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Psychometric validation of the Mental Toughness Scale (MTS) in Chilean university athletes

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Abstract

Background Mental toughness (MT) is a key psychological resource for performing under pressure in youth and university sport. Contemporary theory conceptualizes MT as multidimensional, rather than a single global trait. This study aimed to provide a Spanish adaptation of the Mental Toughness Scale (MTS) and to examine its multidimensional structure, reliability, and decision utility for screening and follow-up in university sport.

Methods Chilean university athletes completed a Spanish back-translated MTS and a general self-efficacy (GSE) measure. Competing structures were tested using Exploratory Structural Equation Modeling (ESEM; WLSMV, GEOMIN). A bifactor model was additionally estimated to evaluate total-score interpretability (ECV, ωH). Internal consistency (McDonald's ω) and concurrent validity (MTS–GSE correlations) were estimated. Receiver Operating Characteristic (ROC) analyses using Youden's J identified a pragmatic, specificity-oriented threshold to support exploratory screening, profiling, and follow-up decisions in university sport.

Results A two-factor, 10-item solution showed excellent fit (RMSEA = 0.04; CFI = 0.99; TLI = 0.98) and outperformed unidimensional alternatives, supporting the multidimensionality of MT in line with established conceptual models. Internal consistency was excellent (ω = 0.90). MT correlated moderately with GSE ($r = .57$, $p < .001$). ROC analysis yielded AUC = 0.80 (95% CI 0.75–0.85). A cut-off of ≥ 49.5 optimized specificity (~ 95%) with acceptable sensitivity (~ 55%), supporting an exploratory, conservative approach to screening and follow-up in applied settings. The bifactor model also showed excellent fit (RMSEA = 0.044; CFI = 0.994; TLI = 0.990), with the general factor accounting for most common variance (ECV = 0.73) and high general-factor reliability (ωH = 0.90), suggesting that the total score largely reflects a general mental toughness construct while the specific factors capture meaningful components.

Conclusions The Spanish 10-item, two-factor MTS provides a brief, reliable, and theoretically coherent assessment of MT, capturing its multidimensional nature in university sport. Beyond psychometric adequacy, a specificity-oriented cut-off offers actionable guidance for screening, referral, and monitoring. The translation and analytic protocol is

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readily replicable and can scaffold multi-site benchmarking and future measurement invariance across Spanish-speaking contexts.

Keywords Mental toughness, Multidimensional assessment, Exploratory structural equation modeling, Reliability, ROC analysis, Cut-off, University athletes, Spanish adaptation

Introduction

Mental toughness (MT) is linked to both performance and psychological health in sport [1, 2], and recent structural models in athletes further support this association [3]. Mentally tougher athletes outperform peers under pressure, report less competitive anxiety [4], and adapt better during injury recovery [5]. Yet no Spanish-language tool has been validated for Latin-American university sport, where athletes juggle academic and competitive demands. This gap is particularly salient given that journals in the field continue to publish instrument development and validation studies [6, 7].

Currently, MT is conceived as a multifaceted psychological resource that enables athletes to stay confident, focused, and resilient under pressure [8]. According to Gucciardi et al. [9], it comprises values, attitudes, and behaviors that sustain persistence when challenges are complex and motivation when conditions are favorable, facilitating consistent pursuit of high-level goals. Recent work shows that higher MT cushions daily stress in student-athletes [10], mediates coach–athlete communication effects [11], and can be strengthened through adventure-based interventions [12].

Despite extensive research over two decades, consensus on MT's definition, dimensionality, and practical utility remains elusive [8]. However, in the last eight years, the literature has demonstrated significant progress, reaching certain agreements about its multidimensional nature [13–15] and its relative stability [16–19]. Moreover, it has been acknowledged that MT can be developed through training [15, 20].

Alongside the growing attention MT has received, several instruments have been designed for its assessment, each based on different theoretical models and diverse factorial structures [21]. Among the most frequently used questionnaires are the Mental Toughness Questionnaire 48 (MTQ48) and its shortened versions MTQ18 and MTQ10 [22, 23], the Sports Mental Toughness Questionnaire (SMTQ) [24], as well as the Mental Toughness Index [1] and the Mental Toughness Scale [25]. Other researchers have used instruments such as the Psychological Performance Inventory [26], the Psychological Performance Inventory-A [27], the Mental, Emotional and Bodily Toughness Inventory [28] or the Mental Toughness in Sport Questionnaire [29]. Many of these scales were developed without consensus on dimensionality, leading to shorter unidimensional versions to enhance statistical fit [23]. However, although convenient, a unidimensional approach may underestimate the construct's complexity [30, 31], potentially overlooking crucial aspects relevant for capturing the range of psychological responses athletes display under pressure.

In this context, the Mental Toughness Scale (MTS) [25] is of particular interest. It is a brief instrument (11 items), theoretically based on Jones et al.'s approach [32, 33], which proposes that MT includes various cognitive, behavioral and affective components. Studies in the United States and Turkey [34–37] have reported Cronbach's alphas above 0.80 and adequate fit indices under unidimensional models. Nevertheless, many of these validations rely on traditional confirmatory methods (Confirmatory Factor Analysis, CFA), which do not adequately account for cross-loadings nor the possibility of more than one factor underlying item responses [21]. Additionally, its application outside the US and Turkey is limited, particularly in Latin America, where instruments to assess MT are scarce [13]. This shortage is especially pressing in countries with expanding university-sport systems such as Chile. Validation indicators from prior MTS studies are summarized in Table 1.

Chile's National University Sports Federation (FENAUDE) coordinates 7500 student-athletes across 28 institutions. Balancing academic and sport demands can tax self-regulatory resources [41], underscoring the need for concise, validated tools. A Spanish MTS would assist FENAUDE in talent identification and athlete-welfare programs while providing a common metric for forthcoming multi-center studies in Latin America.

