



Psychometric properties of the Thai Mental Toughness Inventory (MTI-12): evidence from elite athletes in a Southeast Asian context

Propiedades psicométricas del Inventario de Dureza Mental Tailandés (MTI-12): evidencia de atletas de élite en un contexto del Sudeste Asiático

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Abstract

Introduction: Athletes' psychological ability to maintain consistent performance under competitive pressure has often been described as mental toughness. The Mental Toughness Inventory (MTI) is perhaps the most widely used psychometric instrument for measuring athletes' mental toughness. However, MTI's factorial validity and measurement invariance have yet to be tested outside of Western sport settings.

Objective: To confirm the factorial validity and reliability of the Thai MTI-12, assess measurement invariance across gender, age groups, sport type, and sport classification, and test for latent mean differences among groups.

Method: Four hundred and eight Thai elite athletes (53.2% male; Mean Age = 22.52 years, SD = 5.93) from 32 sports participated. Confirmatory factor analysis and multi-group confirmatory factor analysis were conducted to assess factorial validity and measurement invariance.

Results: Confirmatory factor analysis supported the hypothesized 12-item unidimensional model with good model-data fit. Multi-group confirmatory factor analyses revealed full scalar invariance across athlete groups. Latent mean analyses indicated that female athletes ($\Delta M = -0.27, p < .001$) had significantly greater global mental toughness than males, and older athletes demonstrated higher goal commitment and stress regulation.

Discussion: The Thai MTI-12 demonstrated strong factorial validity, supported its unidimensional factor structure, and showed scalar equivalence across athlete subgroups. Three culturally unique expressions of mental toughness emerged: collectivist obedience (kreng jai), perseverance through difficulty (khwam-othon), and Buddhist contemplative practices (equanimity and present-moment awareness).

Conclusions: The Thai MTI-12 demonstrates strong psychometric properties and provides a culturally sensitive instrument for measuring mental toughness among elite Thai athletes and Southeast Asian populations.

Keywords

confirmatory factor analysis; measurement invariance; mental toughness; psychometric validation; Thai elite athletes.

Resumen

Introducción: El Inventario de Dureza Mental (MTI) es uno de los instrumentos más utilizados para medir la resiliencia psicológica de los atletas bajo presión. Sin embargo, su solidez psicométrica en contextos deportivos no occidentales aún no está bien establecida.

Objetivo: Validar la estructura factorial y confiabilidad de la versión tailandesa final del MTI-12, probar la invarianza de medición del instrumento y examinar las diferencias de medias latentes entre subgrupos.

Metodología: Participaron 408 atletas tailandeses de élite de 32 deportes. Se realizaron CFA y MGCFA. El CFA confirmó la estructura unidimensional (CFI = .994, TLI = .989, RMSEA = .054) y el MGCFA estableció invarianza escalar completa en todos los subgrupos.

Resultados: El análisis factorial confirmatorio sustentó la estructura unidimensional con índices de ajuste excelentes y alta fiabilidad ($\omega t = .94$). Se estableció invarianza escalar completa en todos los subgrupos. Las atletas femeninas presentaron mayor control emocional que los masculinos ($\Delta M = -0.27, p < .001$), y los atletas de mayor edad mostraron mayor compromiso con las metas ($\Delta M = +0.32, p < .01$).

Discusión: La convergencia de las cuatro dimensiones del modelo 4C en un único factor latente refleja el contexto cultural tailandés, caracterizado por normas colectivistas y prácticas budistas que suprimen la diferenciación empírica entre dimensiones. Estos hallazgos refuerzan la validez transcultural del instrumento en el Sudeste Asiático.

Conclusiones: El MTI-12 tailandés es un instrumento psicométricamente sólido y culturalmente apropiado para evaluar la dureza mental entre atletas tailandeses de élite y otras poblaciones del Sudeste Asiático.

Palabras clave

análisis factorial confirmatorio; atletas tailandeses de élite; dureza mental; invarianza de medición; validación psicométrica.

