Research article

Personality Grit and anaerobic performance in american taekwondo athletes

Personalidad Grit y rendimiento anaeróbico en taekwondoin estadounidenses

Personalidade Grit e Desempenho Anaeróbio em Atletas de Taekwondo Americanos

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ABSTRACT

The purpose of this study was to assess the relationship between anaerobic performance and Grit personality in American taekwondo practitioners, its degree of influence, as well as any differences that may exist between genders. This study employed a quantitative, descriptive-correlational methodology, conducted on a population of (n=121) taekwondo practitioners affiliated with the USAT. Grit personality was measured using the Grit Scale, and anaerobic performance was assessed through the Anaerobic Sprint Test based on running (Rast). According to the results, a positive and significant correlation between anaerobic capacity and power with Grit was identified in men ($p<0.005$ and $p<0.007$ respectively). Likewise, these two variables were significantly related to Grit ($p<0.001$) in the total sample. In the case of women, there were no significant relationships. The fatigue index showed no significant correlations. Grit personality influenced up to 14% in anaerobic capacity and power in men ($p<0.001$ and $p<0.002$, respectively) and 12% in these two aspects for the total sample ($p<0.000$ in both cases). Finally, the findings indicate a relationship between power, anaerobic capacity, and Grit personality in men and the total sample, with a significant influence of Grit on anaerobic performance. Such relationships were not found in women. Although no significant gender differences were found in Grit, anaerobic capacity, and power, differences were found in the fatigue index, indicating a disparity in fatigue resistance between genders.

Key words: Grit; Anaerobic capacity; Anaerobic performance in taekwondo athletes.

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RESUMEN

El propósito de este estudio fue evaluar la relación entre el rendimiento anaeróbico y la personalidad Grit en taekwondoin estadounidenses, su grado de influencia, así como las diferencias que puedan existir entre sexos. Este estudio tuvo una metodología cuantitativa, descriptiva-correlacional, realizada en una población de (n=121) taekwondoin, vinculados a la USAT. La personalidad Grit fue medida mediante la escala Grit, y el rendimiento anaeróbico a través de la prueba del sprint anaeróbico basado en la carrera (Rast). De acuerdo con los resultados se pudo identificar en hombres, una correlación positiva y significativa entre la capacidad y potencia anaeróbica con el Grit ($p<0.005$ y $p<0.007$ respectivamente). Asimismo, estas dos variables se relacionaron significativamente con el Grit ($p<0.001$) en el total de la muestra. En el caso de las mujeres, no hubo relaciones significativas. El índice de fatiga no presentó correlaciones significativas. La personalidad Grit influyó hasta un 14% en la capacidad y potencia anaeróbica en hombres ($p<0.001$ y $p<0.002$, respectivamente) y un 12% en estos dos mismos aspectos para la muestra total ($p<0.000$ en ambos casos). Finalmente, los hallazgos indican una relación entre la potencia, capacidad anaeróbica con la personalidad Grit en hombres y en el total de la muestra, con una influencia significativa del Grit en el rendimiento anaeróbico. No se encontraron tales relaciones en mujeres. Aunque no se hallaron diferencias significativas por sexo en el Grit, capacidad y potencia anaeróbica, sí que se encontró en el índice de fatiga, indicando una disparidad en la resistencia a la fatiga entre sexos.

Palabras clave: Grit; Capacidad anaeróbica; Rendimiento anaeróbico; Taekwondistas.

RESUMO

O objetivo deste estudo foi avaliar a relação entre o desempenho anaeróbico e a personalidade Grit em praticantes de taekwondo americanos, seu grau de influência, bem como as diferenças que possam existir entre os sexos. Este estudo utilizou uma metodologia quantitativa, descritiva-correlacional, realizada em uma população de (n=121) praticantes de taekwondo afiliados à USAT. A personalidade Grit foi medida usando a Escala Grit, e o desempenho anaeróbico foi avaliado através do Teste de Sprint Anaeróbio baseado em corrida (Rast). De acordo com os resultados, foi possível identificar nos homens uma correlação positiva e significativa entre a capacidade e potência anaeróbica com o Grit ($p<0.005$ e $p<0.007$, respectivamente). Da mesma forma, essas duas variáveis estavam significativamente relacionadas ao Grit ($p<0.001$) na amostra total. No caso das mulheres, não foram encontradas relações significativas. O índice de fadiga não apresentou correlações significativas. A personalidade Grit influenciou até 14% na capacidade e potência anaeróbica em homens ($p<0.001$ e $p<0.002$, respectivamente) e 12% nesses dois aspectos para a amostra total ($p<0.000$ em ambos os casos). Finalmente, os achados indicam uma relação entre potência, capacidade anaeróbica e a personalidade Grit em homens e na amostra total, com uma influência significativa do Grit no desempenho anaeróbico. Tais relações não foram encontradas em mulheres. Embora não tenham sido encontradas diferenças significativas por sexo no Grit, capacidade e potência anaeróbica, foi encontrada diferença no índice de fadiga, indicando uma disparidade na resistência à fadiga entre os sexos.

