MID05310

Developing a Test for Mental Toughness: The Mental Toughness Inventory (MTI)

Simon C. Middleton, Herb W. Marsh, Andrew J. Martin, Garry E. Richards, and Clark Perry
SELF Research Centre, University of Western Sydney, Australia

The Mental Toughness Inventory (MTI) is a 67-item self-report paper and pencil test that assesses 12 characteristics of mental toughness (self-efficacy, potential, mental self-concept, task familiarity, value, personal bests, goal commitment, perseverance, task focus, positivity, stress minimisation, and positive comparisons) along with one global mental toughness factor (Middleton et al., 2004a). The purposes of the current study were to (a) refine the size of the MTI whilst maintaining its strong psychometric properties, and (b) assess the equivalence of the MTI factor structure across sub-elite to elite athletes. The MTI was administered to 438 aspiring elite athletes (aged 12 to 18 years) based at an elite sports high school along with 292 elite athletes (aged 11 to 38 years) from various institutes of sport around Australia (including the Australian, NSW and WA Institute of Sport, NSW and WA Institute of Sports, ACT Academy of Sport, Australian Rugby Union Wallabies, and Australian Cricket). A series of confirmatory factor analyses (CFA) produced a 36-item MTI measuring all 12 factors of mental toughness. The reliability coefficients for each of the factors ranged from .82 to .94 across both sub-elite and elite athlete samples Goodness of fit for the CFA was good for each sample individually, but also multi-group CFA proved the MTI factor structure to be stable across both groups.

This research aimed to refine the already developed Mental Toughness Inventory (MTI) and to assess its psychometric properties across sub-elite to elite athletes. Earlier qualitative research defined mental toughness as an unshakeable perseverance and conviction towards some goal despite pressure or adversity (Middleton, Marsh, Martin, Richards & Perry, in press, 2004b). The authors also identified a 12 factor model of mental toughness. This 12 factor model was utilised to guide the development of the Mental Toughness Inventory (MTI; see Middleton et al., 2004a), producing a 67-item MTI specifically designed to measure twelve components of mental toughness (Self-Efficacy, Future Potential, Mental Self-Concept, Task Familiarity, Value, Personal Best Motivation, Goal Commitment, Task Specific Attention, Perseverance, Positivity, Positive Comparisons, Stress Minimisation) along with one global mental toughness factor. This 67-item MTI was piloted with 438 athletes enrolled at an elite sports high school in Sydney (Age range= 12-19 years, mean= 14.29, SD= 1.54 years) and also with 292 elite athletes from various institutes of sport such as the Australian Institute of Sport and the Australian Rugby Union team the Wallabies (Age range= 11-38, mean= 18.55, SD= 4.48 years). Analysis revealed reliability coefficients for each of the factors ranging from .82 to .94 and acceptable goodness of fit for the confirmatory factor analysis. The current study seeks to further refine the number of items whilst maintaining the instrument's strong psychometric properties. The current study also seeks to evaluate the equivalence of the MTI as a test of mental toughness across different athlete samples (such as elite and sub-elite athletes).

An Historical Perspective

In early work on mental toughness, Loehr (1982, 1986) emphasised that athletes and coaches felt that at least fifty percent of success is due to psychological factors that reflect mental toughness. Similarly, Gould, Hodge, Peterson, and Petlichkoff (1987) emphasised that coaches feel that mental toughness is important in achieving success, while Norris (1999) has emphasised the importance of mental toughness in developing champion athletes.

Despite widespread agreement on the importance and benefits of mental toughness (Goldberg, 1998; Hodge, 1994; Jones, Hanton, & Connaughton, 2002; Loehr, 1982, 1986) and calls to identify psychological attributes that create champions, high quality research into mental toughness is limited. Recently, Middleton et al. (2004c) completed a series of in-depth qualitative interviews, drawing on the experience of elite athletes and coaches to unearth a conceptualisation and definition of mental toughness. The interviews of 33 elite athletes and coaches (including 25 current or former elite athletes, of whom 15 had achieved an Olympic Gold Medal or World Champion status) were transcribed verbatim and analysed qualitatively to reveal underpinning components of mental toughness. Components of mental toughness were allowed to emerge from the interview data, whilst the interpretation of these components was guided by relevant theory. The strength of this approach to data analysis is that it allows the researcher to benefit from both qualitative experience and established sources of theory. The results indicated that mental toughness is multi-dimensional and consists of twelve components, including: self-efficacy, potential, mental self-concept, task familiarity, value, personal bests, goal commitment, perseverance, task focus, positivity, stress minimisation, and positive comparisons. Mental toughness was defined as *an unshakeable perseverance and conviction towards some goal despite pressure or adversity*. The researchers foreshadowed the development of the Mental Toughness Inventory (MTI) based on their conceptualisation of mental toughness.

The predecessor to the Middleton et al (2004c) research was the work done by Jones, Hanton and Connaughton (2002). They too conducted a qualitative study of elite athletes, aiming to define mental toughness and to determine the essential attributes required to be a mentally tough performer. The definition that emerged from their analysis concluded that:

> *Mental toughness is having the natural or developed psychological edge that enables you to:*
> *1) Generally, cope better than your opponents with the many demands (competition, training, lifestyle) that sport places on a performer; and,*
> *2) Specifically, be more consistent and better than your opponents in remaining determined, focused, confident, and in control under pressure (p. 209).*

They also identified twelve attributes as keys to mental toughness. These included attributes such as self-belief, an unshakeable focus, high levels of desire and determination (especially at times of distress), and overall consistency of effort and technique despite life and sport stresses.