Whether the MTS truly reflects a unidimensional structure— as originally proposed—or exhibits multiple factors is especially relevant [14, 15]. We therefore adopted Exploratory Structural Equation Modeling (ESEM), a method that blends the flexibility of exploratory factor analysis with the rigor of CFA while permitting non-zero cross-loadings—thus giving a more realistic view of multidimensional constructs [42, 43]. Recent sport-psychology validations confirm ESEM's suitability for mental-toughness research [44–47].

Despite the growing body of research on MT, no peer-reviewed study has yet validated the Mental Toughness Scale [25] within any Latin-American population. The only psychometric work from the region concerns a different instrument — the Mental Toughness Inventory (MTI) — recently adapted for Brazilian athletes through confirmatory factor analysis [14]. Accordingly, the factorial structure and cross-cultural stability of the

Table 1 Validation indicators of the mental toughness scale

Authors, Year	Country	Sample	No. of Factors	% Variance	No. of Items	RMSEA	CFI	TLI	Reliability
Madrigal et al., 2013 [25]	United States	271 university and non-university athletes, 143 basketball university athletes	1	47.23%	11	0.062	0.94	-	Cronbach's Alpha: 0.86, Test-retest: $r = .90$
Madrigal & Gill, 2014 [38]	United States	4 university athletes	1	-	11	-	-	-	Cronbach's Alpha: 0.86, Test-retest: $r = .90$
Erdoğan, 2016 [34]	Turkey	210 individual and team sports athletes	1	47.23%	11	0.06	0.96	0.96	Cronbach's Alpha: 0.87, Test-retest: $r = .79$
Madrigal et al., 2016 [5]	United States	190 female athletes	1	-	11	-	-	-	Cronbach's Alpha: 0.83, Test-retest: $r = .90$
Wilson & Madrigal, 2017 [36]	United States	54 female university-level athletes	1	-	11	-	-	-	Cronbach's Alpha: 0.86
Madrigal et al., 2017 [39]	United States	525 university athletes	1	-	11	0.087	0.92	0.90	Cronbach's Alpha: 0.88, Test-retest: $r = .90$
Yasar & Turğut, 2020 [37]	Turkey	117 elite judo athletes from the Turkish national team	1	-	11	-	-	-	Cronbach's Alpha: 0.87
Özsarı et al., 2021 [40]	Turkey	367 licensed active athletes	1	-	11	0.057	0.97	0.96	Cronbach's Alpha: 0.88
Özsarı et al., 2024 [35]	Turkey	276 licensed and active taekwondo athletes	1	-	11	0.047	0.96	-	Cronbach's Alpha: 0.86

original MTS remain unexamined across Latin-American cultures. By applying ESEM to a sample of Chilean university athletes and benchmarking the solution against published Turkish and US collegiate datasets, the present study fills this empirical gap and provides initial structural evidence for the scale in the Southern Cone. Future studies should formally test measurement invariance across sex, sport type, and Spanish-speaking countries.

Therefore, the present study investigated the psychometric properties of the MTS among Chilean university athletes, aiming: (a) to determine whether its factorial configuration is unidimensional or multifactorial, (b) to assess the overall reliability of the scale, and (c) to examine criterion validity with the General Self-Efficacy Scale. If a well-fitting, multidimensional model is identified, evidence will support the MTS's utility as a concise, culturally appropriate instrument for university sport contexts, bolstering the idea that reducing MT to a single component could underestimate its complexity.

This study constitutes a significant step forward in clarifying the dimensions of MT by applying robust methods to identify them, ensuring greater precision and reliability in the findings. By minimizing the impact of methodological bias, it fortifies the validity of the construct within the scientific framework, ensuring that its definition is based on empirical evidence rather than biases from less robust techniques. The following sections describe the methods employed—including ethical considerations and alignment with the Declaration of Helsinki—and the results, structured around dimensionality and ESEM, reliability, and criterion validity. Finally, we detail the theoretical and practical implications for sport psychology, emphasizing how this study broadens prior evidence in Spanish-speaking populations and reinforces the tailoring of training programs based on MT.

Methods

Design

This study utilized a correlational-predictive design to examine the dimensionality, reliability, and validity of the MTS in Chilean university athletes. Causality within this model was inferred through statistical control of variables rather than by random assignment or experimental manipulation [48, 49]. Such a design enables the testing of causal hypotheses statistically [50] and is particularly suitable for evaluating factorial validity and assessing the practical applicability of self-report questionnaires in the context of sport psychology [46].

Participants

The sample comprised 200 university athletes (mean age = 22.5 years, SD = 3.8) across 10 sports, including individual disciplines (e.g., swimming, athletics, tennis) and team sports (e.g., basketball, soccer, volleyball). Overall, 86.5% regularly participated in inter-university competitions, and 68.5% were men whereas 31.5% were women.

Inclusion criteria were: (a) being enrolled at a Chilean university and (b) currently engaging in sport training and/or competition during the current academic year.

Exclusion criteria: (a) presence of severe injuries preventing sports practice at the time of evaluation, (b) incomplete questionnaire responses.

The wide range of disciplines and the presence of active inter-university competitors ensure representativeness within the realm of sport psychology in Chile, aligning

with recommendations for diverse and representative sampling in psychometric research [21].

Procedure

After ethics approval from the Ethics Committee of the Faculty of Sport, University of Porto, sports-department staff at ten universities invited athletes to complete a brief survey either on paper during team meetings or online via a secure link. Participation was voluntary and anonymous; all athletes provided written informed consent in accordance with the Declaration of Helsinki. The Spanish version of the Mental Toughness Scale was developed via forward–back translation and expert review to ensure conceptual equivalence and was administered together with the General Self-Efficacy Scale. Completing both instruments required approximately 10–15 min.