Palavras chave: Grit; Capacidade anaeróbica; Desempenho anaeróbio; Atletas de taekwondo.

INTRODUCTION

The importance of psychological aspects in sports performance has been widely recognized in the literature. These aspects play a crucial role in mental preparation, motivation, concentration and determination in athletes, which are relevant elements for sports performance and success (Abdullah et al., 2016; Castilla & Ramos, 2012; Gilchrist et al., 2018). Researchers, athletes and coaches agree that the effectiveness of sport is directly influenced by the psychological aspect (Abdullah et al., 2016; Castilla & Ramos, 2012; Gilchrist et al., 2018; Nagle et al., 1975; Silva et al., 1981). It has always been said that physical aspects are one of the most relevant factors in sport, since they can favor performance by 45% to 48%; However, psychological variables turn out to be even more decisive, favoring said performance by up to 85% (Nagle et al., 1975; Silva et al., 1981).

In this same sense, one of the most studied and substantiated psychological aspects in sports performance is personality, since it can affect motivation, perseverance, resilience and the ability to face challenges in athletes (Abdullah et al., 2016; Castilla & Ramos, 2012; Gilchrist et al., 2018; Esmaeilnejad et al., 2023). In addition, various studies have explored the relationship between personality and sports performance, providing ample evidence of its importance in this area (Parker et al., 2020; Tang et al., 2019). In this context, multiple theories and models have been developed to characterize personality, seeking to understand which traits favor this sports performance. One of these models is known as the Grit personality or simply Grit, which was developed by psychologist Angela Duckworth, and has gained recognition in psychological and sports research. In 2007, authors such as Duckworth, Peterson, Matthews and Kelly, proposed a non-cognitive instrument that was ultimately considered to determine the potential in predicting performance called Grit (Sigmundsson et al., 2020). Grit refers to long-term perseverance and passion to achieve goals, despite obstacles and difficulties (Duckworth, 2016). Furthermore, this body of knowledge could explain the reasons why certain individuals exhibit unique behaviors and manage to significantly increase their performance, even in the face of various adversities that may arise in the sports field (Sigmundsson et al., 2020). Grit is recognized as an essential merit that plays a crucial role in various achievements by establishing the ability to pursue goals in the sports field despite facing adversities and moments of failure. The Grit personality involves characteristics of resilience by regaining motivation in the face of adversity or failure, as pointed out by Duckworth; in addition, Grit determines persistence in the face of challenges, including selflessness and the diverse passions that can emerge during difficult times, which is essential in assessing the consistency of interests, perseverance and effort towards specific goals and objectives (Duckworth et al., 2007). Angela Duckworth, author of the personal development book Grit: The Power of Passion and Perseverance, makes a comparison between individuals who exhibit the Grit trait and their ability to face adversities, highlighting their ability to more effectively use their capabilities in the long term. These individuals, instead of focusing on mistakes or setbacks, on short-term goals, maintain their focus on the main objective, considering mistakes as an integral part of the learning process for the future. Numerous research supports the idea that Grit is a stronger predictor of success compared to emotional intelligence and talent. It is important to note that possessing Grit traits involves pursuing a single long-term goal with persistence and passion, rather than having multiple goals (Duckworth, 2016).

The Grit personality has been studied in the sports context and evidence suggests that it is related to success in various athletic disciplines. A recent study by Sigmundsson et al. (2020) examined this relationship in a sample of soccer players. The results showed that athletes with the highest levels of Grit had superior athletic performance in terms of achievements and physical abilities. This is supported by Duckworth (2016), indicating that:

> Long-term persistence is essential in any athletic career. Athletes face challenges, both physical and mental, throughout their careers, and those with higher levels of Grit are likely to overcome these obstacles with a consistent dedication to their goals.

Furthermore, Grit personality has been linked to greater sports resilience, supported by the study conducted by Esmaeilnejad et al., 2023, who investigated this relationship in soccer players. The results indicated that players with the highest Grit scores showed a greater ability to recover from fatigue and maintain consistent performance during competition. On the other hand, Rafiee et al. (2022) investigated the relationship between Grit personality and sports performance self-efficacy in a sample of athletes. The results revealed that athletes with higher levels of Grit experience a positive and significant influence on their self-efficacy, with this relationship being mediated by the participatory performance variable. Players with high levels of Grit are more likely to maintain their focus and determination even when experiencing physical fatigue. Persistence, an integral part of the Grit personality, can drive athletes to overcome physical and psychological barriers associated with fatigue, allowing them to maintain consistent performance over time. Furthermore, long-term passion can act as a motivational driver that prevents fatigue from negatively affecting the quality of play (Duckworth, 2016). Additionally, Grit personality has been linked to discipline and adherence to physical training programs. Kiernan et al. (2023) examined the relationship between this construct and exercise adherence. The results showed that people with higher levels of Grit tend to maintain a long-term training program, suggesting that Grit personality may be a predictor of consistency in physical training. In this order of ideas, it can be indicated that there is a consistent relationship between Grit and various aspects related to sports performance.

