

Mental Toughness and Resilience in Trail Runner's Performance

Masters Dissertation

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RESUMO

O *Trail running* é um desporto outdoor que tem vindo a atrair um número crescente de participantes e se tem vindo a tornar numa das modalidades mais populares da corrida de *endurance*. Ocorre em terrenos e condições ambientais variáveis que vão influenciar o estado do atleta do ponto de vista biomecânico e psicológico, influenciando assim a *performance* geral durante a corrida. A *performance* no *trail running* é influenciada por vários fatores físicos e psicológicos e pode ser afetada por ocorrências imprevisíveis. Não obstante o papel inquestionável dos fatores psicológicos, nomeadamente da robustez mental e da resiliência nos desportos de *endurance* e o interesse crescente no estudo destes tópicos nos últimos anos, o seu impacto na *performance* tem sido pouco analisado. Adicionalmente, os fatores relacionados com a *performance* no *trail running* ainda não são completamente conhecidos e os dados referentes a predições de *performance* ainda são escassos. Consequentemente, o objetivo deste estudo foi analisar as variáveis psicológicas dos atletas de *trail*, nomeadamente a robustez mental e a resiliência e as suas associações na *performance*, contribuindo com um estudo transversal quantitativo. Os resultados demonstram que o modelo aplicado, englobando as variáveis de robustez mental, resiliência e *performance*, apresentou um ajuste adequado aos dados. Os efeitos diretos apresentaram associações positivas, nomeadamente: a) a robustez mental apresentou uma associação significativa com a resiliência; b) a resiliência apresentou uma associação significativa com a *performance*. O modelo de regressão não linear demonstrou que a robustez mental apresentou uma associação positiva com a *performance* considerando a resiliência como mediadora. No total, considerando os efeitos diretos e indiretos, os modelos explicam 21% da variação da

performance em atletas de *trail*, realçando a importância dos constructos psicológicos – robustez mental e resiliência – e dando um *input* na forma como os profissionais do desporto de endurance devem ter conta e incluir no treino e em provas, uma estratégia de abordagem holística psicossocial para atingir os objetivos propostos e melhores *performances*.

Palavras-chave

Endurance, performance, resiliência, robustez mental, trail running,

ABSTRACT

Trail running is an outdoor sport that is becoming one of the most popular disciplines in endurance running and attracting a growing number of participants. Occurs in variable terrains and environmental conditions who have an influence on both biomechanical and psychological state of the runner and therefore on the overall performance during the race. Trail running performance is influenced by many physical and psychological factors and can be stilted by unpredictable occurrences. Nonetheless the unquestionable paper of psychological factors, namely mental toughness and resilience in endurance sports and the growing interest in studying these topics in recent years, its impact on performance has been poorly analyzed. Even though, the factors related to performance in trail running are still not fully understood and data on performance predictions are still relatively scarce. Consequently, the purpose of this study was to analyze the psychological variables of trail runners, mental toughness and resilience, and their association in performance, contributing athwart with a quantitative cross-sectional study. The results showed that the measurement model including mental toughness (MT), resilience, and performance variables, exhibited adequate fit to the data. Standardized direct effects revealed positive associations, more specifically: a) MT displayed a significant association with resilience; b) resilience was significantly associated with performance. The indirect regression paths showed that MT displayed a positive association with performance considering resilience as mediator. In total, considering direct and indirect effects the model's explain 21% of performance variance in trail runners, highlighting the importance of these psychological constructs - MT and resilience – and giving an input in the way endurance sports professionals, should take in count and include in training and races a holistic psychosocial approaching strategy to achieve their goals and obtain better performances.

Keywords

Endurance, mental toughness, performance, resilience, trail running.

LIST OF PUBLICATIONS

The present dissertation is comprised of the following paper:

Gameiro, N., & Monteiro, D. (under review). Mental Toughness and Resilience in Trail Runner's Performance. *International Journal of Sports Science & Coaching*.

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ABBREVIATIONS

AVE – Average Variance Extracted

CD-RISC-10 – 10 item Connor-Davidson Resilience Scale

CFA – Confirmatory Factor Analysis

CFI – Comparative Fit Index

CI – Confidence Interval

CR – Confidence Reliability

e.g. – *exempli gratia*

FIML – Full Importation Robust Likelihood

i.e. – *id est*

ITRA – International Trail Running Association

KM - Kilometer

M – Mean

ML - Maximum Likelihood

MT – Mental Toughness

RMSEA – Root Mean Square Error of Approximation

SD – Standard deviation

SMTQ – Sports Mental Toughness Questionnaire

SRMR – Standardized Root Mean Residual

TLI – Tucker-Lewis Index

VIF – Variance Inflation Factor

"SOMETIMES I'VE MADE THE WRONG PATH,
BUT I'VE LEARNED THAT IT'S NO USE TO LAMENT:
I'LL HAVE TO TAKE THE MISTAKE AND RECOVER THAT LOST TIME IN THE RACE."