Translation and adaptation of instruments

The scale was translated and culturally adapted following commonly recommended procedures for cross-cultural adaptation of self-report measures [48, 51, 52]. Three bilingual translators independently translated the original items into Spanish. A reconciliation meeting was then conducted with a discussion panel (research team members and translators) to compare versions, resolve discrepancies, and ensure semantic and conceptual equivalence, with particular attention to clarity and cultural appropriateness for Chilean university athletes. The resulting Spanish version was reviewed and refined through consensus. A formal pilot test (e.g., cognitive interviews) was not conducted prior to data collection; this is acknowledged as a limitation and should be addressed in future studies to further strengthen evidence based on response processes.

Instruments

Mental Toughness Scale (MTS) [25]

It comprises 11 items on a 5-point Likert scale (1 = "strongly disagree", 5 = "strongly agree"). Initially designed under a multidimensional hypothesis, the unidimensional version showed better statistical fit. Previous studies report Cronbach's alphas > 0.80 [35–37].

General Self-Efficacy Scale (GSE) [53, 54]

A 10-item instrument using a 4-point Likert scale (1 = "does not describe me at all", 4 = "completely describes me"). A Cronbach's alpha of 0.84 has been reported in earlier adaptations [54]. This scale was used as a criterion variable, given the theoretical and empirical relationship between MT and self-efficacy [55, 56].

Data analysis

Factorability assessment

Preliminary factorability of the correlation matrix was evaluated using the Kaiser–Meyer–Olkin (KMO) index and Bartlett's test of sphericity, as recommended in psychometric literature prior to exploratory and SEM-based factor modeling [46, 57, 58]. Sampling adequacy was assessed using the KMO index, with values above 0.80 considered indicative of meritorious suitability. The factorability of the correlation matrix was evaluated via Bartlett's test of sphericity, where statistical significance ($p < .05$) supports the appropriateness of factor analysis [46]. Given that ESEM is robust to moderate violations of multivariate normality and multicollinearity, it was adopted to estimate the latent structure [42].

Exploratory Structural Equation Modeling (ESEM)

We estimated dimensionality with ESEM, which combines the flexibility of exploratory factor analysis with confirmatory rigour and permits non-zero cross-loadings [42, 43]. Competing unidimensional, two-factor, and three-factor models were fitted in Mplus 7.0 using the WLSMV estimator and oblique GEOMIN rotation; fit was judged via RMSEA < 0.05, SRMR < 0.05, CFI > 0.90, and TLI > 0.90 [46]. Interfactor correlations were examined to assess discriminant distinctiveness between dimensions [46].

To group items into valid dimensions, we applied Howard's rule (2016). Specifically, from the rotated factor matrix, we excluded items with factor loadings (w) below 0.40 on their main factor, cross-loadings below 0.30 on other factors or factor loading differences under 0.20 [59, 60]. We also excluded items that did not consistently relate to the dimension's meaning, as well as dimensions with fewer than two items [61].

To examine whether the total MTS score reflects a general latent factor, an additional bifactor model was estimated. In this model, all items loaded on a general mental toughness factor and on their respective specific factors. To evaluate the strength of the general factor, explained common variance (ECV) and omega hierarchical (ωH) were calculated. These indices allow assessing whether the total score primarily reflects a general construct or whether the multidimensional structure is dominant [62].

Reliability

Internal consistency was evaluated using McDonald's ordinal omega (Ω) for both the total score and each dimension, derived from CFA models for ordinal indicators estimated with WLSMV (THETA parameterization). 95% confidence intervals (95% CIs) were obtained via bootstrap. Ω values above 0.70 were interpreted as acceptable and above 0.90 as excellent [63–65].

Criterion and concurrent validity

Criterion-related evidence was examined through ROC analysis as an exploratory decision-utility approach, using the General Self-Efficacy Scale (GSE) as a pragmatic external reference dichotomized at the median (low/high). The optimal cut-off was determined via Youden's J, prioritizing high specificity (>90%) and acceptable sensitivity (>50%) in line with prior recommendations for brief screening tools in sport contexts [66]. Because this external reference is not a gold-standard criterion for mental toughness and dichotomization reduces information, ROC results are interpreted cautiously and are intended to inform screening and follow-up rather than diagnostic classification. Concurrent validity was examined through correlations between MTS and GSE, expecting positive associations consistent with prior literature [55, 67].

Reporting guidelines

Reporting follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations for observational studies, and relevant COSMIN-Reporting items were considered for studies on measurement properties.

Results

Dimensionality assessment and model selection

Preliminary analyses confirmed the data's suitability for factor analysis using the KMO index (0.86) and Bartlett's test of sphericity (χ^2 = 1019.6, p < .001). Using ESEM, one-, two-, and three-factor solutions were estimated for the 11-item MTS scale. Although the three-factor solution showed excellent overall fit indices (RMSEA ≤ 0.05; CFI ≥ 0.99; TLI ≥ 0.98), it presented a single-item dimension. Furthermore, the two-factor solution revealed substantial cross-loadings on item 2. Therefore, following the methodological recommendations of Lloret-Segura et al. [61] and Williams et al. [60], a refined 10-item two-factor structure was chosen for subsequent analyses.

Beyond statistical evidence (i.e., salient cross-loadings), the removed item from the original 11-item pool ("I know when to celebrate successes but also when to stop and focus on the next challenge") was also flagged on content grounds. The wording is double-barreled, combining two potentially distinct self-regulatory processes (celebrating success vs. rapidly refocusing on the next challenge), which can reduce content specificity and contribute to heterogeneous responding. In addition, the verb "stop" ("detenerme") may be interpreted ambiguously (e.g., pausing/recovering vs. interrupting celebration vs. attentional refocusing), plausibly contributing to unstable loadings across dimensions.