As mentioned at the beginning, physical parameters also become relevant in sports performance. In particular, this study will refer specifically to anaerobic capacity, defined as maximum efforts sustained for a few seconds (Barbero et al., 2006). Furthermore, anaerobic performance is typical of disciplines such as taekwondo, whose capacity is expressed in combats through accelerations, movements, kicks, punches, jumps and changes of direction generating muscle contractions for short periods and at a very high intensity, allowing fast and demanding fights (Barbero et al., 2006; Pieter, 2010; Sáez, 2016). There are various validated instruments and tests to evaluate anaerobic performance in taekwondoins; however, there is a test that has begun to gain popularity, and it is known as the sprint test based on running or Rast test by its acronym in English (Keir et al., 2013; Sáez, 2016; Tayech et al., 2018; Zagatto et al., 2009). The Rast test is a reliable and widely used tool to assess anaerobic capacity and power in athletes. It consists of performing a series of short maximal sprints with recovery periods between them (Keir et al., 2013). This test is a tool used in different sports disciplines, including taekwondo (Seo et al., 2015; Liu & He, 2022; Panda et al., 2022; Zagatto et al., 2009).

In a study conducted by Liu & He (2022) they examined Rast test performance in elite taekwondo athletes. The results revealed that Rast test performance was positively related to competitive success

in taekwondo, indicating that improved anaerobic capacity and power may provide advantages to taekwondo athletes in competitions. Furthermore, the Rast test has been used to monitor training progress. A study by Seo et al. (2015) investigated the effects of a high-intensity training program on the anaerobic capacity of junior taekwondo athletes. The results demonstrated significant improvements in anaerobic performance after the program, suggesting that this test may be useful to assess and track the progress of anaerobic performance in this discipline. Additionally, the Rast test can also be used as a talent screening and selection tool in taekwondo. A study by Li et al. (2018) examined the performance of this test in athletes practicing this discipline and found that those with a superior performance in the Rast test also showed a superior performance in competition. These findings support the usefulness of the Rast test as an indicator of potential talent and performance in this sport.

Based on the previous considerations, we propose the central hypothesis of this study: there is a positive relationship between the Grit personality and the performance in the Rast test in taekwondo athletes. In addition, we seek to quantify the degree of influence of the Grit personality variable on the anaerobic performance of these athletes. This approach is based on the considerable existing evidence that supports the association between the Grit personality and performance in anaerobic tests. These two constructs may be related since Grit implies having a hard-working mentality, endurance and determination to overcome challenges and maintain focus on achieving goals (Duckworth, 2016; Duckworth et al., 2007). In the context of the Rast test, the relationship between Grit and anaerobic performance may be relevant due to the demanding and challenging nature of the test (Tayech et al., 2018; Zagatto et al., 2009). This test requires muscular explosiveness and mental toughness to maintain maximal effort throughout the test. For example, a study by Parker et al. (2020) examined the relationship between Grit and performance in anaerobic capacity tests in collegiate athletes. The results showed a positive and significant correlation between Grit levels and performance in anaerobic capacity tests (Parker et al., 2020). However, it is important to note that the relationship between Grit and the Rast test may not be highly determinant, as there are other factors that influence sports performance. In addition to Grit personality, specific training, genetics, and other psychological aspects such as motivation and confidence may also influence performance on the Rast test (Liu & He, 2022). Grit personality, with its focus on long-term perseverance and passion, may be related to better performance on the Rast test and other anaerobic capacity tests (Liu & He, 2022; Tang et al., 2019). However, further research is required to fully understand the relationship between these two constructs. Multiple factors need to be considered to gain a more complete understanding of athletic performance on tests such as the Rast test.

On the other hand, another research hypothesis was formulated which is: there are significant differences between men and women with regard to the performance variables in the Rast test and the Grit personality, or, on the contrary, as an alternative hypothesis it was proposed: there are no differences in both sexes in these variables. We consider that the biological, sociocultural and psychological differences documented in the literature could influence sports performance and the manifestation of personality, and we want to explore whether these differences are evident in our sample of taekwondoins. The above statement is supported by different authors such as Mangine et al. (2014), who indicate that there are biological differences between men and women, such as muscle characteristics and body fat distribution, which can influence the advantages and disadvantages that each gender experiences in different sports. In addition, hormonal levels, such as androgens, can have