In another qualitative study into mental toughness, Fourie and Potgieter (2001) analysed written responses from 131 expert coaches and 160 elite athletes. Their analysis identified twelve components of mental toughness including: motivation level, coping skills, confidence maintenance, cognitive skill, discipline and goal directedness, competitiveness, possession of prerequisite physical and mental requirements, team unity, preparation skills, psychological hardiness, and ethics. In contrast to Jones et al. (2002), the researchers did not propose a definition but instead suggested that further work was needed to finalise a working definition of mental toughness.

A Measure of Mental Toughness

Until recently, there has been difficulty in developing a suitable measure of mental toughness. This goal has been significantly undermined by the absence of an operational definition and conceptual model of mental toughness. Middleton et al's (2004) definition and conceptual model of mental toughness provide a significant opportunity to advance the field.

In professional practice, Loehr's Psychological Performance Inventory (PPI – 1986) was probably one of the earliest tests of mental toughness. Loehr published the PPI in his classic book on mental toughness (1986) and claimed that the instrument measured the seven most important psychological factors that reflect mental toughness: self-confidence, negative energy, attention control, visual and imagery control, motivation, positive energy, and attitude control. Although Loehr offered an intuitively and conceptually appealing discussion of the instrument, he presented no psychometric support for its use.

Middleton et al (2004c) evaluated the construct validity of responses to Loehr's (1986) mental toughness test, the Psychological Performance Inventory (PPI), by 263 student-athletes from an elite sports high school. As confirmatory factor analysis (CFA) yielded poor model fit and an improper solution for the *a priori* model, exploratory factor analysis was carried out using all the original PPI items. Item deletion and exploration of three through to ten alternative factor structures yielded a five-factor model that fitted the data well. Whereas the alternative structure yielded a much better model fit than the original PPI structure, further analyses showed that a variety of key correlates of mental toughness were more strongly correlated with the factors based on the original structure than factors based on the alternative structure. In conclusion, neither the original PPI nor the subset of PPI items in the better-fitting alternative model were sound measures of mental toughness. Good instrumentation must be strong in terms of conceptual/theoretical considerations, psychometric properties, *and* relationships to key correlates hypothesised to be meaningfully related to it.

Middleton et al's (2004b) conceptualisation and definition of mental toughness provided a reasonable platform from which develop the MTI. Based on their model, a large pool of items was developed to measure the twelve components of mental toughness along with a global mental toughness scale. The model of mental toughness offered by Middleton et al., and the pool of items designed to measure that model, formed the basis of the MTI. Given that mental toughness has broad relevance (i.e., sport, education, business, military), the MTI was developed in a way that can be easily translated into different performance environments, even though the evaluation of this generalisability is beyond the scope of this current investigation. Middleton et al. (2004a) piloted the MTI with a large representative sample of athletes to refine, and test the instrument (i.e., reliabilities, confirm factor structure). Results were good, yielding reliabilities for each of the factors ranging from .87 to .95 and acceptable goodness of fit with confirmatory factor analysis.

A Construct Validation Approach

There now exists general agreement among sport and exercise psychology researchers for the need to develop sports psychology instruments that are relevant to sport settings (rather than to adopt general instruments from other areas of research) and to evaluate them within a construct validity framework (Gill, Dzewaltowski, & Deeter, 1988; Marsh, 1997; 2002; Ostrow, 1996). A construct validation approach to the development of instruments is based on theory, followed by item and reliability analysis, exploratory and confirmatory factor analysis, tests of convergent and divergent validity, validation in relation to external criteria, and application in research and practice. The availability of measures in the sport and exercise research that meet these ideals is limited. Thus there remains a need for: (a) more carefully developed instruments, (b) better articulation of the links between instrument design, theory, and practice, and (c) improved application of methodological and statistical techniques. The focus of this research is to utilise the construct validation approach in developing the Mental Toughness Inventory.

Construct validity investigations can be classified as within-network or between-network studies. Within-network studies explore the internal structure of a construct. They begin with a logical analysis of internal consistency of the construct definition, measurement instruments, and generation of predictions. This is followed by studies that typically employ empirical techniques such as factor analysis. Between-network studies attempt to establish a logical, theoretically consistent pattern of relations between measures of a construct and other constructs. This research is often based on correlational procedures (e.g., structural equation models). The present investigation utilises both within-network and between-network approaches to investigate the validity of the Mental Toughness Inventory.

The Present Investigation

The objective of the MTI is to provide a psychometrically sound, easily administered mental toughness instrument that is appropriate for athletes in a wide variety of settings. The 67-item Mental Toughness Inventory was developed through earlier work (Middleton et al's (2004a) to measure thirteen factors (self-efficacy, potential, mental self-concept, task familiarity, task value, personal bests, goal commitment, perseverance, task specific attention, positivity, stress minimisation, positive comparisons, and global mental toughness). The overall aim of the present investigation was to refine the total number of items and the design of the MTI, guided by psychometric criteria, to produce a scientifically sound instrument capable of assessing mental toughness in athletes. Then, following on from that goal, the second aim was to assess the equivalence of the MTI factor structure across sub-elite and elite athletes (i.e., using multiple group confirmatory factor analysis).

Method

Participants

This study utilised two participant samples, a sub-elite athlete sample and an elite athlete sample. The first sample was 438 aspiring elite athletes who attend a specialised sports high school in Sydney, Australia. The school is one of the most prestigious sports high schools in Australia. Each year, student athletes from across the state compete for enrolment in major sports, including basketball, softball, rugby league, soccer, baseball, swimming, track and fields, dance aerobics, cricket and netball. The sample included 274 males (62.6%) and 164 females (37.4%). The participants ranged in age from 12 to 18 years of age (mean= 14.34 years, SD=1.50 years). The second sample was 392 elite athletes from various institutes of sport around Australia (including the Australian Institute of Sport, New South Wales Institute of Sport, Western Australia Institute of Sport, ACT Academy of Sport, Australian Rugby Union Wallabies, and Australian Cricket). The elite athlete sample consisted of 202 males (51.5%) and 190 females (48.5%). The elite athlete participants ranged in age from 11 to 38 years of age (mean= 18.55, SD= 4.48 years).