After confirming sampling adequacy again (KMO = 0.86; Bartlett's test = 939.5, p < .001), three alternative models were compared using ESEM for the 10-item scale: one-dimensional, two-factor, and three-factor. The indices showed that the two-factor model presented a superior fit (RMSEA = 0.04, SRMR = 0.03, CFI = 0.99, TLI = 0.98), whereas the one-dimensional model was insufficient (RMSEA = 0.14, SRMR = 0.08, CFI = 0.91, TLI = 0.88). The three-factor solution did not reach convergence after the maximum number of iterations in Mplus [68]. Therefore, the two-factor model was selected as the final solution, since it showed a better fit and explained a greater proportion of variance (61%) compared to the one-dimensional model (48%). The two latent factors were moderately correlated (r = .51, p < .001), indicating related but distinguishable dimensions of mental toughness. Fit indices for competing ESEM models are reported in Table 2.

Standardized factor loadings for the 11-item pool (two- and three-factor ESEM solutions) are presented in Table 3.

Factor identification

The two-factor structure was formed around:

> Winning Mindset – a cognitive-affective disposition characterized by high self-confidence, unwavering focus under pressure, and a determined drive to capitalize on competitive opportunities. This dimension consists of items 1, 2, 3, and 8.
> Preparation Mindset – a disposition defined by disciplined effort, steadfast perseverance, and sustained commitment to long-term goals achieved through proactive training. This dimension comprises items 4, 5, 6, 7, 9, and 10.

Table 2 ESEM models for the mental toughness scale

Factorial Model; Items	KMO	Bartlett's statistic X2	% variance	χ^2 (df)	RMSEA	CFI	TLI	SRMR	McDonald's Ordinal omega ω
1 Factor; 11 items	0.86	1019.6*	47	141.88* (44)	0.10	0.95	0.94	0.06	0.90
2 Factors; 11items	0.86	1019.6*	58	61.95* (34)	0.06	0.98	0.97	0.04	0.90
3 Factors; 11 items	0.86	1019.6*	66	37.72* (25)	0.05	0.99	0.98	0.03	0.90
1 Factor; 10 items	0.85	939.5*	48	176.801*(35)	0.142	0.914	0.889	0.083	0.90
2 Factors; 10 items	0.85	939.5*	61	38.70* (26)	0.04	0.99	0.98	0.03	0.90

*(p < .01)

Table 3 Standardized factor loadings of the mental toughness scale for the two- and three-factor models (11 items)

Items	Two factors		Three factors		
	Winning Mindset	Preparation Mindset	Attitude/Mindset	Training	Competence
	λ Estimate	λ Estimate	λ Estimate	λ Estimate	λ Estimate
1. Poseo una confianza interior que me permite creer que puedo conseguir lo que me proponga.	0.90*	−0.04	0.61*	0.00	0.50*
2. Sé cuándo celebrar los éxitos pero también cuando detenerme y enfocarme en el próximo desafío	0.31*	0.31*	0.27*	0.43*	−0.00
3. Tengo una mentalidad ganadora que puedo usar en el momento preciso de la victoria.	0.85*	0.01	0.36*	−0.00	0.64*
4. Sé lo que se necesita hacer para alcanzar el nivel de desempeño requerido para ganar.	0.44*	0.19*	0.13	0.15	0.30*
5. Tengo la paciencia y disciplina para controlar mis esfuerzos en la conquista de cada objetivo en la búsqueda del triunfo.	0.26*	0.34*	0.16	0.33*	0.17
6. Aunque esté cansado (a), continúo entrenando para lograr mi objetivo.	−0.07	0.79*	0.01	0.77*	−0.09
7. Utilizo a mi favor todos los elementos de un entorno de entrenamiento difícil.	−0.00	0.66*	−0.07	0.59*	0.01
8. Soy capaz de aumentar mi esfuerzo si ello es necesario para alcanzar la victoria.	0.31*	0.56*	−0.00	0.34	0.39*
9. Encuentro la manera de superar los obstáculos que aparezcan en mi camino.	0.45*	0.37*	−0.01	0.10	0.58*
10. Acepto, incorporo e incluso agradezco los elementos del entrenamiento que se consideran dolorosos.	0.00	0.62*	−0.01	0.54*	0.07
11. Tengo un compromiso total con mis objetivos de rendimiento, hasta agotar la última oportunidad de éxito	0.27*	0.66*	0.00	0.37*	0.32*

Items are presented in Spanish as administered in the validated version of the scale

*($p < .01$)

Table 4 Standardized factor loadings of the two-factor model of the mental toughness scale with 10 items

Item	Winning Mindset			Preparation Mindset		
	λ Estimate	S.E.	Est./S.E.	λ Estimate	S.E.	Est./S.E.
1. Poseo una confianza interior que me permite creer que puedo conseguir lo que me proponga.	0.88*	0.07	11.77	–0.03	0.08	–0.37
2. Tengo una mentalidad ganadora que puedo usar en el momento preciso de la victoria.	0.86*	0.04	20.20	0.01	0.01	0.58
3. Sé lo que se necesita hacer para alcanzar el nivel de desempeño requerido para ganar.	0.44*	0.07	5.83	0.20*	0.08	2.42
4. Tengo la paciencia y disciplina para controlar mis esfuerzos en la conquista de cada objetivo en la búsqueda del triunfo.	0.24*	0.09	2.61	0.33*	0.08	4.05
5. Aunque esté cansado (a), continúo entrenando para lograr mi objetivo.	–0.08	0.09	–0.84	0.78*	0.07	10.25
6. Utilizo a mi favor todos los elementos de un entorno de entrenamiento difícil.	–0.00	0.04	–0.05	0.67*	0.05	12.21
7. Soy capaz de aumentar mi esfuerzo si ello es necesario para alcanzar la victoria.	0.31*	0.08	3.56	0.57*	0.07	8.23
8. Encuentro la manera de superar los obstáculos que aparezcan en mi camino.	0.45*	0.07	6.20	0.38*	0.06	5.55
9. Acepto, incorporo e incluso agradezco los elementos del entrenamiento que se consideran dolorosos.	0.00	0.05	0.03	0.61*	0.05	10.69
10. Tengo un compromiso total con mis objetivos de rendimiento, hasta agotar la última oportunidad de éxito.	0.27*	0.08	3.18	0.66*	0.07	9.21