an impact on strength and endurance, which can affect performance in physical activities (Bassett et al., 2020). Similarly, other research has highlighted the importance of sociocultural and psychological factors in creating these disparities. For example, Chalabaev et al. (2013) point out that social expectations and gender roles influence the participation and dedication of men and women in different sports, which can affect their opportunities for development and success. Lirgg (1991) found that differences in self-confidence can lead women to underestimate their own athletic abilities, which can limit their performance in competitions and physical tests. Furthermore, intrinsic and extrinsic motivation can vary between genders and have an impact on persistence and effort in practice and competition (Lirgg, 1991). Sex differences in sports performance are the result of a complex interaction between biological, sociocultural, and psychological factors. Although disparities may be apparent, it is important to address these differences to promote equity and equality in sports. Based on the above, the aim of this study was to evaluate the relationship between anaerobic performance and Grit personality in American taekwondoin, their degree of influence, as well as the differences that exist between sexes in these variables.

METHODS

Design

The design of this study was correlational, descriptive, and cross-sectional, carried out in a population of American taekwondoin of both sexes belonging to the youth category, linked to the National Taekwondo Federation or USA Taekwondo (USAT), during the period from December 2018 to November 2019 (Hernández et al., 2018).

Population and sample

The finite population comprised (n=415) elite taekwondoins belonging to various categories (cadets, juniors, and seniors) of the National Taekwondo Federation USAT. The sample was selected in a non-probabilistic manner, conveniently choosing taekwondoins from the junior category, that is, young athletes between the ages of 13 and 17, due to the accessibility and permissions provided through the Taekwondo camps linked to USAT. The selection criteria included those athletes of both sexes who presented the absence of metabolic, cardiovascular, and musculoskeletal injury risks, evaluated through a brief interview and the use of the PAR-Q (Shephard, 1988). The participants, minors, had the voluntary authorization of themselves and their parents or guardians responsible by signing the informed consent and assent. Youth category taekwondoins who had injuries or discomfort during the physical tests, as well as those who did not complete the process, were excluded. Initially, a sample of (n=125) taekwondoins was available; however, (n=3) did not complete the test in its entirety, and (n=1) did not provide the corresponding permissions. No taekwondoins reported injuries or discomfort during the test, resulting in a final selection of (n=121) taekwondoins for this study.

A forecast calculation of the effect size, statistical power, and the expected margin of error in this non-probabilistic population of taekwondoins was performed.

Sample size (n)

$$n = \frac{(Z_{\alpha/2} + Z_{\beta})^2 \times \sigma^2}{\delta^2}$$

$Z_{\alpha/2}$ = critical value of the standard normal distribution for $\alpha/2$,

$Z\,\beta$ = critical value of the standard normal distribution for β,

σ = population standard deviation,

δ = effect size you want to detect.

Effect size (d)

$$d = \frac{\mu 1 - \mu 2}{\sigma}$$

$\mu 1$ = men's average,

$\mu 2$ = women's average,

σ = common standard deviation.

Standard error (e)

$$E = d \times \frac{\sqrt{n^1 + n^2}}{n^1 \times n^2}$$

E = standard error,

d = effect size.

n^1; n^2 = sizes of the two samples.

Effect Size (d): A large effect size (d=0.80) was estimated, based on the standardized difference between the means of two populations. Level of Significance (α): A commonly accepted significance level of 0.005 was used. Statistical Power ($1-\beta$): A statistical power of 80% was sought, corresponding to a β=0.20. Finally, critical values of the standard normal distribution: $Z\alpha/2 \approx 1.96$ and $Z\beta \approx 0.84$ were used for α=0.05 and β=0.20. Therefore, with the correct sample sizes: 66 men and 55 women, total 121, the standard error (e) would be approximately 0.1458.

Procedure

To collect the information, permission was formally requested through a letter addressed to the directors and coaches of each taekwondo camp belonging to USA Taekwondo (USAT). Once

authorized, the procedures and objectives of the study were explained; likewise, the consent document and informed assent were provided to them (since the athletes were minors) for their respective completion. In addition, some socio demographic data such as age, sex and group were taken.

The data collection was carried out in the morning hours in each of the taekwondo camps, during the preparatory period; that is, when the athletes were not in the competition stage; likewise, before evaluating the athletes, the protocols and tests to be carried out were socialized to them; in addition, a pilot test directed by professionals in exercise and sports sciences was carried out, so that the participants became familiar with the tests.