Measures

As described earlier, the version of the MTI being tested here is a 67-item self-report instrument designed to measure the following thirteen scales. Each is represented by five items (seven for Global Mental toughness), one of which is presented with each scale:

Self-Efficacy. "No matter what the pressure, I still believe in myself."
Task Value. "This activity is one of the most valuable parts of my life."
Potential. "I feel my future in this area will be good."
Task Familiarity. "My experience makes me stronger when performing."
Personal Bests. "To have done my best is the most important thing to me."
Stress Minimisation. "I am good at minimizing the effects of stress."
Mental Self-Concept. "I excel because of my mental strength."
Positivity. "When things are bad I try to turn it around into something positive."
Perseverance. "I keep working at things until I overcome them."
Positive Comparison. "Seeing the opposition feeling the pressure builds my confidence."
Task Specific Attention. "I get absolutely focused on the task, nothing distracts me."
Goal Commitment. "No matter what, I remain committed to my goals."
Global Mental Toughness. "Overall I am mentally tough."

Thus, the design of the instrument –twelve specific and one global *a priori* scales along with the items intended to measure each of the scales – provides an *a priori* model that is the basis of subsequent analyses to be described.

Key Correlates.

Three key correlates were also included in the study: multidimensional athletic self-concept, flow, and life effectiveness. These correlates were measured by the EASDQ, FLOW, and the ROPELOC instruments. These measures were selected on the basis of their conceptual relatedness to mental toughness either as correlates or outcomes of individuals' mental toughness. Hence, they are deemed to be feasible constructs with which to validate the MTI structure.

Elite Athlete Self-Description Questionnaire (EASDQ): The EASDQ is a 28-item self-report instrument designed by Marsh, Hey, Johnson and Perry (1997; also see Marsh, Hey, Roche, & Perry, 1997; Marsh, 1997, 2002) to measure six components of elite athletes' self-concept: Skills, Body, Aerobic, Anaerobic, Mental, and Overall Performance. Participants responded to the items using a 6-point true-false response scale. Research (Marsh, Hey, Johnson & Perry, 1997; Marsh, Hey, Roche, & Perry, 1997; also see Marsh, 1997, 2002) demonstrates that EASDQ responses are reliable and have a well-defined factor structure as shown by confirmatory factor analysis. Marsh (2002) reported that EASDQ responses by elite swimmers were strongly correlated with performances in 16 different events and contributed to prediction of subsequent performance in international championships beyond what could be explained in terms of previous performances.

Flow Trait Scale (FLOW): The 36-item FLOW instrument is based on Csikszentmihalyi's theory of flow as applied to a sport setting (see Jackson & Csikszentmihalyi, 1999). The instrument, developed by Jackson and colleagues (Jackson & Eklund, in press; Jackson & Marsh, 1996; Marsh & Jackson, 1999), measures nine flow experiences in sport: action-awareness merging, clear goals, unambiguous feedback, concentration on task, sense of control, time transformation, and autotelic (intrinsically rewarding) experience. Research (Jackson & Eklund, in press; Jackson & Marsh, 1996; Marsh & Jackson, 1999) demonstrates that the Flow responses are reliable (reliability coefficients varied between .80 and .92) and have a well-defined factor structure as shown by confirmatory factor analysis. Middleton et al (2004a) demonstrated that five of the nine flow factors correlate strongly with the global mental toughness scale (challenge-skill, clear goals, concentration, control, and autotelic experience). In order to reduce the total size of the testing package for the participants, we only included these five scales in this administration.

Review of Personal Effectiveness and Locus of Control (ROPELOC) The ROPELOC instrument (*ROPELOC*; Richards, Ellis & Neill, 2002) was developed to tap into key psychological and behavioural aspects of human functioning that indicate a person's effectiveness in a variety of areas. The ROPELOC measures 14 areas of personal effectiveness including personal abilities and beliefs (Self-Confidence, Self-Efficacy, Stress Management, Open Thinking), social abilities (Social Effectiveness, Cooperative Teamwork, Leadership Ability), organisational skills (Time Management, Quality Seeking, Coping with Change) an 'energy' scale called Active Involvement and a measure of overall effectiveness in all aspects of life. The instrument consists of 45 items, all of which are rated on a scale of "1-False, Not like me" to "8-True, Like me". Research demonstrates that the ROPELOC is psychometrically sound in terms of reliability and factor structure (Richards et al, 2002). Richards et al. (2002) reported high reliabilities for each of the ROPE factors (range = .79 to .90), as well as substantial factor loadings (range=.65 to .86).

Procedures

All participants were informed that the researchers were interested in how they engage in their sport with the view to assisting coaches in promoting mental toughness. Anonymity was guaranteed and participants were assured that the data would be used for research purposes only and not for athlete selection purposes. Each testing session began with a brief set of instructions. The researchers worked through the background/demographic questions on an accompanying instrument with each group. Following this, the rating scale was explained, and participants then completed a few related example items. All participants were encouraged to seek assistance from a member of the research group if they were experiencing any difficulties in responding to an item. Participants were then asked to work through the questionnaire and submit the completed form to the researcher when they had finished.