Items are presented in Spanish as administered in the validated version of the scale

*($p < .01$)

It was observed that items 3, 4, 7, 8 and 10 displayed notable cross-loadings, but each retained its relevance in the principal dimension, maintaining enough items per factor [62, 69]. Standardized factor loadings for the final 10-item two-factor ESEM model are presented in Table 4.

As shown in Fig. 1, the final two-factor ESEM solution aligns with the multidimensional conceptualization of mental toughness, with salient target loadings on Winning Mindset and Preparation Mindset and minimal cross-loadings.

Bifactor model evaluation

To examine whether the total MTS score reflects a general latent factor, a bifactor model was estimated. The model showed excellent fit (RMSEA = 0.044, CFI = 0.994, TLI = 0.990). The general factor accounted for a substantial proportion of the common variance (ECV = 0.73), and the reliability attributable to the general factor was high (ωH = 0.90). These findings suggest that the total score largely reflects a general mental toughness construct, while the two specific factors capture meaningful components of this broader construct.

At the subscale level, the specific ECV values were 0.40 for Winning Mindset and 0.20 for Preparation Mindset, while omega hierarchical subscale coefficients (ωHS) were 0.27 and 0.10, respectively.

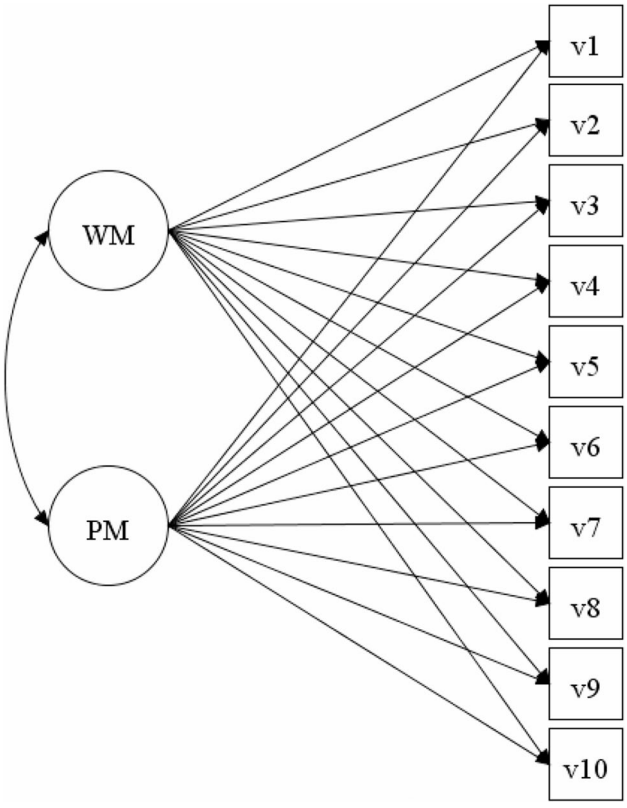

Fig. 1 ESEM two-factor model of the Spanish 10-item MTS. Standardized factor loadings are shown for Winning Mindset and Preparation Mindset. Residuals and the interfactor correlation are omitted for clarity. Abbreviations: MTS = Mental Toughness Scale; ESEM = Exploratory Structural Equation Modeling

Reliability

The MTS exhibited high internal consistency for the total score (Ω = 0.905, 95% CI [0.889, 0.920]) and for both dimensions: Winning Mindset (Ω = 0.872, 95% CI [0.843, 0.896]) and Preparation Mindset (Ω = 0.948, 95% CI [0.932, 0.961]).

Criterion and concurrent validity

ROC analysis yielded AUC = 0.80 (95% CI = 0.75–0.85; $p < .001$). The optimal cut-off ≥ 49.5 maximized Youden's J (sensitivity ≈ 55%, specificity ≈ 95%), values comparable to those reported in earlier validation studies [66, 70]. Additionally, MTS correlated strongly with GSE ($r = .57$, $p < .001$), matching literature linking MT and self-efficacy [55, 67].

As shown in Fig. 2, the ROC curve yielded an AUC = 0.80 (95% CI 0.75–0.85), with the optimal cut-off ≥ 49.5 maximizing Youden's J and favoring specificity (~ 95%) with acceptable sensitivity (~ 55%).

Discussion

The central objective of this investigation was to evaluate the psychometric properties of the MTS in Chilean university athletes, to determine its dimensionality, internal consistency, and criterion validity. This approach addresses a gap, as most existing scales were validated under unidimensional assumptions and less robust methods.