Initially, the Grit scale was applied to them as an interview. The Grit scale measures determination (Duckworth et al., 2007). This instrument contains 10 items in total that are equally distributed in two subscales: passion and perseverance. For each item there is a 5-point Likert-type scale that scores the extent to which one agrees with each item or statement (i.e., 5 = Very much, 1 = Not at all). The Grit scale has a maximum score of 5 (highly determined) and a minimum of 1 (very little determined). To obtain the average of the Grit personality, all scores were added and divided by the number of items on the scale (Duckworth, 2016; Duckworth & Quinn, 2009). Additionally, the Grit scale has adequate validity and reliability indexes. In addition, the distribution of items per factor in both scales is consistent with the original validations and those carried out in other countries (Duckworth & Quinn, 2009). After taking the Grit personality, the athletes' weight was measured in kilograms (kg) using a TANITA BC-585F model scale to obtain body mass, which is essential for the Rast test calculations. They were asked to wear loose clothing and stand barefoot on the scale. Three weight measurements were taken to avoid bias. Then, the respective warm-up was conducted, led by sports science professionals, which consisted of mobility and an increase in heart rate, using ballistic movements that, according to the taekwondoin, corresponded to an intensity of 2 to 3 on the Borg perceived effort scale (modified). After the warm-up, the Running-Based Anaerobic Sprint (Rast) test was applied. Test protocol designed to evaluate power and anaerobic capacity through repeated speed. Due to its accuracy as a test and its simplicity, the Rast is commonly used by exercise professionals to monitor performance (Keir et al., 2013; Vargas et al., 2009). Additionally, this test is a reliable, non-invasive, inexpensive and validated by multiple studies instrument to measure the anaerobic power of athletes (Andrade et al., 2015; Tayech et al., 2018; Vargas et al., 2009; Zagatto et al., 2009).

The Rast test was applied one by one, according to the order in which the participants were interviewed on the Grit scale. Each of the taekwondoin performed six maximum sprints, at a distance of 35 m, with 10 seconds of recovery between each sprint (as proposed by the test). The distance was determined and marked with two cones to differentiate its ends. There were three evaluators who timed the time of each sprint in order to take the average of their results and avoid measurement bias. In addition, one evaluator recorded the time used to cover each of the speed races (noting down to the hundredth of a second) (Andrade et al., 2015; Keir et al., 2013; Tayech et al., 2018; Zagatto et al., 2009). Finally, after obtaining the necessary data, the calculations were carried out, which were:

To obtain the power, the following formula was used:

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

After obtaining the 6 power outputs from each of the sprints, the anaerobic capacity was calculated, which is obtained through the total work completed during the duration of the test; that is, the sum of all the maximum power outputs.

$$\text{Sum of the six sprint PMS}$$

After applying the power formula, to obtain the minimum power, the sprint that obtained the lowest value is selected, and for the maximum power, the sprint with the highest value is selected.

On the other hand, the fatigue index is the value represented by the speed at which power (W) decreases in the participant's performance. The lower the value, the better the participant's ability to maintain performance and vice versa. Participants with high values in the fatigue index may need to improve their anaerobic capacity and resistance to fatigue. The following formula was used to find the fatigue index (Andrade et al., 2015; Keir et al., 2013; Tayech et al., 2018; Zagatto et al., 2009):

$$\frac{\text{(Maximum power – minimum power)}}{\text{Total time spent on the 6 sprints}}$$

Ethical considerations

This study was conducted in compliance with the rights protected by the 2013 Declaration of Helsinki (World Medical Association [WMA], 2013). In this regard, through the signing of informed consent, participants were informed of the objective of the study, the procedures to be carried out, voluntary participation and confidentiality of the information. Participants were identified with codes in the analyzed database.

Statistical analysis

For statistical analysis, all information was entered into an Excel spreadsheet and then transferred to the SPSS version 25 statistical software. Categorical variables were described as percentages and frequencies. The Kolmogorov-Smirnov test was used to assess normality (n>50 samples). Continuous variables that showed a normal distribution were expressed as mean and standard deviation (SD) and those that showed the opposite, as median and interquartile range (IQR). Regarding the differences between means of both sexes, the assumption of homogeneity was first reviewed with the Levene test, as well as compliance with the assumption of normality; then the Mann-Whitney U test and Student's T test were applied, according to the behavior of the variables. Likewise, the statistical power and the sample effect size were reviewed with Cohen's d. For the correlation between the Grit personality variables and those corresponding to anaerobic performance, which are continuous variables, the Pearson correlation coefficient test was applied for the anaerobic capacity and power variables in the women's group, and the Spearman test for the others. In this same sense, the established significance level was $p \leq 0.005$. Finally, a simple linear regression was performed on those statistically significant variables to determine the degree of influence of the independent variable on the dependent variables.

RESULTS

The total sample consisted of 121 taekwondo athletes, with an almost homogeneous sample between groups, of which 54.54% (N = 66) were male and 45.45% (N = 55) were female. The mean age of the male participants was 14.30 years (±0.92) and that of the female participants was 14.07 (±0.97).