KILIAN JORNET, TRAIL RUNNER

INTRODUCTION

The present dissertation was developed in the scope of the Master's degree in Exercise Prescription and Health Promotion of Higher School of Education and Health Sciences of Polytechnic of Leiria. The study entitled Mental toughness and resilience in trail runner's performance aimed to analyze the psychological variables of trail runners and their association in performance. More specifically, the relationship between mental toughness and resilience and athletic performance, resorting to a cross-sectional design and contributing athwart a quantitative study, for a better understanding of these two constructs and their association. The study begins with a contextual analysis of the impact of exercise and trail running, where the specificities of this endurance modality are described, and current concerns are outlined. Then, with the growing interest of trail running, an approach to psychological constructs in sports, namely mental toughness and resilience, and their implication in performance, ending this section with current research, objective, and hypothesis of the study. After this thematic introduction, the next section explores the methods, namely the participants, where the sample is described, measures used, procedures of data collection and statistical analyzes are explained. Then, in the results section a preliminary analysis is presented, following a discussion where the results of the study are interpreted in the light of the existing evidence, and the strengths, limitations and agenda future research is then enhanced, followed by conclusion and references.

MENTAL TOUGHNESS AND RESILIENCE IN TRAIL RUNNER'S PERFORMANCE

ABSTRACT

The purpose of this study was to analyze the psychological variables of trail runners, mental toughness and resilience, and their association in performance, contributing athwart with a quantitative cross-sectional study. In total, 307 Portuguese trail runners (60 female), with ages between 20 to 66 ($M=41.98$; $SD=7.74$) were considered for analysis. The results showed that the measurement model including the factors MT, resilience, and performance variables, exhibited adequate fit to the data: $\chi^2= 150.01$ (74); $BS-p=.003$; $CFI= .953$; $TLI=.942$; $RMSEA= .058$ 90% (.045, .071) and $SRMR=.042$. Standardized direct effects revealed positive associations, more specifically: a) MT displayed a significant association with resilience; b) resilience was significantly associated with performance. The indirect regression paths showed that MT displayed a positive association with performance considering resilience as mediator ($\beta=.09$ IC = .010, .168; $p=.02$). In total, considering direct and indirect effects the model's explain 21% of performance variance in trail runners.

Keywords: Endurance, mental toughness; performance; resilience; trail running.

INTRODUCTION

Exercise benefits are well described in literature (e.g., Spittler & Oberle, 2019), contributing in a favorable way to the physiological, psychological, and social development of the human being (Bostancı et al., 2019). Traditional recreational running is a very popular form of exercise around the world (Waśkiewicz et al., 2019), creating positive lifestyles changes (Gajardo-Burgos et al., 2021). Over the last years running bigger distances are getting more interest (Spittler & Oberle, 2019), probably due to the demanding modern societies adversities and overcome challenges (Goddard et al., 2019). Parallel to this tendency, there is an increase in athlete's participation in off road or track endurance races (Easthope et al., 2014; Malliaropoulos et al., 2015; Suter et al., 2020) involving unsurfaced mountain trails with extensive vertical displacement and different distances known as trail running (Easthope et al., 2014; Malliaropoulos et al., 2015). Trail running is an outdoor sport (Viljoen et al., 2022) that is becoming one of the most popular disciplines in endurance running (Gros Lambert et al., 2020) and attracting a growing number of participants (Scheer et al., 2019). Has been recognized by the International Association of Athletics Federations as a new running discipline (Perrotin et al., 2021), and it is estimated that there are 20 million of trail runners with an increase of participation in the last decade (Viljoen et al., 2022). With a strong sense of sports ethics and a sense of humility, it is a sport that respecting the environment takes place amid nature in a demanding environment for body and mind (ITRA, 2022a). The races are characterized by pedestrian competitions open to everyone, with a minimum possible of paved roads (20% maximum) (Malliaropoulos et al., 2015), can range from a few kilometers to a multiday marathon (more than 200km) (Viljoen et al., 2022). These endurance races occur in variable terrains, including very often significant climbs and descents (elevation gain and loss), environmental conditions like cold, heat, altitude, snow, and humidity (Perrotin et al., 2021) creating the overall level of difficulty for a given race (ITRA, 2022a). This conditions, have an influence on both biomechanical and psychological state of the runner and therefore on the overall performance during the race (Perrotin et al., 2021). Given this, there exists a need to pay attention to runner's senses to explore their capabilities and develop physical and mental abilities (ITRA, 2022a). Over the last years, trail running has