Findings confirm that the MTS shows excellent fit under a two-factor ESEM model (RMSEA < 0.04, CFI > 0.99, TLI > 0.98), explaining 61% of variance, and demonstrates excellent internal consistency for the total score (Ω = 0.905, 95% CI [0.889, 0.920]) as well as strong-to-excellent reliability for both dimensions: Winning Mindset (Ω = 0.872, 95% CI [0.843, 0.896]) and Preparation Mindset (Ω = 0.948, 95% CI [0.932, 0.961]). Moreover, the two latent factors were moderately correlated ($r = .51$, $p < .001$), indicating related yet distinguishable dimensions of mental toughness. Several items showed secondary loadings across factors, which is not unexpected when measuring complex psychological constructs such as mental toughness. Allowing cross-loadings often yields more realistic factor structures and prevents inflated factor correlations that may occur in overly restrictive CFA models [43]. Moreover, moderate cross-loadings should be interpreted theoretically rather than treated solely as statistical artifacts, as they may reflect conceptual overlap between related dimensions [30]. Despite the moderate interfactor correlation observed, the dimensions remain conceptually distinguishable, supporting acceptable discriminant validity in line with established SEM criteria [71]. This supports using the MTS as a short, consistent instrument suitable for measuring MT in Chilean university athletes [65]. Likewise, the positive correlation with Self-Efficacy (GSE) reaffirms its concurrent validity, by demonstrating that MT is linked to one's sense of personal capacity [55, 56]. These findings are particularly relevant for university athletes balancing academic and sporting commitments [20, 72]. Taken together, these associations are consistent with the view that mentally tougher athletes mobilize adaptive cognitions and affective resources under pressure, aligning with work linking MT to affect and coping in youth and young adults [73, 74].

The bifactor analysis further indicated that the general factor explained a substantial proportion of common variance (ECV = 0.73), with high reliability attributable to the general factor (ωH = 0.90). This suggests that the total MTS score is largely driven by a general mental toughness construct. At the same time, the two dimensions identified through ESEM appear to capture meaningful subcomponents of this broader construct rather than completely independent traits. The use of indices such as explained common variance and omega hierarchical allows researchers to evaluate the relative strength of general and specific factors in multidimensional scales and to determine whether total scores primarily reflect a general construct or multiple distinct dimensions [62].

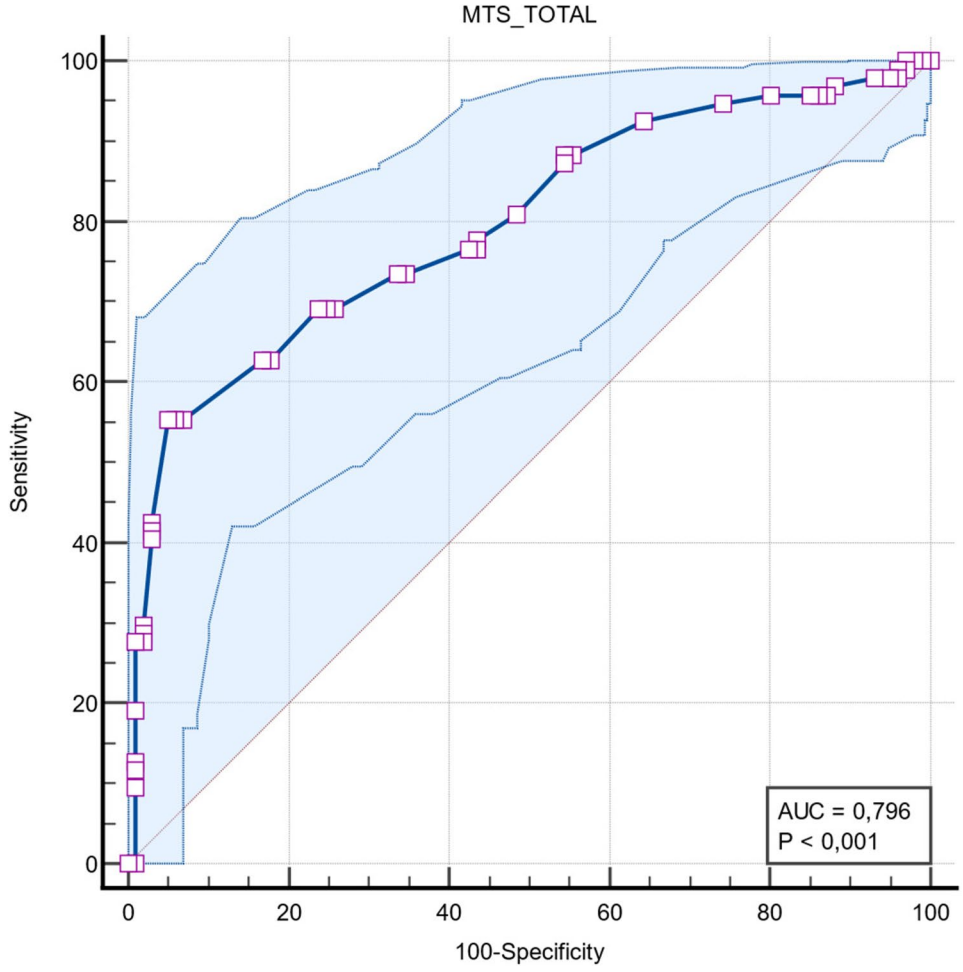

Fig. 2 Receiver Operating Characteristic (ROC) summary for the Mental Toughness Scale total score. The curve displays the trade-off between sensitivity and specificity. The optimal cut-off (≥ 49.5) identified via Youden's J is indicated; AUC = 0.80 (95% CI 0.75–0.85). Abbreviations: AUC = area under the curve

The present ROC findings extend correlation-based evidence by suggesting that an MTS total score above 49.5 is more likely to co-occur with higher general self-efficacy in this sample, a construct repeatedly linked to mental toughness [53]. Although sensitivity was only moderate (≈ 55%), the exceptionally high specificity (≈ 95%) may be useful for exploratory, conservative screening and follow-up contexts where minimizing false positives is prioritized—i.e., avoiding classifying athletes as "high MT" when they may benefit from additional psychological support. Importantly, because general self-efficacy is not a gold-standard criterion for mental toughness and the ROC reference was based on a sample-specific median split, these results should be interpreted as an exploratory decision-utility estimate rather than diagnostic "rule-in" evidence. Recent work on brief screening approaches in sport populations reports comparable cut-off performance, supporting the potential applied relevance of specificity-oriented thresholds [75]. Similar cut-off performance has been observed in independent samples [66, 70], which may indicate that the threshold is relatively robust across datasets; nevertheless, replication using norm-referenced external criteria and/or performance-based indicators, and across sport levels, is warranted.