Table 1 identifies the central tendency and dispersion measures of the fundamental variables of this study corresponding to the Rast test and the Grit personality. The central tendency and dispersion measure that best fit each variable was used according to the results of the Kolmogorov-Smirnov normality test. According to the results obtained, a total anaerobic power of (321.75; P25 = 248.97; P75 = 434.32) could be identified, this variable being higher in the female sex according to its central tendency measure. On the other hand, the total anaerobic capacity had a median of (1881.65; P25 = 1434.10; P75 = 2540.80) and this in turn was almost similar in both sexes. Regarding the fatigue index of all participants, this variable showed a median of 4.30, and at the same time was higher in women when compared with the results of men. Finally, the Grit personality was higher in men (3.96 ± 0.51) compared to their female counterparts (3.89 ± 0.39).

Table 1

Key variables of anaerobic capacity in sprint and Grit personality in taekwondoin of both sexes.

Characteristics	N	Mean	SD	Median *	IQR*
Power (w)					
Male	66	398.00	±224.2	320.80*	P25= 257.65; P75= 475.21
Female	55	328.31	±130.3	321.75	P25= 225.60; P75= 403.95
Total	121	336.32	±190.2	321.75*	P25= 248.97; P75= 434.32
Anaerobic capacity (w)					
Male	66	2358.07	±1332.9	1902.72*	P25 = 1494.31; P75 = 2734.46
Female	55	1931.71	±796.8	1785.25	P25 = 1357.35; P75 = 2325.15
Total	121	2164.27	±1137.3	1881.65*	P25 = 1434.10; P75 = 2540.80
Fatigue index (w/s)					
Male	66	6.99	±5.08	4.80*	P25 = 3.08; P75 = 8.51
Female	55	4.54	±3.08	3.95*	P25 = 2.15; P75 = 5.50
Total	121	5.87	±4.89	4.30*	P25 = 2.92; P75 = 7.35
Grit Personality					
Male	66	3.96	±0.51	3.95	P25 = 3.60; P75 = 4.40
Female	55	3.89	±0.39	3.60	P25 = 3.60; P75 = 4.20
Total	121	3.93	±0.46	3.90	P25 = 3.60; P75 = 4.30

Note: N= total sample; SD= standard deviation; IQR = Interquartile range; * = Non-normal distribution.

According to the Mann-Whitney U test and T-test, it was determined that there were no significant differences by sex in the different variables studied; however, the fatigue index was close to significance $p < 0.025$, so it can become a differentiating indicator between men and women in performance. Likewise, a small effect size was determined in the personality variable Grit, (≤ 0.20) and a medium effect size in the other variables (≤ 0.50). On the other hand, the variables power and anaerobic capacity showed a strong statistical power $1\text{-}\beta = 0.871$ and $1\text{-}\beta = 0.827$ respectively. The fatigue index, on the other hand, $1\text{-}\beta = 0.797$ and the personality Grit $1\text{-}\beta = 0.763$, were below $1\text{-}\beta \leq 0.80$. (Table 2)

Table 2

Mann-Whitney U/Student T test for sex differences, effect size and statistical power.

Characteristics	Mann Whitney U	Z	P	1- β	*d*
Power (w)	1560.00	-1.327	0.184	0.871	0.380
Anaerobic capacity (w)	1524.00	-1.515	0.130	0.827	0.388

Fatigue index (w/s)	1383.00	-1.327	0.025*	0.797	0.526
	Student's t	**gl**	**P**	**1- β**	***d***
Grit Personality	-0.736	119	0.463	0.763	0.154

* Note = d = effect size; 1- β = statistical power; P = Significance; gl = degrees of freedom; Z = standardized or typified variable

Table 3 shows the correlation between the main variables analysed in this study. In the case of males, a positive and statistically significant correlation was found between anaerobic capacity ($p < 0.005$) and anaerobic power ($p < 0.007$). Likewise, both total anaerobic capacity ($p < 0.001$) and total power ($p < 0.001$) also showed a direct and statistically significant relationship with the Grit personality. On the other hand, in the case of females, positive relationships were observed in all the variables analysed; however, only anaerobic capacity and power showed a tendency towards significance. In contrast, the total fatigue index did not show significant correlations in any case.

Table 3

Sex correlation between Grit personality and anaerobic capacity in taekwondoin.

Characteristics	Grit Personality Male		Grit Personality Female		Total Grit	
	Spearman's rho coefficient	p	Spearman's rho/Pearson's r coefficient*	p	Spearman's rho coefficient	p
Anaerobic capacity	**0.341**	**0.005****	0.265*	0.051	**0.298**	**0.001****
Power	**0.331**	**0.007**	0.261*	0.055	**0.296**	**0.001****
Fatigue index	0.228	0.066	0.025	0.857	0.165	0.061

Note: * = Correlation with Pearson r; ** = statistically significant

According to simple linear regression analysis, it was determined that the Grit personality has an influence of up to 14% on the performance of anaerobic capacity in men, as reflected by the coefficient of determination of 0.147, this relationship being significant $p < 0.001$. Similarly, it was observed that the Grit personality also exerts an influence of up to 14% on anaerobic power in the male sex, this association being significant $p < 0.002$. In the case of anaerobic capacity in the total set of participants, it was found that Grit had an influence of 12%, indicated by the coefficient R2, being statistically significant with a value of $p < 0.000$. Finally, it was determined that the Grit personality exerts an influence of 12% on power in the total group of participants, this relationship being significant. $p < 0.000$. (Table 4)

Table 4

Simple linear regression analysis. Grit personality acts as an independent variable or predictor of anaerobic performance.