become more accessible to non-professional athletes, despite the compromise that it needs in terms of time for training, work schedule and personal life (Rochat et al., 2017). In addition, several aspects may occur during a race (Suter et al., 2020), consequences of high and variable exigencies of this sport (Scheer et al., 2019), including a combination of physical, tactical, and psychological factors that can lead to success or failure (Liew et al., 2019). In trail running, like in all other sports, performance is influenced by many physical characteristics like toughness, strength, speed, agility, and by athletes' psychological status, motivation, concentration, and mental factors (Namli & Demir, 2019). Characteristic of endurance activity is surely the mental and physical reintegration due to the fatigue induced by the effort of performance (Diotaiuti et al., 2021). Even though, performance can be stilted by unpredictable occurrences like, weather conditions, mechanical failures, pain, or discomfort related to physical and mental states (Diotaiuti et al., 2021). This phenomenon's makes imperative that athletes prepare in a targeted and comprehensive way (Scheer et al., 2019). Nonetheless the influence of psychological factors in endurance sports is undeniable and a growing interest in studying these topics in recent years, its impact on performance has been poorly analyzed (Méndez-Alonso et al., 2021) existing a lack of data referring to these topics (Scheer et al., 2019). Even though, the factors related to performance in trail running are still not fully understood and data on performance predictions are still relatively scarce, different mental resources are important for an athlete to be prepared for exigency and challenges of sport (Moreira et al., 2021).

MENTAL TOUGHNESS IN SPORT

Mental toughness (MT) is a psychological construct that have been demonstrated as important in sport (Brace et al., 2020; Cooper et al., 2020; Jones & Parker, 2019), and his research and practice have become frequent in the last two decades in the areas of sport and exercise psychology (Gucciardi, 2017), being associated to beneficial behaviors and sport performance outcomes (Stamatis et al., 2020). However, regarding its conceptualization, there is still no consensus yet (Hardy et al., 2014). Gucciardi et al. (2015) define MT as “a personal capacity to produce consistently high levels of

subjective (e.g., personal goals or strivings) or objective performance (e.g., sales, race time, GPA) despite everyday challenges and stressors as well as significant adversities”. Additionally, Zeiger and Zeiger (2018) defined MT as “a state-like psychological resource that is purposeful, flexible and efficient in nature for the enactment and maintenance of goal-directed pursuits”, enabling striving (e.g., effort), surviving (e.g., coping) and thriving (e.g., performing) (Jones & Parker, 2019). MT shares conceptual space and is being correlated with various psychological constructs (Brace et al., 2020; Jones & Parker, 2019), like optimism, pessimism, coping, youth experiences, achievement goals and sport motivation, developmental assets, and stress appraisal (Jones & Parker, 2019), resilience, self-belief, and emotional intelligence (Nicholls et al., 2015). Nicholls et al. (2015) suggest that it might be the presence of other psychological constructs that permit mentally tough individuals to distinguish under stressful circumstances rather than just coping (Nicholls et al., 2015). Evidence suggests that MT is a multifaceted construct that supports performance excellence (Cowden, 2017; Jamatul Shahidah Shaari et al., 2020), irrespective of the type, direction, and degree of demands experienced (Cowden, 2017). Additionally, MT is considered central to sport performance (Anthony et al., 2016) and is referred as an important prerequisite for a higher sustained athletic level (Goddard et al., 2019). This attribute is classified as a critical factor for success (Souter et al., 2018), because of the paper that develops in increasing the controlled adaptative response to positive and negative pressures, situations, and events (Cowden, 2017). The implicit association between MT and success and better performance results have been increasing attention in quality research, especially with retrospective studies in elite athletes (Cowden, 2017). Despite the promising potential to develop MT, presently there is no evidence to prescribe a specific approach. Nevertheless Stamatis et al. (2020) suggest that due to sport-specific differences in MT, intervention should consider cultural and contextual attributes of each sport. Additionally, studies started to quantify the predicting role of MT with competitive (Cowden, 2016) and noncompetitive (Gucciardi et al., 2016) performance indicators. Although, the results have not been discussed in detail and there still exists an empiric scarcity about this conceptual association between MT and athletic performance, more specifically if MT is noticeable in better performance, achievement, or success outcomes, or more susceptible to be evidenced in non-performance factors (Cowden, 2017). Cowden (2017) highlighted the importance of statistically controlled studies to control more accurately the paper of MT on performance outcomes. Stamatis

et al., (2020) highlighted the importance of studies with objective indicators of athletic performance to state evidence for MT interventions.

