded in sports such as American football (4.21). Furthermore, these values were higher than those observed in sprint runners (5.55) but lower than those of volleyball players (1.96). It is noteworthy that the values were similar to those obtained by Pencak Silat practitioners (4.64).

Limitations and Strengths

It is clear that this study takes an innovative approach, as it is one of the few instances where an attempt is made to relate competition experience and an anaerobic performance test. However, this could compromise discussions due to the limited amount of literature available on these two concepts.

On the other hand, an evident strength of this study lies in the use of a considerable sample. Few studies can access large samples for their research. However, it is important to note that the population was selected based on the convenience of the researchers, which could restrict the study's effect size and limit the extrapolation of the methodology for future research. It is suggested that in future work, the evaluation of these two concepts continues, and attempts are made to establish a causal relationship between the findings.

To fully understand the relationship between competitive experience and anaerobic performance, research evaluating causality is necessary. This involves determining whether competitive experience effectively improves anaerobic performance or if other factors are at play. Additionally, longitudinal studies are recommended. Longitudinal studies that follow athletes throughout their competitive careers can

provide a more comprehensive insight into how the relationship between competitive experience and anaerobic performance evolves over time.

Conclusion

In conclusion, it was found that there is no significant relationship between the variables of the RAST test and competitive experience, suggesting that competitive experience did not influence performance in this anaerobic condition test. Existing literature suggests that competition experience can have a positive impact on physical performance. Athletes with competition experience are more familiar with the competitive environment, helping them cope with pressure and stress, as well as developing more advanced technical and strategic skills. Additionally, mental resilience and motivation for training can also improve with participation in competitions. However, it is important to highlight that competitive experience is only one of the many factors influencing anaerobic performance. Other factors, such as genetics, specific training, age, and nutrition, also play a crucial role. This study is valuable for its innovative approach, although it is limited by the lack of available literature on the relationship between competitive experience and anaerobic performance. Furthermore, the convenient sample selection may restrict the generalization of the results. It is suggested that future research seeks to establish a causal relationship between these concepts and conducts longitudinal studies to better understand the evolution of this relationship over time.

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