Variables	R	R^2	B	SE	B	t	p

Anaerobic capacity Male	0.384	0.147	1976.08	594.44	0.384	3.32	**0.001***
Power Male	0.374	0.140	324.23	100.44	0.374	3.22	**0.002***
Total anaerobic capacity	0.355	0.126	1743.24	420.68	0.355	4.14	**0.000***
Total Power	0.347	0.121	284.94	70.50	0.347	4.04	**0.000***

Note: R2= R Square; β = Beta; p = significance

DISCUSSION

The purpose of this study was to determine whether performance in the Rast test depends on Grit personality levels and how much influence this variable has on the anaerobic performance of this population. According to this, a significant relationship was identified between anaerobic capacity, anaerobic power and Grit personality in men, with an influence of this on performance of up to 14% for both variables. Similarly, a significant association was found between power and anaerobic capacity of the total population with a percentage of influence of 12% of Grit on anaerobic performance.

These previous relationships can be supported according to a meta-analysis carried out by Rascado et al. (2014) who examined the relationship between personality and performance in physical tests in the sports field. The results indicated that personality traits such as self-efficacy, motivation, determination, optimism and achievement orientation were positively related to sports performance in physical tests. Likewise, another argument holds that the Grit personality can influence the ability to overcome obstacles and stay motivated in sport. On the other hand, a study by Stambulova et al. (2009) found that athletes with higher Grit are more likely to adopt effective strategies to overcome challenges and setbacks during their sporting career. This ability for perseverance and adaptability allows them to stay motivated and committed despite difficulties, which can favor their sporting performance. Grit is also related to the growth mindset in sport. A study by Sarkar & Fletcher (2014) found that Grit is positively associated with the belief in the ability to improve and develop through effort and practice. Athletes with higher Grit tend to have a growth mindset, which allows them to face challenges (such as physical tests) and constantly seek growth and improvement in their sporting performance. On the other hand, there are studies that have specifically evaluated the Grit personality with sporting performance, and have found no relationship between these variables. For example, a study conducted on Japanese athletes determined that the Grit personality trait was not significantly associated with competitive performance independent of sex, age, years of athletic experience, and sporting events (Ueno et al., 2018). Another study conducted by Akiba & Tsunoda (2016) on a sample of (n = 178) athletes revealed that there was no significant association between Grit and performance, however, these studies differ from our results that do demonstrate the relationship and influence of the Grit personality trait on anaerobic physical performance.

Certainly, the approach of this study is novel as it is the first attempt to explore the Grit personality trait in specific tests and specific physical capacities, since multiple previous studies are based on associations between other psychological variables or with competitive achievements. The results of this study are supported by previous findings based on grit, which found that individuals with higher grit or grit scores accumulated more time in sport-specific activities compared to less gritted

individuals (Duckworth et al., 2011). Therefore, we could deduce that athletes with higher grit are more likely to endure long periods of time dedicated to taekwondo-specific training activities for performance enhancement. Conversely, taekwondo athletes with lower grit may be less inclined to participate in extended periods of training and/or physical preparation, and thus are less likely to sustain the long periods of practice necessary for optimal performance in physical tests (Ford & Williams, 2012; Ford et al., 2009).

It is clear that the Rast test is not specific to the taekwondo population as there are other tests that assess anaerobic capacity with movement patterns and conditions that are similar to the sport; however, this running-based sprint test may be reliable in this population and this is because taekwondo itself is a discipline of intermittent efforts where the athlete attacks, defends and counterattacks intensely for a few seconds, so the Rast test can provide a similar reflection in terms of effort during taekwondo combat (Keir et al., 2013; Tayech et al., 2018; Zagatto et al., 2009). Furthermore, many of the protocols to assess these athletes require invasive procedures and sophisticated equipment (e.g., contact sensor, triaxial accelerometer, preamplifiers, 3D motion tracking, piezoelectric sensor and technology), which limits their wide application or feasibility due to their accessibility (Tayech et al., 2018). Added to the above, the running-based anaerobic speed test is a valid field test adapted from the 30-second Wingate test (Tayech et al., 2018; Zagatto et al., 2009). The Rast is used to assess anaerobic power in athletes, and it has relative and absolute reliability among taekwondo practitioners (Tayech et al., 2018). The authors who approve this instrument for these populations also indicate that non-specific training such as taekwondo-specific training can induce improvements in power and aerobic capacity in general terms and that both non-specific and taekwondo-specific tests can be used to evaluate and monitor these improvements (Ouergui et al., 2020).