RESILIENCE IN SPORT

As previously referred, another construct that is frequently mentioned with MT is resilience (Liew et al., 2019). This construct in sport has aroused interest due to the necessity of athletes of using and optimize a range of mental qualities to protect them from overcome stressors, adversities, and failures (Galli & Gonzalez, 2015; Sarkar & Fletcher, 2014). Sport is an election place to study resilience beyond unexpected adversities like serious injuries, or stressors of psychosocial nature (e.g., losing a match, maladaptive interactions with coach), physiological nature (e.g., high training loads) or non-typical (e.g., pandemic situations) (den Hartigh et al., 2022). Additionally, athletes submit themselves in evaluative environments where exists highly consequences (e.g., winning or losing) (Galli & Gonzalez, 2015). In this perspective, to limit psychological resilience to other forms of resilience, Fletcher and Sarkar (2012) firstly define resilience as “the role of mental processes and behavior in promoting personal assets and protecting an individual from the potential negative effect of stressors”. Additionally, resilience is the individual capacity of recognizing his limits, accept and go further difficulties with optimism (Diotaiuti et al., 2021). Roebuck et al. (2020) conceptualize resilience has a “high-order trait that reflects the ability of a person to maintain normal psychological functioning in the setting of a stressor”. Although, there still exists some controversy between the definition and the concept of resilience in research and practice in sport, with some investigations noting difficulties with operationalizing and measuring resilience in this context and in non-sport settings (Galli & Gonzalez, 2015). Even though resilience has been studied with multidisciplinary interest as a dynamic process with personalized perspective (den Hartigh et al., 2022), research in sports led investigators into two possible approaches (Galli & Gonzalez, 2015). In one hand, examining the psychosocial factors that predict performance following an initial failure in the same task, seeing resilience as a behavior of performing successfully after initial fail, trying posteriorly to identify how to enhance athlete’s resilience (Galli & Gonzalez, 2015). On the other perspective, resilience is

investigated by understanding the thoughts, beliefs, emotions, and behaviors of athletes who demonstrate capacity to overcome from adversity in sport (Galli & Gonzalez, 2015). Nonetheless the unquestionable paper of personal qualities in resilience (Galli & Gonzalez, 2015), namely positivity, determination, competitiveness, commitment, maturity, persistence, passion for the sport (Sarkar & Fletcher, 2014), social and environmental contexts appear to have an athlete's important role too (Galli & Gonzalez, 2015). In qualitative studies, research have been focusing on psychological elements that protect athletes against stressors, underlining positive personality, motivation, confidence, focus and perceived social support as main protective factors (Sarkar & Fletcher, 2014). Additionally, positive personality traits, more specifically adaptative perfectionism, optimism and competitiveness are linked has important dealing with stressors (den Hartigh et al., 2022). Consequently, studying this dynamic process of bouncing back to normal functioning following stressors and more specifically the interest in how long it takes to return to normality following hostile situation is imperative to prevent performance depletion and psychological or physical issues (den Hartigh et al., 2022). Utilizing biopsychosocial and scientific data, it is possible to determine warning signs with the view to identify resilience losses (den Hartigh et al., 2022).

MENTAL TOUGHNESS, RESILIENCE AND PERFORMANCE: CURRENT RESEARCH

As demonstrated in previous studies, resilience can interact with other psychological constructs in sport like hardiness, coping, MT and post traumatic growth (Galli & Gonzalez, 2015). The relationship between resilience and MT in sport has been described by Gucciardi et al. (2008) and Nicholls et al. (2015) and more recently by Moreira et al. (2021). Resilience is a construct that is very similar to MT (Cowden et al., 2016) and very often cited together (Gucciardi et al., 2009; Liew et al., 2019) and like MT, conceptualization, operationalization, and measurement have not yet generated consensus (Cowden et al., 2016). Although sharing similar conceptual space, their relation has not been explicitly clarified (Nicholls et al., 2015). Nonetheless, it is important to clarify some dissimilarities. Clough et al. (2002) proposes that confidence, a component of MT, is the distinguishing factor between both constructs, in line with

this, Cowden et al. (2016) found that a possible convergence or equivalence between constructs, could possibly be a consequence for discrepancy among constructs. Anthony et al. (2020) underlines the fact that resilience “reflects an emergent outcome that characterizes a system’s (e.g., individual, team) trajectory of functioning in terms of sustaining healthy levels or bouncing back quickly to homeostasis following adversity exposure, whereas MT is concerned solely with a psychological capacity of individuals or resource (which has the potential to foster resilience outcomes, e.g., protective factor)”. Aryanto & Larasati, (2020) point the fact that resilient individuals control their behavior remaining focused, despite identifying and controlling negative influences, while MT individuals can reject outside negative effects. MT could be applied to positive circumstances, representing a group of personal attributes that impact the way in which adversity, challenges and goals are surrounded and assessed (Cowden et al., 2016). On the other hand, resilience is mostly associated to negative contexts, including possession of and/or the presence of protective and vulnerability factors, influencing the relationship between risk and positive adaptation, including a series of important attributes outside of the self (e.g., perceived social support) (Cowden et al., 2016). Nonetheless, Cowden et al. (2016) emphasize the studies conducted by Gerber et al. (2013) where MT is seen as “a resilience resource or protective factor that moderates the association between risk and adaption levels to facilitate positive outcomes”. In line with the inherent growing of sport’s interest, in general, in trail running, due to the growing concern in races and interest by sport professionals, the undivided attention in characteristics that can develop better ways of training and compete, with the objective of getting better performances during races (Méndez-Alonso et al., 2021) have become a priority. In this way, owing to limitation of the physical training, the possibility and limitlessness of training psychological characteristics has become crucial (Zeiger & Zeiger, 2018). Given the promising results of MT (Guszkowska & Wojcik, 2021; Méndez-Alonso et al., 2021) and resilience (Diotaiuti et al., 2021; Galli & Gonzalez, 2015) in sports endurance performance. One other aspect that is relevant to note is the fact that endurance runners have shown raised levels of tenacity, determination, and tolerance of negative affect (e.g., resilience traits) (Diotaiuti et al., 2021). Nonetheless, quantitative studies analyzing these constructs recurring to validated instruments in endurance sports, namely in trail running is still scarce, where the direct and indirect associations of this constructs appear to be neglected.