Statistical Analyses

Confirmatory Factor Analysis(CFA) and Multigroup CFA: CFA performed with LISREL version 8.54 (Joreskog & Sorbom, 2003), was used to test the psychometric properties of the MTI. In CFA, the researcher posits an *a priori* structure and tests the ability of a solution based on this structure to fit the data by demonstrating that (a) the solution is well defined, (b) parameter estimates are consistent with theory and *a priori* predictions, and (c) the χ^2 and subjective indices of fit are reasonable (Marsh, Balla & McDonald, 1988; McDonald & Marsh, 1990). Maximum likelihood was the method of estimation used for the models. In evaluating goodness of fit of alternative models, we emphasize the root mean square error of approximation (RMSEA). Although the RMSEA is apparently the most widely endorsed criterion of fit, we also present the Non-Normed Fit Index (NNFI), the relative noncentrality index (RNI), the χ^2 test statistic, and an evaluation of parameter estimates.

For RMSEAs, values of less than .05 and .08 are taken to reflect a close fit and a reasonable fit respectively (see Joreskog & Sorbom, 1993; Marsh, Balla & Hau, 1996; Schumacker & Lomax, 1996). The NNFI and RNI vary along a 0-to-1 continuum in which values greater than .90 and .95 are typically taken to reflect acceptable and excellent fits to the data respectively (McDonald & Marsh, 1990). The RNI contains no penalty for a lack of parsimony so that improved fit due to the introduction of additional parameters may reflect capitalization on chance, whereas the NNFI and RMSEA contain penalties for a lack of parsimony. Whereas tests of statistical significance and indices of fit aid in the evaluation of the fit, there is ultimately a degree of subjectivity and professional judgment in the selection of a 'best' model.

Testing for the invariance of the MTI factor structure between sub-elite and elite athletes samples involved mulitgroup CFA. Multigroup CFA involves comparing a number of CFA models in which aspects of the factor structure are systematically held invariant across groups. Invariance was specifically determined by comparing the resulting fit indices when elements of the factor structures were constrained. Relatively invariant fit indices demonstrate invariant factor structure. The present analyses examined the comparative fit indices for a number of models that held successive elements of the factor structure invariant across sub-elite and elite athletes.

Results and Discussion

Refining the number of items

To ensure that the instrument was brief and concise, yet maintained psychometric soundness required that we achieve an acceptable level of reliability (e.g., at least .8) based on scales having a relatively small number of items. As a guide, we aimed to: (a) reduce the length of the MTI; (b) measure and maintain the content of all 13 factors in the MTI; (c) maintain reliability estimates of at least .80; and (d) provide a factor structure in which goodness of fit indexes met acceptable standards. Thus the first task in data analysis was to work through the MTI subscale-by-subscale with a view to removing items that were not loading particularly well on hypothesised subscales. This process involved examining results from (a) a series of one-factor congeneric CFA models, (b) a full model CFA, and (c) Cronbach's alpha coefficients given the removal of each item from the subscale.

Item strength was considered in relation to multiple criteria. Items were selected using the following guidelines:

(a) Items that best measured the intended construct as inferred on the basis of corrected item-total correlations and the size of standardized factor loadings in CFA;

(b) Items that had minimal cross-loadings as evidenced by LISREL's modification indexes indicating the extent to which the fit would be improved if an item were allowed to load on a factor other than the one it was intended to measure and expected size of the cross-loading;

(c) Items that had minimal correlated uniquenesses, particularly with other items within the same scale. In the case where two items within the same scale had substantial correlated uniquenesses, only one of the two items was retained;

(d) The number of times that an item was left blank (although the proportion of missing responses was very small – less than 1%);

(e) A subjective evaluation of the content of each item in order to maintain the breadth of content of the original construct;

(f) Sufficiently parsimonious items in each scale in order to maintain a coefficient alpha estimate of reliability of at least .80.

Using the elite athlete sample as a starting point, a series of models were explored in which the original 13 factors were retained, but poor fitting items were eliminated. Observations of factor loadings and modification indexes clearly demonstrated that the original MTI factor Mental Self-Concept and the Global Mental Toughness Factor were highly related. The best items from both factors were taken to 'collapse' the original two factors into one factor called Mental Self-Concept. The original MTI contained 5-items per factor (7 for Global). Reducing the size of the instrument from 5- to 3-items per factor (based on the strength of the items) maintained a very good fit of responses to the model (see below for fit statistics for both sub-elite and elite).

Construct Validation of the MTI

Confirmatory factor analysis of the MTI by group (i.e., sub-elite and elite athlete samples)

Having excluded poorer fitting items, the resulting MTI contained 12 factors comprising three items each (36-items in total). CFA was used to test the *a priori* model behind the MTI. CFA results are presented by looking at the CFA fit indexes for Sub-elite first, then for Elite, and then for the Mulitgroup CFA models.

MTI CFA on Sub-Elite Athlete Sample: The first-order factor structure underlying the twelve components of the MTI was well defined, with the CFA yielding a χ^2 of 1275.15 (df=528), a NNFI of .99, RNI of .99, and RMSEA of .057. The factor loadings, factor correlations, and reliabilities (Cronbach's alphas) are presented in Table 1 illustrating the highest loading on any factor as .90 and the lowest as .72.

MTI CFA on Elite Athlete Sample: The first-order factor structure underlying the twelve components of the MTI was well defined, with the CFA yielding a χ^2 of 926.75 (df=528), a NNFI of .99, RNI of .99, and RMSEA of .044. The factor loadings, factor correlations, and reliabilities (Cronbach's alphas) are presented in Table 1 illustrating the highest loading on any factor as .94 and the lowest as .72.