Another interesting finding is the fatigue index, which is higher in females compared to males (the lower this index, the better the resistance to fatigue) (Keir et al., 2013; Zacharogiannis et al., 2004; Zagatto et al., 2009). This can be supported by research that has recorded gender differences in fatigue resistance (Akiba & Tsunoda, 2016). In accordance with the above, although it is not known exactly if this is true, it is true that there are some reasons that could explain this phenomenon: one, it could be due to the composition of the muscle fibers, that is, estrogens could influence the size, weight, regeneration and contractility of the fibers (Haizlip et al., 2015; Hunter, 2016; Lanning et al., 2017). In addition, there are studies that indicate that women have a higher proportion of slow-twitch fibers, or type I, in relation to men, who seem to have a higher proportion of fast-twitch fibers (Haizlip et al., 2015; Lanning et al., 2017), although it is clear that there are more physiological and morphological reasons that can explain this phenomenon. In any case, it is essential to evaluate the differences by sex in order to create specific and individualized strategies. This is even more important considering that the literature has found gender differences in different performance variables, and comparisons between sexes in sports are still latent (Smith, 1979).

In relation to gender differences in the other variables, the absence of significant disparities is observed. This situation could be explained by considering that aspects such as the Grit personality, which amalgamates persistence and long-term passion, could be more influenced by individual and training factors than by gender differences (Duckworth, 2016; Sigmundsson, 2020). The dedication, commitment and determination necessary to excel in taekwondo could be common elements that

contribute to similar levels of Grit among elite taekwondoin, regardless of their gender (Sigmundsson, 2020).

In terms of power and anaerobic capacity, the results could be supported by physiological development, since both men and women experience similar changes during adolescence, including increased muscle mass and anaerobic capacity (Bridge et al., 2009; Pieter, 2010; Sáez, 2016). Since both genders have gone through comparable stages of physical development, it is plausible that they present similar levels in the variables analyzed. In addition, adaptation to training may vary individually, and the response to power and anaerobic capacity training could depend more on personal factors than on gender differences. In this specific sample, it is possible that the response to training was similar in both genders (Bridge et al., 2009; Liu & He, 2022; Pieter, 2010).

Strengths and Limitations

It is clear that the approach of this study is novel, since few times to date have attempted to evaluate Grit with anaerobic performance tests; however, this may limit the discussions due to the scarce literature on these two constructs.

On the other hand, a strength of this study consists in the use of a considerable population, since there are few investigations that can access large populations for research; nevertheless, the population was chosen at the convenience of the researchers, which could limit the magnitude of the study's effect, as well as the methodology being extrapolable for future studies. It is recommended for future deliveries to continue evaluating these two constructs and look for a causal explanation between the findings.

CONCLUSION

The results obtained determined a relationship between anaerobic power, anaerobic capacity and Grit personality in both men and the total sample. In addition, a significant influence of Grit on anaerobic performance was observed. On the other hand, no significant relationships were found between these variables in the case of the female sex.

Regarding the differences between sexes in the variables of Grit personality, anaerobic capacity and anaerobic power, no significant disparities were identified; however, it is relevant to highlight that there are differences between sexes in the variable fatigue index, since this showed significance, which suggests that there could be a fundamental difference in resistance to fatigue between sexes, as indicated by said indicator. It is plausible that the differences in resistance to fatigue between men and women are attributed to various physiological, psychological and sociocultural factors.

It is worth mentioning that a high score was observed on the Grit scale in the population studied, which denotes the presence of considerable levels of determination. These findings support the premise that grit and perseverance are key traits that impact athletic performance. Athletes with a high resilience personality are more likely to demonstrate greater dedication and persistence in their training, which could translate into better progress in anaerobic performance. However, further research is imperative to delve deeper into the underlying mechanisms of this association. It is essential

to explore other factors that may affect the connection between grit personality and anaerobic performance, such as motivation, resilience, and coping strategies. These findings underline the relevance of fostering grit and perseverance in athletes, as these attributes may play an essential role in improving physical-sports performance, especially in terms of power and anaerobic capacity.

Practical applications

The outstanding Grit scale score within the studied population highlights the relevance of fostering grit and perseverance among athletes. This not only has implications for improving athletic performance, but also suggests potential benefits in terms of coping skills and resilience in everyday contexts. Social applications can be realized through personal and mental development programs in sports settings, designed to cultivate these resilient traits. The results obtained indicate a relationship and a degree of influence between the Grit personality, characterized by long-term perseverance and passion, and anaerobic performance. This correlation opens the door to practical applications, such as the integration of psychological training programs within sports planning. These programs can be specifically designed to foster grit and persistence, thus contributing to enhancing athletes' anaerobic performance.

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