Additionally, this highlights the MTS's effectiveness in capturing essential aspects of the athlete mindset that predict performance and resilience [56]. Notably, MTS showed a strong association with GSE, echoing evidence that higher perceived efficacy is closely tied to athletes' capacity to cope with and overcome sport-related challenges [1, 76]. Thus, MTS not only contributes to a global measure of MT but offers differentiated information to design targeted interventions in university sport psychology [20, 77].

This study addresses a gap in the literature related to the need for brief instruments—not exceeding 10–15 items—yet robust in structure. While previous research validated the MTS using unidimensional CFA models [25, 34, 36], those studies did not adopt structural-exploratory approaches (ESEM) that allow cross-loadings. Consequently, the evidence compiled here suggests that

MT, as expressed in Chilean university sport, is better represented by at least two related dimensions—Winning Mindset and Preparation Mindset—rather than a strictly unidimensional framework, which may fall short in capturing MT's complexity [30, 31]. Additionally, as a 10-item instrument, the MTS strikes a balance between brevity and precision, supporting feasibility in applied university-sport settings.

In this sense, the labels represent an empirical refinement of how mental toughness is expressed in this sample while remaining consistent with broader theoretical frameworks that conceptualize MT as a constellation of multiple, interrelated psychological resources. Importantly, "Winning Mindset" and "Preparation Mindset" are intended as descriptive headings for ESEM-derived item clusters rather than novel foundational constructs, broadly distinguishing cognitive–affective resources (e.g., confidence and competitive focus) from behavioral/preparatory components (e.g., disciplined practice and persistence). This approach aligns with scale-development and construct-validation principles that emphasize iteratively refining measurement models based on empirical evidence while preserving theoretical coherence [78, 79]. Methodologically, using ESEM can help avoid overly restrictive simple-structure assumptions and can yield more realistic representations of complex constructs, supporting empirically informed refinement of the latent structure [43]. Conceptually, the resulting dimensions remain compatible with contemporary MT scholarship and its nomological network [1].

The nature of MT has been debated for more than two decades [1, 80]. On the one hand, there is a tradition conceptualizing MT as a "general skill" or unidimensional trait [1, 81, 82], while other authors stress its multidimensionality [9, 14, 15, 32]. Attempts to operationalize MT as a multifactorial construct via self-report questionnaires have proven challenging [1, 83]. Nevertheless, our findings support a two-factor solution that aligns with multifactorial frameworks originally proposed by Jones et al. [32, 33] and underscores the value of distinguishing cognitive, behavioral, and attitudinal components when assessing MT. Specifically, Preparation Mindset reflects MT as expressed through tangible behaviors such as disciplined practice, perseverance, and fatigue tolerance, whereas Winning Mindset highlights cognitive–affective elements closely tied to self-efficacy beliefs and perceived competence [67, 76]. This interpretation is also consistent with literature identifying anticipatory readiness and adaptive cognitive appraisals as central aspects of MT [84]. Finally, as some MT attributes may be common across sports while others may be sport-specific, a portion of variance may remain difficult to capture comprehensively with brief multifactorial instruments [84, 85].

From an applied perspective, validating the MTS within Chilean university sport provides a brief and reliable measure to support screening, profiling, and monitoring of mental toughness, helping coaches and sport psychologists to inform targeted support and intervention planning aimed at promoting athletes' performance-related functioning and psychological well-being. In practical terms, the "Winning Mindset" dimension captures a cognitive–affective orientation defined by high self-confidence, focused attention under pressure, and determination in competitive contexts [56, 77], whereas the "Preparation Mindset" emphasizes disciplined effort, perseverance, and sustained commitment to long-term goals through proactive training behaviors as fundamental to developing MT.

Such a two-dimensional approach fosters personalized interventions that accommodate each athlete's diverse needs [86, 87]. Likewise, being a brief instrument, the MTS can be easily integrated into ongoing monitoring or periodic assessments, which simplifies adoption in day-to-day university teams [77].

The validated Chilean version of the MTS may support applied psychological practice within Chilean university sport, including initiatives aligned with FENAUDE's 2023–2026 Strategic Plan, by providing a brief and psychometrically supported measure for screening and monitoring purposes. In addition, the availability of a validated Spanish version may facilitate cross-institutional research collaborations within the Southern Cone and encourage future multicenter studies; however, broader benchmarking efforts and policy-oriented applications (e.g., guideline development) should be pursued cautiously and contingent on additional validation across institutions, sport levels, and countries.

One strength of this study is the use of ESEM, which permits the detection of cross-loadings and a more flexible model than traditional CFA [42]. In addition, our sample spans 10 disciplines, boosting representativeness of Chilean university sport and enhancing the study's credibility [21].

The validation of the MTS within the Chilean university context raises important questions regarding the cross-cultural applicability of this two-factor structure. Our findings reinforce the multidimensional nature of MT, showing partial convergence with the theoretical models advanced by Jones et al. [32, 33]. Cross-cultural sport psychology research suggests that constructs such as pressure tolerance, competitive mindset, and training adherence may vary in meaning or behavioral expression across cultural contexts [80, 88]. Accordingly, future research should test measurement invariance and external validity across Spanish-speaking countries and diverse competitive levels and, where possible, complement quantitative work with qualitative approaches to

contextualize similarities and differences in athletes' lived experiences of MT.