In the present study the objective was to analyze the psychological variables of trail runners and their association in athletic performance in terms of the International Trail Running Association Index (ITRA Index). More specifically, the relationship between MT and resilience and athletic performance, contributing athwart a quantitative study for a better understanding of these two constructs, outlining similarities and differences. More specifically, in agreement with previous studies (Cowden et al., 2016; Hosseini & Besharat, 2010; Méndez-Alonso et al., 2021; Nicholls et al., 2015), the following hypothesis was tested: mental toughness and resilience should be positively related of performance.

METHODS

PARTICIPANTS

A total of 307 Portuguese trail runners (60 female), with ages between 20 to 66 ($M=41.98$; $SD=7.74$). The number of races finished varied between 1 to 69 ($M=15.94$; $SD=13.01$). In addition, the average of KM made in certified trail races was 971.12 and the average of positive ascent was 46.45 KM, while negative ascent was 45.90 KM.

MEASURES

Mental toughness. The Sport Mental Toughness Questionnaire (SMTQ: Sheard et al., 2009), in Portuguese version (Fonseca, 2012). The SMTQ was established to ascertain athlete's mental toughness levels. This questionnaire is comprised of 14-item, which are answered in a four-point Likert-type scale ranging from "not at all true" [1] to "very true" [4]. Posteriorly the items are grouped into three factors: confidence – six items (e.g., I interpret threats as positive opportunities); constancy – four items ("I give up in difficult situations") and control – four items ("I am overcome by self-doubt). Previous studies supported the validity and reliability of this measure in athletes (Sheard et al.,

2010). To this study three constructs were created (confidence, constancy and control) representing mental toughness (e.g., (Miçooğulları, 2017).

Resilience. The 10 item Connor-Davidson Resilience Scale (CD-RISC-10) (Connor & Davidson, 2003) in Portuguese version (Almeida et al., 2020). The CD-RISC-10 measures the resilience in general population and has been tested in athletes revealing adequate psychometric properties (Galli & Gonzalez, 2015). This scale is comprised of 10-items, which are answered in a scale from 0 (not true at all) to 4 (true nearly all the time). Posteriorly the items were grouped into one factor which represents the level of resilience. Over the years several studies (e.g., Nartova-Bochaver et al., 2021), supported its validity and reliability in different countries.

Performance. ITRA Performance Index is a tool for ranking athletes based on their performance level and is used to compare the speed of trail runners of all around the world (Méndez-Alonso et al., 2021). The scale sets a maximum of 1000 points corresponding to the theoretical best possible performance (world record performance for that distance), taking account to finish time and specific race characteristics, namely distance, elevation gain/loss and average altitude (ITRA, 2022b). Utilizes an indirect method (based on the statistical analysis of a database of more than 5.3 million individual results), the technicality of the terrain is also a factor included in this factor (ITRA, 2022b). Then, a general performance index is calculated achieving the weighted mean of the five best results over the previous thirty-six months (permitting reliable statistical calculations and giving the possibility of an injured athlete to continue to appear), regardless the distance of each one (ITRA, 2022b). By finishing a certified ITRA race (from a minimum of 2km till more than 190km), the result will appear in ITRA performance index (ITRA, 2022b).

PROCEDURES: DATA COLLECTION

Data were collected in accordance with the Helsinki Declaration (2013) and the Ethics Committee of the Polytechnic of Leiria gave its approval for its implementation (CE/IPLEIRIA/26/2021). This is a cross-sectional study, and for its implementation,

several trail runners were contacted to explain the objectives of the study. Subsequently, a google forms form was sent for completion. Before data collection, potential participants were informed about the main objectives of the study, the estimated time to complete the assessment battery (approximately 12 minutes) and all ethical procedures were followed. Before completing the questionnaires, participants had to complete a check box, ensuring that they understood the aims of the study, and that they agreed to participate. Participants were thanked for their contribution, but no compensation was provided.