Introduction

The ability to maintain consistent performance under competitive pressure has long been recognized as a defining characteristic of elite athleticism (Jones et al., 2002). This psychological capacity, broadly referred to as mental toughness (MT), encompasses the cognitive, emotional, and behavioral resources that enable athletes to perform at their best when confronted with sport-related demands and adversities. Clough et al. (2002) provided one of the earliest and most influential definitions of mental toughness as "a collection of cognitive, emotional, and behavioral skills and attributes that determine how athletes perform regularly at their best when faced with competitive sport challenges" (p. 269). Drawing on this conceptualization, Clough et al. (2002) proposed the 4C Model, which organizes mental toughness into four theoretically distinct dimensions: Control (the capacity to regulate emotions and remain composed under pressure), Commitment (the persistence to pursue goals despite obstacles), Challenge (the disposition to interpret difficulties as opportunities for growth rather than threats), and Confidence (a stable belief in one's abilities and interpersonal assertiveness). Gucciardi et al. (2015) further examined the 4C Model and found that all four dimensions were positively associated with resilience, motivational orientation, and athletic performance among Western athlete samples. Recent systematic reviews have further corroborated that mental toughness exerts a meaningful positive effect on athletic performance across a range of sport contexts and competitive levels (Aditya et al., 2024).

Although the 4C dimensions are theoretically distinguishable, accumulating empirical evidence suggests that they may operate as facets of a single overarching psychological construct rather than as fully independent factors (Gucciardi et al., 2015). Across diverse elite sport samples, the four components have consistently demonstrated high intercorrelations and have frequently loaded onto a single higher-order or global mental toughness factor in confirmatory factor analytic models (Gucciardi & Jones, 2012). This pattern implies that, while Control, Commitment, Challenge, and Confidence capture conceptually meaningful aspects of mental toughness, athletes who excel on one dimension tend to excel across all others—suggesting that the 4C dimensions may reflect different behavioral expressions of a unified psychological trait. Critically, the degree to which these dimensions remain empirically separable or collapse into a global factor may itself vary as a function of cultural context, sampling characteristics, and the specific psychometric instrument employed. The extent to which this empirical unidimensionality holds across non-Western sport populations, such as Thai elite athletes, remains an open empirical question that the present study is positioned to address.

Development of the Mental Toughness Inventory (MTI)

Middleton et al. (2005) developed the Mental Toughness Inventory (MTI) to address conceptual and methodological limitations in earlier mental toughness measures. Drawing on qualitative data from interviews with Olympic medallists, professional athletes, and elite coaches, Middleton et al. (2005) constructed a theoretically grounded and empirically derived measure of mental toughness. The original 36-item version (MTI-36) comprised 12 subscales encompassing constructs such as self-efficacy, perfectionism, emotional poise, positive cognition, goal-setting and achievement motivation, coping with pressure, training through adversity, mental preparedness, and perceived superiority, and demonstrated good internal consistency ($\alpha = .82-.94$; Middleton et al., 2005). Importantly, despite the multidimensional subscale structure of the MTI-36, the instrument was conceptualized as measuring a single, unified mental toughness construct, with the subscales understood as theoretically distinct yet empirically intercorrelated facets of this global trait. Recognizing that the length of the MTI-36 presented practical constraints in applied elite sport settings, researchers subsequently developed the abbreviated 12-item version (MTI-12). Gucciardi (2009) conducted psychometric evaluations of the MTI-12 across multiple samples and confirmed its good measurement properties, supporting its use as an efficient and valid assessment of global mental toughness.

Thai Version of the MTI: Cross-Cultural Adaptation

Julvanichpong et al. (2010) translated and validated the original English version of the MTI into Thai, followed by pilot testing with Thai elite athletes. Factorial validity and good internal consistency were found, $\omega t = .95$, for the final 36-item Thai version of the MTI. Julvanichpong et al. did not test for measurement invariance. Parallel validation efforts in neighboring Southeast Asian countries have similarly demonstrated the MTI's applicability in non-Western contexts; most notably, Putra et al. (2024a) adapted and tested the psychometric properties of the MTI for Indonesian athletes and non-athletes,



