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A Psychometric Evaluation of the Recovery Stress Questionnaire for Athletes (RESTQ-Sport)

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A PSYCHOMETRIC EVALUATION OF THE RECOVERY STRESS QUESTIONNAIRE FOR ATHLETES (RESTQ-SPORT)

by

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ABSTRACT

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The University of Wisconsin-Milwaukee, 2017
Under the Supervision of Professor Barbara B. Meyer

The Recovery Stress Questionnaire for Athletes (RESTQ-Sport; Kallus & Kellmann, 2016) has been utilized in over one hundred research studies on overtraining in sport (Kallus & Kellmann, 2016). Despite recommendations from researchers to incorporate the RESTQ-Sport into existing practices for monitoring athletes' responses to training load, gaps in the literature impede the translation of the measure from research to practice (Saw, Main, & Gastin, 2015a; Taylor, Chapman, Cronin, Newton, & Gill, 2012). To address gaps in the literature and enhance knowledge regarding the measurement nuances of the RESTQ-Sport, three systematic studies were completed in the current dissertation project.

For all three studies, online survey data were collected from athletes (N = 567) participating at various levels of competitive sport (i.e., collegiate, professional, Olympic/international). Results of the first study revealed several problems with the RESTQ-Sport measurement model, including item redundancy, inadequate scale reliability, and inadequate validity of the hierarchical factor structure. Results of the first study also indicated some evidence to support the simple structure underpinning profile analysis (i.e., 76 items loading on to 19 scales; Kellmann, 2010). Results of the second study revealed that while there is considerable overlap between the Profile of Mood States (POMS) and the RESTQ-Sport, additional (29-46%) variance in RESTQ-Sport responses must be explained by variables other than mood states. Results of the second study, in conjunction with those of the first study, demonstrate that the POMS and RESTQ-Sport may be equally effective for identifying athletes at risk of overtraining, yet the RESTQ-Sport may provide more information than the POMS that can be used to enhance the specificity of individualized mood repair interventions. Results of the third study revealed that exercise intensity tolerance, pain catastrophizing, perceived susceptibility to sport injury, and chronic psychological stress are variables that explain significant proportions of variance in the perceived stress and recovery of non-contact and contact sport athletes'. Results of the third study highlighted the particular influence of chronic psychological stress on RESTQ-Sport responses. Taken together, the results of the dissertation research advance the RESTQ-Sport literature from a measurement perspective, and therefore prompt several implications for the improvement of professional practice.

This dissertation is dedicated to:

(1) the athletes who deserve the opportunity to live the dream and compete at world's best form,

and

(2) the sport scientists and practitioners dedicated to providing athletes with such opportunity, working tirelessly behind the scenes to enhance athletes' health and performance.

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Chapter I: Introduction & Literature Review

Background & Practical Context

Prompted by the pressure to win in elite sport, researchers have been and continue to be challenged to identify the most effective and efficient methods of athlete training and performance enhancement. Independent of training modality, research has generally supported the notion of a supercompensation principle, in which systematic overloads in training followed by sufficient periods of recovery yield positive training adaptations and increases in performance (Bosquet, Montpetit, Arvisais, & Mujika, 2007; Fleck, 1999; Gabbett, 2016; Issurin, 2008, 2016). However, the consistent and successful application of this principle in practice is rarely achieved due to logistical barriers such as individual differences, sport-specific nuances, and resources available (Kenttä & Hassmén, 1998; Meeusen et al., 2013). The logistical barriers to applying the supercompensation principle in practice are further compounded by the rapidly growing body of literature on methods of quantifying training load, prescribing training load dosage, and determining levels of "sufficient" recovery (Bartlett, O'Connor, Pitchford, Torres-Ronda, & Robertson, 2017; Drew & Finch, 2016; Gabbett, 2016; Halson, 2014; Schwellnus et al., 2016; Soligard et al., 2016; Wallace, Slattery, & Coutts, 2014). While utilizing methods of periodization (i.e., planned cycles of training) increases the likelihood of successfully achieving supercompensation following training overloads, mismanagement of these cycles often results in in overtraining (Bompa, 1999; Issurin, 2016; Kenttä & Hassmén, 1998).