STATISTICAL ANALYSIS

Descriptive statistics including means and standard deviation, as well as bivariate correlations were calculated for studied variables. In addition, a two-step maximum likelihood approach (ML) (Kline, 2016) in AMOS 27.0 was performed namely: 1) a confirmatory factor analysis (CFA) to test the psychometric properties of measurement model including convergent and discriminant validity and composite reliability (Hair et al., 2019). Convergent validity was assessed via average variance extracted (AVE), considering values higher than or equal .50 as adequately (Fornell & Larcker, 1981). Discriminant validity was estimated through the square correlations between factors, and it was considered adjusted when the square correlations were below to AVE of each factor (Hair et al., 2019). Additionally, the internal consistency of each of the latent variables under study was also calculated, from the composite reliability (Raykov, 1997), assuming as cut-off value for its adequacy coefficients $\geq .70$ (Hair et al., 2019; Raykov, 1997); 2) a structural model was established to test the hypothesis made. The model's fit for both measurement model and structural model was observed through the traditional goodness-of-fit indexes, specifically: Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) and absolutes: Standardized Root Mean Residual (SRMR) and Root Mean Square Error of Approximation (RMSEA) and its confidence interval (CI 90%), as recommended by several authors (e.g., Byrne, 2016; Hair et al., 2019; Kline, 2016; Marsh et al., 2004) and the following cut-off values were adopted: CFI and TLI $\geq .90$; RMSEA and SRMR $\leq .08$ (e.g., Byrne, 2016; Hair et al., 2019; Kline, 2016; Marsh et al., 2004). Standardized direct and indirect effects on the dependent variable

were also analyzed. The significance of direct and indirect effects was analyzed using a bootstrap resampling procedure (1000 bootstrap samples), through a 95% CI. The indirect effect was considered significant (≤ 0.05) if the 95% CI did not include zero (Williams & MacKinnon, 2008). We chose to consider confidence intervals rather than the probability of significance (p-value) due to recent evidence of mediation without a significant relationship between variables (Hayes, 2018).

RESULTS

PRELIMINARY ANALYSIS

The Full Information Robust Maximum Likelihood (FIML) was used to handle the small amount of missing data at the item level (missing at random = 4%) as proposed by Enders (2010). Additionally, no outliers (univariate and multivariate) were identified. Item-level descriptive statistics indicated no deviations from univariate normality due to the Skewness and Kurtosis are comprised between -2 and +2 and -7 and +7, respectively (Hair et al., 2019). However, Mardia's coefficient for multivariate kurtosis (47.83) exceeded expected values (5.0) for the assumption of multivariate normality (Byrne, 2016).

Therefore, Bollen-Stine bootstrap on 2000 samples was employed for subsequent analysis (Nevitt & Hancock, 2001). Finally, the collinearity diagnosis was checked using variance inflation factor (VIF) and tolerance tests and results revealed values between 1.56 to 1.88 for VIF and 0.38 to 0.77 for tolerance test, demonstrating acceptable conditions for regression analysis (Hair et al., 2019; Kline, 2016). Then, descriptive statistics and bivariate correlations were calculated for all variables under analysis.

Table 1. Descriptive statistics, bivariate correlation, convergent and discriminant validity, and composite reliability

	M	SD	1	2	3	AVE	CR
1.MT	3.09	.48	1		-	.67	.82
2.Resilience	3.12	.54	.62**	1	-	.56	.84
3.Performance	650912.38	543875.30	.23**	.13**	1	-	-

Note. MT= mental toughness; M= mean; SD= standard deviation; AVE= average variance extracted; CR= composite reliability

Descriptive statistics showed that the participants presented scores above midpoint for MT and resilience. Looking at bivariate correlations, positive and significant associations were found between all variables under analysis, specifically: a) MT was positively associated with resilience and performance; b) resilience was positively associated with performance. The measurement model including the factors MT, resilience, and performance variables, exhibited adequate fit to the data: $\chi^2= 150.01$ (74); BS-p=.003; CFI= .953; TLI=.942; RMSEA= .058 90% (.045, .071) and SRMR= .042 since CFI and TLI were above and SRMR and RMSEA were below to the previous reported cut-off values.