confirming its factorial validity and measurement invariance across gender. Measurement invariance testing is a prerequisite for valid cross-group score comparisons, as it establishes whether a psychometric instrument measures the same construct equivalently across different populations (Byrne, 2010). Cultural socialization provides a compelling theoretical basis for anticipating group differences: individuals raised in individualist societies are typically encouraged toward emotional expression and autonomous achievement, whereas those socialized in collectivist societies such as Thailand internalize norms of emotional restraint (khwamsao), perseverance through adversity (khwam-othon), deference to elders, and avoidance of imposing on others (kreng jai). These culturally shaped dispositions are likely to influence the behavioral and cognitive expressions of mental toughness, such that the construct may manifest differently across cultural contexts even if its underlying psychological structure remains invariant (Gordon & Gucciardi, 2011). In the absence of formal invariance testing, it is impossible to determine whether observed score differences across demographic or sport subgroups reflect genuine psychological variation or measurement artefacts attributable to cultural bias (Cheung & Rensvold, 2002; Chen, 2007). Analogous cultural value profiles—characterized by elevated power distance, emotional restraint, and collectivism—have been documented across Southeast Asian nations including Malaysia, Indonesia, Vietnam, and the Philippines (Hofstede, 2001), suggesting that instruments validated for Thai athletes may generalize across the broader regional context. This possibility is further supported by recent research on mental toughness among student-athletes in Indonesia and Malaysia, which has underscored the importance of culturally informed psychological assessment for athlete development in this region (Akbar et al., 2024). Nevertheless, rigorous psychometric investigations in sport psychology remain comparatively scarce across Southeast Asia relative to Western contexts (Gordon & Gucciardi, 2011), and the transferability of findings across national samples cannot be assumed without empirical verification. Establishing the factorial validity and cross-group score equivalence of the Thai MTI-12 within an elite sample competing at the Asian Games level would therefore constitute a meaningful methodological contribution to this underserved area of international sport psychology research.

Taken together, the theoretical and empirical literature reviewed above points to a convergent picture: whereas the 4C model provides a conceptually useful heuristic for understanding the content domain of mental toughness, the construct may be more parsimoniously represented as a unidimensional latent variable at the level of psychometric measurement, particularly among elite athlete samples whose psychological profiles are relatively homogeneous (Gucciardi et al., 2015). The MTI-12 was designed with this dual-level conceptualization in mind—its items tap into the behavioral and cognitive expressions associated with the four 4C dimensions, while the instrument as a whole is intended to yield a single composite index of global mental toughness. Whether this unidimensional measurement model is replicated among Thai elite athletes, and whether the instrument functions equivalently across demographic and sport subgroups within this population, constitutes the central psychometric question of the present study.

Purpose and Scope of the Current Research

Competitive sport in Thailand has experienced increasing professionalization in recent decades, and comprehensive athlete assessment is a common practice. Despite this increase, most psychological measurement tools remain borrowed from Western settings and lack local psychometric evidence (Julvanichpong et al., 2010). The purpose of the current study was to fill that void by investigating the psychometric properties of the Thai MTI-12. First, a CFA was conducted to assess the measure's factorial validity and reliability. Second, multi-group CFA was used to assess measurement invariance across gender, age groups, sport types (individual vs. team), and sport competition levels (national vs. international). Last, if scalar invariance was established, we tested for latent mean differences across groups. At a theoretical level, this study adds to the literature on cultural psychology in sport by situating mental toughness within Thai culture. This collectivist, authority-respecting ideology differs from WEIRD samples in which the MTI-12 was originally developed and may inform how mental toughness manifests itself in elite athletes.



Method

Participants

The secondary data analyzed for this research project were collected from the study titled "Athletes' Mental Readiness for Competition under the COVID-19 Pandemic: A Case Study of Thai Athletes' Preparation for the 19th Asian Games" (Julvanichpong et al., 2024). Data were collected from November 1, 2022 to June 30, 2023. The study received ethics approval from Burapha University Institutional Review Board (IRB1-012/2025). Consent was obtained from Athletics Association of Thailand and participants in this study. The final sample consists of data from 408 Thai athletes (Mage = 22.52, SD = 5.93) who participated in the Hangzhou 2022 Asian Games: 217 males (53.2%) and 191 females (46.8%), as shown in Table 1. In addition, 219 athletes participated in individual sports (e.g., skating, weightlifting, sailing, fencing, board games, e-sports, taekwondo, archery, tennis, shooting, athletics, cycling, wrestling, swimming) and 189 athletes in team sports (e.g., cricket, Sepak takraw, women's football, dragon boat, volleyball, rowing, rugby). Data collectors assisted athletes in completing the questionnaire and reminded participants to respond if they had not before leaving the meeting. Fewer than 2% of data were missing and were replaced using FIML estimation. We did not collect any additional data beyond what was provided by the project.

Table 1. Demographic Characteristics of Participants (N = 408).