Table 1. Factor Analysis Structure for the MTI using both the Sub-Elite and Elite Athlete Samples

	MTI Factor Structure											
Item Number	**SEFF**	**PCOM**	**VAL**	**POT**	**TFAM**	**PB**	**MIN**	**MSC**	**POSI**	**PERS**	**TFOC**	**COMM**
FACTOR LOADINGS												
Sub-Elite Group												
1	.86	.82	.81	.84	.79	.71	.77	.86	.72	.73	.73	.84
2	.86	.87	.89	.89	.86	.856	.76	.87	.85	.82	.77	.88
3	.86	.90	.86	.89	.85	.785	.79	.85	.84	.85	.88	.86
Elite Group												
1	.86	.89	.88	.83	.84	.72	.85	.92	.81	.81	.77	.83
2	.89	.87	.92	.85	.90	.86	.84	.89	.87	.88	.86	.90
3	.90	.94	.87	.91	.87	.80	.91	.92	.80	.83	.87	.92
FACTOR CORRELATIONS												
Sub-Elite Group												
SEFF	--											
PCOMP	.46	--										
VAL	.59	.33	--									
POT	.67	.33	.79	--								
TFAM	.68	.42	.59	.65	--							
PB	.57	.32	.47	.49	.49	--						
MIN	.64	.38	.34	.44	.50	.39	--					
MSC	.78	.47	.49	.60	.65	.47	.62	--				
POSI	.74	.42	.47	.55	.59	.51	.71	.67	--			
PERS	.81	.46	.64	.70	.64	.60	.56	.70	.69	--		
TFOC	.65	.33	.49	.54	.50	.49	.60	.60	.60	.68	--	
COMM	.73	.38	.71	.76	.65	.62	.48	.60	.63	.80	.64	--
Factor Reliability	.89	.89	.89	.91	.88	.82	.83	.90	.84	.83	.83	.90
Elite Group												
SEFF	--											
PCOMP	.27	--										
VAL	.22	.24	--									
POT	.51	.28	.54	--								
TFAM	.50	.30	.35	.46	--							
PB	.39	.26	.39	.45	.37	--						
MIN	.67	.24	.13	.39	.38	.24	--					
MSC	.69	.28	.24	.46	.50	.35	.58	--				
POSI	.63	.22	.21	.44	.42	.39	.62	.52	--			
PERS	.59	.30	.48	.60	.51	.51	.43	.58	.51	--		
TFOC	.57	.30	.33	.46	.47	.42	.58	.59	.51	.63	--	
COMM	.47	.26	.51	.61	.47	.53	.32	.43	.44	.68	.53	--
Factor Reliability	.91	.93	.91	.90	.90	.84	.90	.94	.86	.88	.88	.93

The Mental Toughness Inventory (MTI) factors are: SEFF= Self-Efficacy; PCOMP= Positive Comparisons; VAL= Value; POT= Potential; TFAM= Task Familiarity; PB= Personal Bests; MIN= Stress Minimisation; MSC= Mental Self-Concept; POSI= Positivity; PERS= Perseverance; TFOC= Task Focus; COMM= Commitment.

Multigroup CFA and Invariance across sub-elite and elite athletes

Multigroup CFA examined the factor structure for sub-elite and elite athletes and allowed all factor loadings, uniquenesses, and correlations to be freely estimated. This model yielded an excellent fit to the data (χ^2 = 2185.37, df = 1056, CFI = .99, NNFI = .99, RMSEA = .051). Although this model is a good fit to the data, it is important to test formally for invariance between sub-elite and elite athletes. The present study therefore examined the comparative fit indices for four additional models across sub-elite and elite athletes. The first model holds the factor loadings invariant across sub-elite and elite athletes; the second holds both factor loadings and uniquenesses invariant; the third holds the factor loadings and correlations invariant; and the fourth holds the factor loadings, the uniquenesses, and the correlations invariant.

Results in Table 2 indicate that when successive elements of the factor structure are held invariant across sub-elite / elite athlete samples, the fit indices are predominantly comparable. Indeed, the application of recommended criteria for evidence of lack of invariance (i.e., a change of 0.01 in fit indices—see Cheung & Rensvold, 2002) indicates that there is relative invariance across all models. This suggests that the factor structure, factor loadings, uniquenesses, and factor correlations are parallel for sub-elite athletes as they are for elite athletes. Taken together, these data suggest that in terms of underlying mental toughness characteristics and the composition of and relationships amongst these characteristics, sub-elite and elite athletes are not substantially different.

Table 2. *Invariance Tests Across Sub-Elite and Elite Athletes*

	Chi Square	DF	CFI	NNFI	RMSEA
All parameters are free (no invariance)	2185.37	1056	.99	.99	.051
LOADINGS are invariant	2271.54	1092	.99	.99	.051
LOADINGS and UNIQUENESSES are invariant	3008.71	1128	.98	.98	.064
LOADINGS and CORRELATIONS are invariant	2463.22	1158	.99	.99	.052
LOADINGS, CORRELATIONS, and UNIQUENESSES are invariant	3137.97	1194	.98	.98	.063

The analysis detailed above suggests a psychometrically sound factor structure – that is, a structure with sound within-network properties. Construct validation requires the demonstration of appropriate relationships between the construct being validated and other known constructs – that is, sound between-network properties. Therefore, the next task is to examine the pattern of relationships between the MTI model and other key correlates described above.

Relating the MTI model to key correlates

Three scales were included within the MTI testing package for the purpose of validation (i.e., in relation to key correlates). These scales related to athletic self-concept, flow and life effectiveness. These measures were selected on the basis of their conceptual relatedness to mental toughness either as correlates or outcomes of individuals' mental toughness. Using content analyses and guidance from theory leads us to expect certain patterns of relationships between the MTI and key correlate factors. Table 3 presents a correlation matrix between both the MTI factors and the factors contained within the EASDQ, FLOW and ROPELOC instruments.

The correlations between the MTI subscales with the key correlates were examined. The MTI factors correlated as expected with the specific validating factors. That is, relationships between specific factors were differentially stronger and weaker as expected (i.e., based on content analyses and theory). For example, MTI factor 'Task Focus' related more strongly with FLOW factor 'Concentration' than with other less theoretically related factors. In terms of validation, then, the MTI subscales have performed well. These results support the validity of the scales within the MTI.