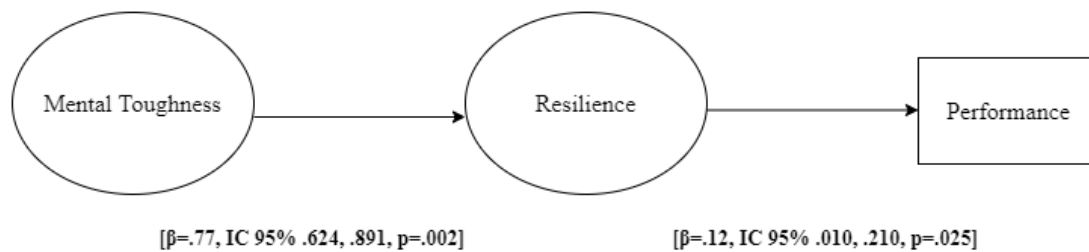
Seeing at the CR coefficients, each factor showed scores above the cutoff (>0.70) revealing adequate internal consistency. Based on the results of the measurement model and reliability analysis, convergent and discriminant validity were calculated. Convergent validity was achieved as the AVE scores were above acceptable cut-off value as seen in Table 1. According to the squared correlations and AVE scores, all factors demonstrated adequate discriminant validity since the squared correlations of each latent variable were lower than AVE scores in each latent variable. The results provide preliminary support to conduct SEM analysis in each sample and examine the direct and indirect effects across variables under analysis.

The results from the SEM analysis showed that the structural model provided an acceptable fit to the data $\chi^2= 150.01$ (75); BS-p=.003; CFI= .954; TLI=.944; RMSEA=

.057 90% (.044, .070) and SRMR= .042 since CFI and TLI were above and SRMR and RMSEA were below to the previous reported cut-off values. Standardized direct effects revealed positive associations (see figure 1). Specifically: a) MT displayed a significant association with resilience; b) resilience was significantly associated with performance.

The indirect regression paths showed that MT displayed a positive association with performance considering resilience as a possible mediator ($\beta=.09$ IC = .010, .168; $p=.02$). In total, considering direct and indirect effects the model's explain 21% of performance variance in trail runners.

Figure 1. Standardized direct effects



DISCUSSION

This study aimed to analyze the associations across mental toughness and resilience with athletic performance in Portuguese trail runners. Overall, the hypothesis was confirmed and will be discussed according to existing literature.

The positive association between MT and resilience was in line with previous research where Nicholls et al. (2015) found significant associations between MT and resilience, referring that “mentally tough athletes are able to excel under pressure”, and in the presence of other psychological constructs can distinguish under stressful circumstances rather than just coping. This fact is in order with the results obtained by Gucciardi et al. (2008), who imply through qualitative investigation that “mentally tough athletes are resilient”. Cowden et al. (2016), found strong positive association in competitive South African Tennis players between MT and resilience, enlightening that this fact evidences the conceptual similarities between the two constructs. The standardized direct effects also revealed the positive association between resilience and performance, in line with what was found by Hosseini and Besharat (2010), where the predicting role of resilience in sporting achievement, psychological well-being and distress of athletes is highlighted.

Indirect regression analysis revealed that MT displayed a positive association with athletic performance, considering resilience as a possible mediator. This result empathizes the relationship and proximity between the two constructs and gives a new input in the study of psychological constructs in performance. Although this proximity, resilience assumes its uniqueness, including the conditions of positive adaptation and adversity as Galli and Gonzalez (2015) refers. This decisive role of resilience in severe adversities that can occur outside of sport context (Cowden et al., 2016), seems to give a mediation base for “the enactment and maintenance of goal-directed pursuits” as Zeiger and Zeiger (2018) suggest, i.e., MT, in order to achieve higher athletic performance levels. Notwithstanding the limited knowledge about the conceptual association between MT and athletic performance, due to the empiric scarcity, the results obtained

are in line with the review of Cowden (2017) and Guskowska and Wojcik (2021) who found a positive correlation between MT and sporting performance in different sports, regardless age, gender, or level of skills. This result emphasizes MT as a multifaceted construct that is central and a prerequisite to sport performance, supporting performance excellence (Cowden, 2017).

In line with the results obtained by Méndez-Alonso et al. (2021), which found that MT and resilience are psychological predictors of success in ultra-trail runners, i.e., better classification and race time in athletes with higher values of MT and resilience. In addition, Méndez-Alonso et al. (2021) highlighted that in these sports athletes show higher values of MT and resilience when compared with other sports or sedentary individuals, as was previously also reported by Galli and Gonzalez (2015). Furthermore, studies have evidenced higher levels of psychological constructs in endurance athletes, namely MT (Aryanto & Larasati, 2020) and resilience (Roebuck et al., 2020), raising the question whether it is an intrinsic characteristic or consequence of training and/or competing. Méndez-Alonso et al. (2021) state that each race works as a psychological factor training, acting as a functional element in the increasing of MT and resilience. This aspect is probably due to the unpredictable conditions and specific characteristics of each trail running race, where each race can perform a mental training by itself. This is a characteristic that sports professionals should take in count in pre-, during and post-race. Although, Brace et al. (2020) with a sample of elite level ultra-marathon runners, demonstrating high levels of MT, did not find effect in performance during a race, being noted by the authors that when having higher values of MT, possibly other factors can interfere more in performance. These results reinforce the important role that the possible indirect associations between psychological constructs may have in performance variance. Endurance sports demand unquestionable mental and physical reintegration owing to the impact of fatigue prompt by the effort of the sport performance (Diotaiuti et al., 2021). In trail running, due to its specificity, exists a necessity of a permanent adjustment to different conditions, e.g., elevation, climate, making imperative to the athlete to control various parameters, namely pace, nutrition, posture, loneliness, and fatigue. However, these athletes present a more effective way of leading with unpleasant situations and perform more effectively, acting with better knowing of their state, e.g., effort and fatigue (Guskowska & Wojcik, 2021). This fact makes it very different from others sports or even from other kind of running races,