Future research should investigate the MTS's factorial invariance across diverse cultural settings, including Asian, African, and European populations. Such cross-cultural validation studies would determine whether the two-factor structure (Winning Mindset and Preparation Mindset) remains stable or requires cultural adaptations. Additionally, qualitative investigations exploring athletes' lived experiences of MT across cultures could provide valuable contextual understanding to complement quantitative findings.

Among the limitations, we did not examine scale invariance across subgroups (e.g., men vs. women, distinct competitive levels), leaving for future research the confirmation of whether the two-factor structure holds in diverse populations [89, 90]. Items with cross-loadings—3, 4, 7, 8 and 10 —may require further refinement [69]. Nevertheless, these items significantly contribute to their respective principal dimension, and each dimension has enough items to ensure stability and reliability [61, 69]. Moreover, focusing solely on university athletes' limits generalization to other competitive levels or contexts. Finally, testing the MTS's discriminant validity by comparing it with other MT scales or conceptually related constructs is also pertinent to confirm a clear differentiation between variables. Additionally, although a multi-translator and panel-based reconciliation procedure was used, we did not conduct a formal pilot phase (e.g., cognitive interviews) to examine response processes and comprehension prior to data collection. Future studies should incorporate cognitive interviewing/pilot testing to strengthen evidence based on response processes and further optimize item wording.

Future research should explore the MTS's factorial invariance in different samples (for instance, elite, amateur athletes or other performance/labor contexts). It would be beneficial to combine the MTS with measures of competitive stress, coping strategies, self-talk, and objective performance outcomes, thus building a more comprehensive understanding of MT, consistent with recommendations for multidimensional assessment of psychological constructs [91]. Likewise, replicating these analyses in other Latin American countries would ascertain whether the two-factor dimensionality persists and examine cultural influences. Finally, it is recommended to compare the MTS with other instruments (MTI, SMTQ, etc.) with strong psychometric properties, to verify convergences and divergences in measuring MT [80].

Future work should also adopt longitudinal or experimental designs to determine whether targeted mental-toughness training actually modifies MTS scores and, critically, whether such changes translate into improved performance or stress-coping efficiency. Randomized controlled trials that follow athletes over an entire competitive season—similar to the two-year program with elite cricketers reported by Bell et al. [81]—would make it possible to examine both intra-individual change and the temporal stability of mental toughness. Complementary quasi-experimental studies in team-sport settings (e.g., goalkeeper-specific training [92]) could establish ecological validity. Finally, multi-center projects in Latin America might test whether MT interventions produce comparable trajectories across cultural contexts, answering the call for applied longitudinal evidence highlighted in recent meta-analyses.

Overall, this research line advances the personalization of interventions, especially for university sport where academic and competitive demands overlap [20]. Validating the MTS with ESEM methodology represents a step towards clarifying and optimizing MT assessment, with significant implications for performance, well-being, and the broader field of sport and performance psychology across diverse competitive and professional contexts.

Although the present study demonstrates robust factorial validity and reliability for the Spanish-language MTS in Chilean university athletes, these findings should be interpreted as foundational rather than prescriptive. The data confirm the scale's internal structure and its positive correlation with general self-efficacy; however, any practical use — such as selection, athlete monitoring, or psychological intervention — remains hypothetical until effectiveness studies verify that MTS-informed decisions lead to measurable performance or well-being gains. Accordingly, the practical suggestions offered below are presented as informed possibilities rather than direct extensions of the current evidence base.

Conclusion

In summary, this research provides evidence that the MTS is a brief, reliable, and multidimensional instrument for measuring MT, validated via ESEM analysis revealing its two-factor structure. Beyond its demonstrated utility among Chilean university athletes, the MTS holds potential benefits for a broader range of athletes and performance-oriented professionals, spanning from developing or elite competitors to other populations facing competitive or performance demands. Thus, the MTS stands as a valuable tool for sport psychology and performance contexts, fostering interventions directed at both performance enhancement and psychological well-being. It is recommended for future studies and professional practice among coaches, psychologists, and other specialists to maximize the efficacy of mental training in diverse competitive scenarios, while simultaneously reinforcing the empirical foundation of MT in various cultural and linguistic settings.

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Authors' contributions
Juan Pablo Guzmán-Muzante (JPGM): Conceptualization; Investigation; Resources; Project administration; Writing—original draft; Writing—review & editing; Supervision. Carlos Serrano (CS): Methodology; Software; Validation; Formal analysis; Data curation; Visualization; Writing—review & editing. Gonzalo A. Riquelme Ortíz (GRO): Methodology; Software; Validation; Formal analysis; Investigation; Visualization; Writing—review & editing. Antonio Manuel Fonseca (AMF): Conceptualization; Methodology; Supervision; Writing—review & editing; Project administration. Ian Scott Kinney (ISK): Writing—review & editing; Validation. Walter A. Abregú Chesta (WACH): Investigation; Writing—review & editing. Alicia E. Romero Carrasco (ARC): Conceptualization; Writing—review & editing. Pedro Severino-González (PSG): Resources; Writing—review & editing. Cristian Cáceres (CC): Methodology; Formal analysis; Writing—review & editing. All authors approved the final manuscript and agree to be accountable for all aspects of the work.

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Data availability
The de-identified dataset, scoring key, and analysis code will be deposited in an open repository (e.g., Harvard Dataverse) and made publicly available upon acceptance (DOI to be added). During peer review, data and materials are available from the corresponding author on reasonable request; a private repository link can be provided to editors and reviewers upon request.

Declarations

Ethics approval and consent to participate
This study complied with the Declaration of Helsinki and was approved by the Ethics Committee of the Faculty of Sport, University of Porto. All participants were adult student-athletes and provided written informed consent prior to data collection. Supporting documentation is available upon request.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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