Table 3. Correlations between MTI Factors and Key Correlates (for Sub-Elite / Elite Athlete Samples)

		MTI Factor Structure												
Scale	**Factor**	**α**	**SEFF**	**PCOM**	**VAL**	**POT**	**TFAM**	**PB**	**MIN**	**MSC**	**POSI**	**PERS**	**TFOC**	**COMM**
EASDQ	**Skill**	.90/.90	.62/.52	.38/.27	.58/.26	.66/.53	.57/.50	.49/.31	.44/.42	.54/.50	.52/.33	.61/.47	.50/.45	.66/.33
	Body	.91/.95	.45/.32	.25/.27	.42/.23	.48/.34	.47/.28	.37/.32	.34/.26	.44/.24	.39/.21	.43/.30	.36/.23	.47/.25
	Aerobic	.88/.93	.53/.33	.34/.20	.44/.20	.53/.22	.47/.29	.43/.23	.39/.24	.49/.30	.47/.25	.54/.29	.47/.27	.56/.22
	Anaerobic	.88/.92	.56/.30	.37/.28	.45/.20	.51/.26	.48/.26	.49/.29	.41/.24	.48/.35	.46/.23	.55/.37	.47/.37	.56/.26
	Mental	.90/.87	.72/.69	.39/.32	.52/.30	.62/.50	.61/.54	.49/.46	.58/.56	.72/.82	.62/.53	.72/.67	.63/.67	.67/.48
	Overall Performance	.91/.91	.72/.76	.37/.33	.59/.33	.67/.55	.65/.59	.56/.47	.55/.50	.63/.63	.64/.45	.69/.60	.57/.58	.72/.47
FLOW	**Challenge-Skill**	.93/.88	.68/.62	.40/.35	.61/.39	.69/.58	.65/.56	.56/.43	.47/.50	.56/.59	.59/.43	.72/.60	.55/.56	.73/.50
	Clear Goals	.91/.91	.69/.47	.33/.25	.64/.48	.70/.62	.64/.38	.58/.43	.44/.33	.56/.37	.57/.38	.71/.50	.56/.45	.79/.69
	Concentration	.87/.90	.70/.60	.32/.33	.56/.41	.65/.53	.63/.47	.50/.46	.52/.51	.63/.58	.57/.50	.66/.62	.64/.74	.72/.62
	Control	.89/.91	.66/.64	.33/.36	.53/.35	.62/.56	.62/.48	.52/.43	.53/.54	.62/.61	.56/.52	.66/.59	.57/.64	.68/.53
	Autotelic Experience	.89/.89	.63/.48	.32/.31	.62/.37	.64/.45	.65/.37	.57/.48	.40/.35	.51/.37	.51/.36	.66/.50	.52/.37	.71/.50
ROPELOC	**Cooperative Teamwork**	.86/.89	.52/.24	.31/.19	.48/.11	.45/.20	.51/.21	.57/.31	.43/.24	.47/.17	.53/.21	.61/.25	.47/.20	.59/.23
	Self-Efficacy	.81/.85	.65/.65	.38/.21	.43/.15	.46/.39	.50/.40	.43/.34	.56/.56	.63/.59	.59/.53	.63/.49	.56/.52	.56/.38
	Leadership Ability	.88/.92	.48/.38	.22/.22	.37/.08	.42/.29	.45/.32	.45/.25	.35/.33	.43/.34	.43/.36	.51/.39	.34/.26	.48/.26
	Internal Control	.81/.75	.64/.27	.39/.28	.56/.37	.57/.40	.61/.30	.58/.41	.48/.18	.60/.18	.54/.21	.66/.43	.50/.29	.63/.44
	Active Involvement	.80/.74	.62/.36	.39/.31	.55/.32	.51/.39	.53/.39	.56/.47	.42/.27	.56/.33	.53/.33	.69/.56	.50/.34	.63/.44
	Open Thinking	.79/.82	.58/.55	.38/.23	.47/.31	.48/.36	.59/.38	.54/.41	.46/.34	.55/.34	.54/.41	.66/.50	.52/.40	.58/.43
	Quality Seeking	.80/.83	.65/.42	.39/.34	.51/.35	.55/.40	.54/.34	.60/.51	.47/.30	.53/.37	.56/.42	.72/.59	.56/.45	.67/.50
	External Control	.74/.83	.11/.01	.08/.04	.10/.07	.10/.04	.03/.08	.06/.03	.08/.01	.09/.05	.10/.03	.08/.02	.03/.05	.05/.02
	Self-Confidence	.81/.80	.72/.58	.33/.33	.51/.34	.61/.59	.63/.47	.56/.47	.49/.42	.62/.49	.60/.51	.68/.54	.51/.44	.65/.52
	Social Effectiveness	.83/.93	.45/.36	.30/.19	.40/.12	.42/.32	.50/.29	.41/.26	.37/.34	.46/.35	.49/.38	.46/.36	.34/.31	.46/.28
	Stress Management	.79/.86	.56/.64	.32/.16	.32/.11	.36/.35	.43/.30	.30/.23	.65/.74	.54/.57	.56/.53	.49/.39	.46/.50	.44/.21
	Overall Effectiveness	.78/.85	.64/.53	.39/.21	.48/.20	.52/.46	.60/.36	.52/.38	.49/.45	.60/.47	.58/.47	.63/.50	.52/.48	.65/.38
	Time Management	.82/.91	.55/.44	.33/.15	.30/.19	.38/.24	.41/.21	.34/.22	.49/.41	.53/.41	.49/.44	.51/.37	.52/.48	.48/.34
	Coping with Change	.86/.92	.61/.56	.36/.18	.40/.19	.45/.33	.54/.34	.41/.28	.54/.56	.58/.50	.56/.47	.58/.47	.45/.51	.50/.36

The Mental Toughness Inventory (MTI) factors are: SEFF= Self-Efficacy; PCOMP= Positive Comparisons; VAL= Value; POT= Potential; TFAM= Task Familiarity; PB= Personal Bests; MIN= Stress Minimisation; MSC= Mental Self-Concept; POSI= Positivity; PERS= Perseverance; TFOC= Task Focus; COMM= Commitment.