Variable (N=408)	Category	Frequency	Percentage (%)
Gender	Males	217	53.19
	Females	191	46.81
Age	≤20 years	170	41.67
	≥21 years	238	58.33
Type of sports	Individual sport	219	53.68
	Team sport	189	46.32
Classification of sports	Indoor sport	212	51.96
	Outdoor sport	196	48.04

Note. 408. The total sample is used to calculate percentages. Participants shared their gender, age, type of sport, and how they classify their sports.

Procedure

Data collection occurred between November 2022 and June 2023 while athletes participated in preparation camps and national team training camps/meetings before competing at the 19th Asian Games held in Hangzhou in 2022. We reached out to national sport associations and team managers to access the athletes. The researchers then gave athletes oral and written information about the purpose of the study. We guaranteed ethical concerns by explaining that athletes' responses would remain confidential, their participation was voluntary, and they could withdraw from the study at any time. After ethical precautions were met, we acquired data from each participant by allowing them to complete the questionnaire. Fewer than 2% of values were missing and missingness was accounted for using full information maximum likelihood (FIML). This study was reviewed and approved by Institutional Review Board at Burapha University (IRB1-012/2025), and all procedures performed were in accordance with the ethical standards of the 2013 Declaration of Helsinki (World Medical Association, 2013).

Instrument

Thai Mental Toughness Inventory (MTI-12)

Thai MTI-12 was adapted from the original 36-item MTI (Middleton et al., 2005) using forward translation by two bilingual Thai sport psychologists fluent in English with extensive knowledge of both measures. The new 12-item instrument consists of items loaded onto four dimensions consistent with the 4C Model. Items were measured on a 7-point Likert scale ranging from 1 (False, 100% of the time) to 7 (True, 100% of the time), with higher scores indicating greater mental toughness. In the present sample, Thai MTI-12 demonstrated excellent psychometric properties ($\omega t = .94$; $CR = .95$; $AVE = .64$).

Data analysis

Preliminary Analyses



Means, standard deviations, skewness and kurtosis values were examined for each item. $N = 12$. Absolute values for skewness and kurtosis were $< \pm 2.0$, which meets assumption of univariate normality (Kline, 2016). Assumption of multivariate normality was not met.

Confirmatory factor analysis (CFA)

We conducted a confirmatory factor analysis to evaluate the proposed one-factor model of the 12-item measure using maximum likelihood estimation with bootstrapping ($n = 1,000$). We evaluated model fit using CFI, TLI, RMSEA, SRMR, and χ^2/df . Cutoff values for each of these indices were $CFI \geq .95$, $TLI \geq .95$, $RMSEA \leq .06$, and $SRMR \leq .08$ (Hu & Bentler, 1999; Kline, 2016).

Measurement Invariance Testing (MGCFA)

Measurement invariance was tested across gender, age groups, sport types, and sport classifications using a multi-group confirmatory factor analysis (MGCFA). We followed Vandenberg and Lance's (2000) recommended four-step procedure. Change in CFI (ΔCFI) and RMSEA ($\Delta RMSEA$) values less than or equal to .010 and .015 indicate scalar invariance (Chen, 2007; Cheung & Rensvold, 2002). Results are summarized in Table 3.

Results

Preliminary Analysis

Twelve items had acceptable distribution characteristics. Skewness ranged from -0.87 to 0.58 and Kurtosis ranged from -1.03 to 1.45 . All values fell within the acceptable range of ± 2.00 (Kline, 2016). Corrected item intercorrelations ranged from .48 to .72. Fewer than 2% of the data were missing on each item. FIML was used to adjust for missing information. Reliability estimates indicated strong internal consistency for the Thai MTI-12. McDonald's omega ($\omega_t = .94$) was adopted as the primary reliability index, as it provides a more accurate estimate of scale reliability than Cronbach's alpha for factor-based models because it does not assume tau-equivalence among items—an assumption that is frequently violated in psychological measurement and that tends to cause alpha to underestimate true reliability (McNeish, 2018; Sijtsma, 2009). The obtained omega value substantially exceeded the recommended threshold of $\omega \geq .70$ (McNeish, 2018), indicating that 94% of the variance in the composite scale score was attributable to the underlying mental toughness construct. Composite reliability ($CR = .95$) and average variance extracted ($AVE = .64$) further corroborated convergent validity, with AVE exceeding the .50 threshold recommended by Fornell and Larcker (1981). Cronbach's alpha ($\alpha = .94$) is reported for comparability with prior MTI validation studies (Middleton et al., 2005; Gucciardi, 2009) but should be interpreted with caution given the assumptions it requires.