making it crucial to use psychological control permanently to reach their sports goals. This fact shows the importance of mental characteristics and evidences the primordial role that psychological preparation should assume in sports (Guszkowska & Wojcik, 2021), namely MT and resilience training. Additionally, demonstrate that performance in these races is multifactorial, and there are a lot of factors that may interfere (Diotaiuti et al., 2021), and the results found in this study show the importance of these two constructs, while others psychological constructs, and social and physiological factors may justify the rest of the athletic performance. Notwithstanding, the complexity of trail running gives a basis for future research in general sports, and in other endurance sports.

The findings of this study, explain 21% of performance variance in trail runners in total, i.e., considering direct and indirect effects, opening a new perspective of intervention in the training sessions and races of athletes for these kind of endurance efforts, more specifically in trail running. Consequently, it opens a widely mental training possibility, i.e., infinitude of mental training to overcome sports goals and obtain better performances. Sports professionals should be aware that mental training should be an integrant part of a holistic psychosocial program (Fletcher & Sarkar, 2016).

STRENGTHS, LIMITATIONS AND AGENDA FOR FUTURE RESEARCH

Trail running is a sport that, due to the challenging and unpredictable conditions where it occurs, leave the athlete in a high level of adaptation and difficulty. It has consequences in both physiological and psychological state of the athlete, influencing athlete's performance. The mental constructs assume an important role in performance, and MT and resilience are frequently associated to this endurance sports. Although previous studies analyzed the association between MT, resilience, and performance, this is the first study that analysing simultaneously MT, resilience, and an observational dependent variable, i.e., performance in trail runners, presents quantitatively the influence of these two constructs in trail runner's performance variance. Using measures with supported validity and reliability and adequate psychometric properties, highlighted the importance of MT and resilience in performance, giving an input in the way endurance sports professionals, more specifically in trail running, should take in count and include in training and races a holistic psychosocial approaching strategy to

achieve their goals and obtain better performances. Additionally, underlines the importance that MT and resilience training should assume in multidisciplinary performance view, taking in consideration the cultural and contextual attributes of each sport and social and environmental context of the athlete.

While the present study contributes with new insights on the associations across MT and resilience in athletic performance in Portuguese trail runners, this study has some limitations that should be addressed. First, the study had a cross-sectional design, which precludes us from determining causality. Experimental studies are needed to examine the effects of mental toughness and resilience on athletic performance. Second, the data from this study was limited to a Portuguese sample which limits generalizability, and the results may differ from other cultures and/or contexts. Third the data was collected in only one moment, namely at the middle of the competitive calendar, limiting the capacity of controlling a possible variation that can occur in MT and resilience values due to training and/or competition.

Future research should analyze MT and resilience during a competitive race calendar, taking in consideration the possible change during a season. Additionally, the association between these and other constructs normally related, should be studied directly and indirectly, using not only cross-sectional designs to obtain causality between the different factors in analysis. With the view to obtain generalized conclusions, studies with other sports and cultures should be included in future investigations. Investigating how these psychological constructs can be trained and increased should be part in future investigations.

CONCLUSION

The importance that psychological preparation should assume in endurance sports is undeniable, more specifically in trail running where, due to its specificity and unpredictable conditions, makes performance variance multifactorial. The permanent adjustment to different conditions and necessity of control various parameters, turns these athletes more effective dealing with these characteristics, performing better and

possibly showing higher values of psychological constructs, namely MT and resilience. The findings of this study explain 21% of performance variance in trail runners in total, i.e., considering direct and indirect effects due to the role of MT and resilience, highlighting the relationship and proximity of the two constructs and their influence in performance variation, making imperative a holistic view of athletic performance. These two constructs demonstrate its multifaceted characteristics, underlining the importance of psychosocial factors. Thus, psychologic training in endurance sports practice, especially MT and resilience training, should comprise training and races to overcome sports goals and obtain better performances. These training programs should consider the cultural and contextual attributes of each sport and social and environmental context of athletes. Due to the unlimited possibility of mental training, the results obtained in this study open new perspectives over endurance sports training, more specifically in trail running, underlining the importance that this kind of races may have in improving results and the racing calendar may assume in general performance.

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