Mental Toughness Measurement

At the heart of this investigation was the aim to evaluate the psychometric (within-network) properties of the MTI, with a view to refining the instrument for further use. The original version of the MTI measured twelve specific components of mental toughness along with one global mental toughness factor, with each factor being measured by 5-items (7 for Global Mental Toughness). The current research refined the MTI down from 5-items per factor to 3-items per factor. Analysis also revealed that the original Global Mental Toughness and Mental Self-Concept factors were highly related. Taking the best items from each and combining these into one factor substantially improved the fit of the data to the athlete responses. CFA demonstrated that the resulting MTI (i.e., 12 factors measured by 3-items each) provided a good fit to the data. Furthermore, multigroup CFA demonstrated that the MTI factor structure is invariant across sub-elite and elite athlete samples. The MTI has proven to be internally strong, demonstrating within-network validity. When the MTI model was related to key correlates, the subscales correlated strongly with these measures and with the global mental toughness measure. From a between-network perspective, then, the MTI has proven itself across a few fundamental tests of validity.

A particular strength of the MTI is its conceptual basis. The factors identified by Middleton et al (2004b) have face validity, are intuitively appealing, and have support from recent qualitative research into mental toughness (Fourie & Potgieter, 2001; Jones et al., 2002). Furthermore, the current quantitative evaluation of the MTI demonstrates the strong psychometric properties. Taken together, the MTI represents a sound instrument, strong in theory, conceptualisation and internal properties.

The development of the MTI has benefited greatly through the combination of both qualitative and quantitative research methods. There are numerous advantages to multi-method research encompassing both quantitative and qualitative approaches (Brewer & Hunter, 1989) and particularly in an area in which there is a need for strong conceptual and theoretical foundations, the use of both these complementary methods is recommended. In this investigation, earlier qualitative research (Middleton et al., 2004b) provided the conceptual and theoretical foundation from which to base the development of the MTI. The quantitative study reported here, then, reinforces and validates the structure put forward by Middleton et al's earlier work. In this way the two approaches, qualitative and quantitative, are complementary techniques. Taking the best of qualitative and quantitative approaches has resulted in the development of a reliable and valid MTI, one that is based on a conceptual and theoretical foundation.

Limitations and Future Directions

When interpreting these findings, it is important to recognise some limitations associated with the research and which may also provide directions for future research. The key correlates were all self-report measures and therefore, broader measures might be included in future research derived through reports by significant others (e.g., coaches), performance outcomes, and observational techniques. All the data collected were cross-sectional and so validation was based on responses from a single point in time. Future research should examine the predictive validity of mental toughness by examining related processes and outcomes over time.

Conclusion

The results of this investigation support the conceptual model of mental toughness proposed by Middleton et al. (2004). Furthermore, the MTI provides a reliable and valid measure of that model. Taken together, these data suggest the MTI is strong on both conceptual, between-network, and within-network grounds. Given this, we suggest the MTI will have direct relevance and benefit in both applied and research contexts.

About the Authors

Mr Cory Middleton is a registered psychologist, with a particular interest in understanding and developing mental toughness. He is the PhD candidate working on the Mental Toughness Research Project through the SELF Research Centre, University of Western Sydney.

Professor Herb W. Marsh is a professor of Educational Psychology, founding Director of the Self-concpet Enhancement and Learning Facilitation (SELF) Research Centre, and served as Dean of Graduate Research Studies (1996-2000) and Pro-Vice Chancellor of Research (1995-96) at UWS. He is the author of internationally recognised psychological tests that measure self-concept, motivation, and university students' evaluations of teaching effectiveness. He is well known in sports psychology for the development of the physical self-concept instruments for elite athletes (Elite Athlete Self Description Questionnaire) and non-elite athletes (Physical Self Description Questionnaire) and methodological contributions to the field.

Dr Andrew Martin is a Post-Doctoral Research Fellow at the SELF Research Centre, University of Western Sydney. He specialises in student motivation with an emphasis on strategies educators can use to enhance student motivation in the classroom. Dr Martin also has a keen interest in research methodology with particular strengths in survey design and structural equation modelling.

Mr Garry Richards OAM, completed undergraduate degrees at the University of Sydney and his further post graduate studies have been through the Australian National University, James Cook University and Sturt University. He was formally Executive Director of Outward Bound, National Chairman of ORCA, and Executive Director of National Outdoor Education and Leadership Services, a national consultancy and research company.

Mr Clark Perry has a long history of working in elite sport in both the US and Australia. His appointments to four Olympic Games, three Commonwealth Games and multiple world championships demonstrate the respect that he has earned in the field of sport psychology.

Contact Details
Professor Herb Marsh,
SELF Research Centre,
University of Western Sydney,
Penrith South DC, NSW 1797, AUSTRALIA.
E-Mail: h.marsh@uws.edu.au.

References

Brewer, J., & Hunter, A. (1989). *Multimethod research: A synthesis of styles*. Newbury Park, CA: Sage.

Fourie, S., & Potgieter, J. R. (2001). The nature of mental toughness in sport. *South African Journal for Research in Sport, Physical Education and Recreation, 23*, 63-72.