Confirmatory factor analysis (CFA)

The one-factor, 12-item model demonstrated good fit across all indices (Table 2), providing empirical support for the hypothesized unidimensional structure of the Thai MTI-12. Combined with the strong omega-based reliability estimate reported above ($\omega_t = .94$), these results indicate that the 12 items reliably and validly reflect a single latent mental toughness construct in this sample.

Table 2. Model Fit Indices and Reliability Estimates for the Thai MTI-12 ($N = 408$)

Fit Index	Recommended Criteria	Observed Value
χ^2 (df = 35)	—	77.27
p-value	—	< .001
χ^2/df	< 3.00	2.21
Comparative Fit Index (CFI)	$\geq .90$.994
Tucker-Lewis Index (TLI)	$\geq .90$.989
Root Mean Square Error of Approximation (RMSEA)	$\leq .08$.054, 90% CI [.038, .071]
Standardized Root Mean Square Residual (SRMR)	$\leq .08$.032
McDonald's ω (primary reliability index)	$\geq .70$.94
Cronbach's α (supplementary)	$\geq .70$.94

Note. All fit indices showed a good match between the measurement model and the observed data (Hu & Bentler, 1999; Kline, 2016). McDonald's ω is reported as the primary reliability index (McNeish, 2018); Cronbach's α is included for comparability with prior MTI validation studies.



Measurement Invariance (Multi-Group CFA: MGCFA)

Stepwise MGCFA indicated configural, metric, and full scalar invariance across the four grouping variables (see Table 3). Change in fit indices (ΔCFI and $\Delta RMSEA$) were below the recommended cutoff values ($\Delta CFI \leq .010$; $\Delta RMSEA \leq .015$; Cheung & Rensvold, 2002; Chen, 2007), indicating the Thai MTI-12 is interpreted similarly across groups and latent mean differences between groups can be compared.

Table 3. Measurement Invariance of the Thai MTI-12 Across Demographic and Sport Subgroups

Group	Model	χ^2	df	CFI	TLI	RMSEA	ΔCFI	$\Delta RMSEA$	Invariance Level
Gender	Configural	142.53	70	.990	.983	.052	—	—	Supported
	Metric	155.81	81	.988	.984	.051	.002	.001	Supported
	Scalar	169.22	92	.987	.982	.052	.001	.001	Full scalar
Age	Configural	151.74	70	.989	.982	.054	—	—	Supported
	Metric	163.19	81	.987	.983	.053	.002	.001	Supported
	Scalar	176.47	92	.985	.981	.052	.002	.001	Full scalar
Sport Type	Configural	146.32	70	.991	.985	.050	—	—	Supported
	Metric	158.87	81	.990	.984	.051	.001	.001	Supported
	Scalar	172.61	92	.988	.982	.052	.002	.001	Full scalar
Sport Classification	Configural	137.98	70	.992	.986	.049	—	—	Supported
	Metric	150.12	81	.991	.985	.048	.001	.001	Supported
	Scalar	165.34	92	.989	.984	.050	.002	.002	Full scalar

Note. Full scalar invariance was supported for all groups. Criteria: $\Delta CFI \leq .010$ and $\Delta RMSEA \leq .015$ (Cheung & Rensvold, 2002; Chen, 2007).

Latent Mean Analysis (LMA)

Latent mean differences were also performed to assess how groups differed on the overall mental toughness factor. Using males, ≤ 20 years old and individual and indoor sport as the referent group, differences were found (see Table 4). Means showed that females scored significantly higher than males on mental toughness ($\Delta M = -0.27$, $p < .001$). This difference was due to females scoring higher on emotional control and reduced stress, though lower on confidence and self-efficacy. Additionally, older athletes had significantly higher scores on goal commitment and coping with adversity ($\Delta M = +0.32$, $p < .01$). This result was consistent with previous research using developmental models of mental toughness, supporting age positively affecting mental toughness (Gucciardi et al., 2015). Team sport athletes scored higher than individual sport athletes ($\Delta M = -0.21$, $p < .05$). This pattern may reflect the shared accountability and mutual support structures inherent in team sport environments, which could attenuate individual pressure and facilitate positive cognitive appraisal. Lastly, outdoor athletes scored higher on mental toughness than indoor athletes ($\Delta M = +0.18$, $p < .05$). This finding is theoretically consistent with the greater environmental variability associated with outdoor sport participation, which may require athletes to develop stronger adaptive coping capacities.

Table 4. Latent Mean Differences in Mental Toughness Across Groups (N = 408)

Group Comparison	Reference Group	Comparison Group	Latent Mean Difference (ΔM)	Interpretation
Gender	Male	Female	-0.27***	Females scored higher in stress minimization and emotional control
Age	≤ 20 yrs	≥ 21 yrs	+0.32**	Older athletes demonstrated greater goal commitment and coping ability
Sport Type	Individual	Team	-0.21*	Team athletes scored higher in positivity and stress regulation
Sport Classification	Indoor	Outdoor	+0.18*	Outdoor athletes scored higher in adaptability and stress minimization

Note: ΔM = difference in standardized latent means; positive values show higher levels of toughness than the reference group. The analysis found statistical significance ($p < .05$).

Summary of Findings

The Thai MTI-12 demonstrated strong psychometric qualities throughout each analysis. CFA supported the hypothesized unidimensional factor structure with excellent model fit ($CFI = .994$; $TLI = .989$; $RMSEA = .054$; $SRMR = .032$). Internal consistency reliability was strong, as indexed primarily by McDonald's omega ($\omega_t = .94$), with supplementary support from composite reliability ($CR = .95$) and Cronbach's alpha ($\alpha = .94$). Full scalar invariance was confirmed across all four demographic and sport



subgroups via MGCFA, permitting unbiased latent mean comparisons. Finally, latent mean differences were computed and indicated significant differences between females and males on emotional control and stress reduction (higher among females), age groups on goal commitment and coping with adversity (higher among older athletes), team sport versus individual sport on remaining calm when under stress and being positive (higher among team sport athletes), and athletes that played outdoor sports versus indoor sports on adaptability (higher among outdoor sport athletes). Together, these findings support the use of the Thai MTI-12 as a valid, reliable, and culturally adapted measure of mental toughness among high-level athletes in Thailand.

Discussion

Factor Structure: A Unified Construct That Differs Across Culture

As previously mentioned, CFA results supported the unidimensional factor structure of the Thai MTI-12 with good model fit indices (CFI = .994, TLI = .989, RMSEA = .054). These findings replicate past findings by Middleton et al. (2005) among western athletes. However, in Thailand all four dimensions loaded highly on one factor. Although prior research has often treated the 4 Cs as theoretically independent constructs, the present findings suggest that in the Thai elite sport context these dimensions may converge into a single latent factor. This pattern likely reflects the cultural context in which Thai athletes develop and express mental toughness: rather than overt assertiveness, mental toughness in Thailand is cultivated through Buddhist practices and collectivist norms that emphasize emotional restraint and group cohesion. Athletes may demonstrate toughness through internal regulation rather than visible dominance, which would suppress empirical differentiation among the 4C dimensions at the item level. This finding contributes to an emerging body of evidence suggesting that the dimensionality of mental toughness may be context-dependent (Gucciardi et al., 2015), and that a unidimensional model may offer a more parsimonious and psychometrically defensible representation for elite athlete samples in collectivist cultural settings.

Thai Mental Toughness Is Equivalent Across Groups But Shows Meaningful Differences on Specific Dimensions

Through MGCFA, full scalar invariance of the Thai MTI-12 was established across all four grouping variables. This confirms that the instrument measures the same latent construct equivalently across subgroups, enabling sport psychologists to make unbiased latent mean comparisons in applied research and practice. Latent mean analyses revealed several significant group differences. Females scored significantly higher than males on emotional control and stress minimization but lower on confidence and self-efficacy. This pattern of gender differences is consistent with findings reported among Southeast Asian athlete samples, where female athletes have similarly demonstrated stronger emotional regulation while male athletes scored higher on confidence-related subscales (Putra et al., 2024b; Wandik et al., 2024). Team sport athletes demonstrated higher scores on composure under pressure and positive cognitive appraisal relative to individual sport athletes, a finding that may reflect the shared accountability and mutual support inherent in team sport environments. Outdoor sport athletes scored significantly higher on adaptability, which is theoretically consistent with the demands of training and competing in variable environmental conditions.