Gill, D. L., Dzewaltowski, D. A., & Deeter, T. E. (1988). The relationship of competitiveness and achievement orientation to participation in sport and nonsport activities. *J. Sport and Exercise Psychology, 10,* 139-150.

Goldberg, A. S. (1998). *Sports slump busting: 10 steps to mental toughness and peak performance.* Chpgn, IL: H. Kinetics.

Gould, D., Hodge, K., Peterson, K., & Petlichkoff, L. (1987). Psychological foundations of coaching: Similarities and differences among intercollegiate wrestling coaches. *Sport Psychologist, 1*, 293-308.

Hodge, K. (1994). Mental toughness in sport: Lessons for life. The pursuit of personal excellence. *J. Phys Ed NZ, 27*, 12-16.

Jackson, S.A., & Csikszentmihalyi, M.C. (1999). *Flow in Sports: The Keys to Optimal Experiences and Performances*. Champaign, IL: Human Kinetics.

Jackson, S.A., & Eklund, R.C. (in press). Assessing flow in physical activity: The Flow State Scale-2 and Dispositional Flow Scale-2. *Journal of Sport and Exercise Psychology*.

Jackson, S. A., & Marsh, H. W. (1996). Development and validation of a scale to measure optimal experience: The Flow State Scale. *Journal of Sport and Exercise Psychology, 18, 17-35.*

Jones, G., Hanton, S., & Connaughton, D. (2002). What is this thing called mental toughness? An investigation of elite sport performers. *Journal of Applied Sport Psychology, 14*, 205-218.

Joreskog, K. G., & Sorbom, D. (1993). *LISREL 8: Structural equation modeling with the SIMPLIS command language.* Chicago: Scientific Software International.

Joreskog, K., & Sorbom, D. (2003). *LISREL 8.54.* Scientific Software International.

Loehr, J.E. (1982). *Athletic excellence: Mental toughness training for sports*. Forum Publishing Company.

Loehr, J.E. (1986). *Mental toughness training for sports: Achieving athletic excellence.* Lexington, MA: Stephen Greene.

Marsh, H. W. (1990). *Self Description Questionnaire (SDQ) II: A theoretical and empirical basis for the measurement of multiple dimensions of adolescent self-concept: An interim test manual and a research monograph*. San Antonio, TX: The Psychological Corporation (Republished in 1992, Publication Unit, SELF Research Centre, Un. W. Sydney).

Marsh, H. W. (1997). The measurement of physical self-concept: A construct validation approach. In K. Fox (Ed.), The physical self-: From motivation to well-being (pp. 27-58). Champaign, IL: Human Kinetics.

Marsh, H. W. (2002). A multidimensional physical self-concept: A construct validity approach to theory, measurement, and research. *Psychology, The Journal of the Hellenic Psychological Society.*

Marsh, H. W., Balla, J. R., & Hau, K. T. (1996). An evaluation of incremental fit indices: A clarification of mathematical and empirical processes. In G. A. Marcoulides & R. E. Schumacker (Ed.), *Advanced structural equation modeling techniques* (pp. 315-353). Hillsdale, NJ: Erlbaum.

Marsh, H. W., Balla, J. R., & McDonald, R. P. (1988). Goodness-of-fit indices in confirmatory factor analysis: The effect of sample size. *Psychological Bulletin, 102,* 391-410.

Marsh, H.W., Hey, J., Johnson, S., & Perry, C. (1997). Elite Athlete Self Description Questionnaire: Hierarchical confirmatory factor analysis of responses by two distinct groups of elite athletes, *Int. J. Sport Psych., 28*, 237-258.

Marsh, H. W., Hey, J, Roche, L. A., & Perry, C. (1997). The structure of physical self-concept: Elite athletes and physical education students. *Journal of Educational Psychology, 89,* 369-380.

Marsh, H.W., & Jackson, S.A. (1999). Flow Experience in sport: Construct validation of multidimensional, hierarchical state and trait responses. *Structural Equation Modelling, 6,* 343-371.

McDonald, R. P., & Marsh, H. W. (1990). Choosing a multivariate model: Noncentrality and goodness-of-fit. *Psychological Bulletin, 107,* 247-255.

Middleton, S.C., Marsh, H.W., Martin, A.J., Richards, G.E., & Perry, C. (2004a). Developing the Mental Toughness Inventory. *Self Research Centre Biannual Conference, Berlin.*

Middleton, S.C., Marsh, H.M., Martin, A.J., Richards, G.E., Perry, C., (2004b). Discovering mental toughness: A qualitative study of mental toughness in elite athletes. *Self Research Centre Biannual Conference, Berlin.*

Middleton, S.C., Marsh, H.M., Martin, A.J., Richards, G.E., Perry, C. (2004c). Mental Toughness: Is the mental toughness test tough enough? *International Journal of Sport and Exercise Science.*

Murphy, S., & Tammen, V. (1998). In search of psychological skills. In J. Duda (Ed.), *Advances in sport and exercise psychology measurement*. (pp. 195-209). Morgantown, WV: Fitness Information Technology.

Norris, E. K. (1999). *Epistemologies of champions: A discoursive analysis of champions' retrospective attributions; Looking back and looking within*. Michigan: Michigan University Microfilms International.

Ostrow, A. C. (1996). *Directory of psychological tests in the sport and exercise sciences (2nd Ed)*. Morgantown, WV: Fitness Information Technology.

Richards, G. E., Ellis, L. A., & Neill, J. T. (2002). *The ROPELOC: Review of personal effectiveness and locus of control. A comprehensive instrument for reviewing life effectiveness.* Self-concept Research Conference: Sydney.

Schumacker, R. E., & Lomax, R. G. (1996). *A beginner's guide to structural equation modeling*. Mahwah, NJ: Erlbaum.