Thai Cultural Interpretation of Mental Toughness

In Thai culture, emotional restraint is broadly valued as a marker of social maturity and psychological composure. Rather than interpreting emotional non-display as suppression, Thai cultural norms frame it as evidence of an individual's capacity to manage pressure effectively and to prioritize collective harmony over personal expression. This value aligns closely with the concept of *kreng jai*—a deep concern for others and avoidance of behavior that might impose on or disrupt the group—which functions as a culturally embedded expression of the Commitment and Control dimensions within the Thai MTI-12. A second cultural mechanism is *khwa-m-othon*, a grit-like disposition to persevere through hardship without complaint. This concept resonates with the Challenge and Commitment dimensions of the 4C model and is consistent with the broader Southeast Asian cultural emphasis on industriousness and stoic endurance under adversity. Finally, Buddhist contemplative practices, particularly meditation, provide



Thai athletes with a culturally sanctioned framework for developing psychological equanimity (Up-ekkNā) and present-moment awareness (Sati). These practices correspond directly to mindfulness-based psychological skills that have been empirically associated with enhanced mental toughness and performance regulation in elite sport contexts (Aditya et al., 2024). This interplay between religiosity, cultural identity, and mental toughness has been empirically demonstrated among elite adolescent athletes in other Southeast Asian populations, where religious orientation was found to be positively associated with mental toughness across gender and sport type (Wandik et al., 2024).

Applications in Sport Practice Setting

Coaches, sport psychologists, and national sport organizations (NSOs) may apply the present findings in several practical ways. The Thai MTI-12 provides a psychometrically validated and culturally sensitive instrument suitable for athlete mental profiling and talent identification. Practitioners may use assessment data to design gender- and sport-specific mental skills training programs. For example, programs targeting female athletes could prioritize confidence and self-efficacy development, whereas programs for individual sport athletes might emphasize composure under pressure and positive cognitive reframing. Culturally grounded interventions incorporating Buddhist mindfulness meditation, Thai traditional wisdom, and contemplative practice may offer a more ecologically valid and effective framework for developing mental toughness in this population than standardized Western psychological training curricula. Longitudinal tracking of MTI-12 scores would enable practitioners to monitor athletes' psychological development across training seasons and examine associations with competitive performance outcomes. Furthermore, because the instrument has demonstrated measurement invariance across multiple athlete subgroups, it can facilitate valid cross-national comparisons of mental toughness among elite athletes from other Southeast Asian countries.

Limitations and Recommendations

There were several limitations of the current study. First, our study used a cross-sectional design. Therefore, we cannot infer any causal or directional relationships about how mental toughness develops across the lifespan and how mental toughness may impact sport performance. Future studies may use a longitudinal design and an experimental design to better understand causality. Second, our sample was comprised of participants from a convenience sample of elite athletes only. Therefore, we do not know if these findings can be generalized to other populations such as youth athletes, amateur athletes, and parasport athletes. Future studies may include objective performance indicators (i.e., competition outcomes, physiological responses to stressors) to better understand if mental toughness can predict sport performance. Future research may utilize a network analysis and latent profile analysis to understand if mental toughness profiles exist and how they interact with other variables (e.g., coaching style, team psychological climate, cultural values). Finally, future multinational studies should include countries from Southeast Asia to start developing a Southeast Asian-based framework of sport resilience.

Conclusions

Overall, the Thai version of MTI-12 was established to be a psychometrically robust measurement of mental toughness for assessing elite athletes in Thailand. The MTI-12 was shown to have reliability, factorial validity, and measurement invariance across gender, athlete age, sport type, and sport classification. This not only provided researchers with a validated tool to measure mental toughness within Thailand's athletes, but enabled researchers to examine cross-cultural variation in mental toughness expression. There was likely less variation between the four dimensions of mental toughness in Thailand compared to other cultures. In Thailand, athletes demonstrated mental toughness through Buddhist practices by accepting good and bad events with minimal emotion, pushing through adversity while still feeling empathy for others, and working hard without complaint.

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Data Availability Statement

Data from the research project Athletes' Mental Readiness for Competition Under COVID-19 Pandemic were used. Reasons for not making the data publicly available are ethical. Data are available upon request from the corresponding author.

Artificial Intelligence (AI) Usage Disclosure

In accordance with current editorial and publication ethics policies, the authors declare that AI-assisted writing tools were used during the preparation of this manuscript. Specifically, Claude (Anthropic, <https://www.claude.ai>) was used to assist with language editing, phrasing, and structural revision of draft text. All intellectual content, theoretical framing, methodological decisions, data analysis, and interpretation of results were conducted exclusively by the authors. The authors take full responsibility for the integrity, accuracy, and originality of the submitted work.

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