Overtraining is broadly defined as a process of training intensification that inadvertently results in decreased performance and increased risk of injury (Hausswirth et al., 2014; Meeusen et al., 2013). Cases of overtraining can be classified across a continuum, involving symptoms characteristic of functional overreaching (FOR), nonfunctional overreaching (NFOR), and overtraining syndrome (OTS) (Cardoos, 2015; Meeusen et al., 2013). The least severe state of overtraining, FOR, is characterized by a short bout (i.e., 72 hours to 14 days) of performance decrement without psychological or physiological symptoms of maladaptation, and is an intentionally manipulated factor to facilitate supercompensation (Meeusen et al., 2013). A more extreme state of overtraining, NFOR, is characterized by a longer bout of performance decrement accompanied by observable psychological and hormonal disturbances (i.e., weeks to months), as a result of training cycle mismanagement. It has been theorized that the current classifications of FOR and NFOR correspond to states of sympathetic and parasympathetic overtraining, respectively (Kenttä & Hassmén, 1998; Meeusen et al., 2013). Finally, the most severe state of overtraining, OTS, is a diagnosable condition characterized by the longest periods of performance decrement (i.e., months to years) and severe psychological and hormonal disturbances (Meeusen et al., 2013). A diagnosis of OTS typically results from critical long-term mismanagement of training periodization, and many times proper diagnosis can only be achieved retrospectively based on total time required to restore health and performance (Cardoos, 2015; Meeusen et al., 2013).

Due to the collective health and performance consequences mentioned above, researchers have recommended that coaches and sport organizations proactively monitor athletes' responses to training to identify athletes at risk of overtraining (Kenttä & Hassmén, 1998; Meeusen et al., 2013). From a biomedical perspective, the diagnosis and therefore prevention of overtraining remains an imprecise process, as there is no consistent evidence for immunological, biochemical, or physiological predictors of overtraining (Meeusen et al., 2013). Alternatively, and from an integrated perspective, research is now indicating that psychological variables such as mood and stress more consistently correspond to early signs of overtraining in athletes than immunological, biochemical, or physiological variables (Carfagno & Hendrix, 2014; Meeusen et al., 2013; Saw, Main, & Gastin, 2016).

The inclusion of psychological variables in the conceptualization of training load has been reinforced in recent International Olympic Committee (IOC) consensus statements on training load management, and the use of subjective measures to monitor athletes' responses to training load has therefore been encouraged (Carfagno & Hendrix, 2014; Meeusen et al., 2013; Saw et al., 2016; Soligard et al., 2016). Concurrent with such sports medicine and IOC consensus statements, several articles have recently been published regarding proper protocols for selecting and implementing subjective, self-report measures in practice (Saw, Kellmann, Main, & Gastin, 2016; Saw, Main, & Gastin, 2015a; Saw, Main, & Gastin, 2015b). The Recovery Stress Questionnaire for Athletes (RESTQ-Sport, Kallus & Kellmann, 2016; Kellmann & Kallus, 2001), a measure of perceived stress and recovery, is commonly recommended by researchers for monitoring athlete responses to training load (Saw et al., 2016).

In the development of the RESTQ-Sport, the construct operationalization of stress and recovery was directly informed by two main theories: Janke and Wolfgramm's biopsychological stress model (1995) and Kellmann's model of the interrelation between stress states and recovery demands (Kellmann, 2002). According to Janke and Wolfgramm's model (1995), stress is operationalized as a deviation from psychophysical balance, eliciting central and autonomic nervous system responses that manifest in physiological, emotional, and behavioral changes. Informed by Kellmann's model (2002), recovery is operationalized as a passive or action-oriented process of restoring psychophysical balance after experiencing stress. According to Kellmann's model, which extends the work of Janke and Wolfgramm (1995), a relationship exists between stress and recovery such that increases in stress require equal amounts of recovery to maintain optimal levels of performance. Kellmann (2010) further suggests that under-recovery during periods of elevated stress states can exacerbate the stress reactions already experienced, leading to unexplained performance declines and other symptoms of overtraining. Concomitantly, extreme levels of stress are thought to inhibit an athlete's ability to select and execute necessary recovery strategies, furthering their vulnerability to overtraining (Kellmann, 2010). In combining these two theoretical paradigms, and since researchers have critiqued the lack of emphasis on recovery in alternative measures such as the Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1971), the RESTQ-Sport is the first measure to evaluate whether or not an athlete is engaging in sufficient recovery relative to the stress experienced. To shed light on the evidence available to support the use of the RESTQ-Sport in practice, a review of the literature on the psychometric properties of the measure as well as the responsiveness of the measure to experimental conditions of training load, illness/injury, and performance is provided below.

Psychometric Properties

The RESTQ-Sport is a 76-item measure of the frequency of stressors, stress reactions, and recovery behaviors (Kellmann & Kallus, 2001). Although Kellmann and Kallus (2001) also developed a 52-item version and a 36-item version of the RESTQ-Sport, few researchers have utilized these shortened versions (Kuan & Kueh, 2015; Laux, Krumm, Diers, & Flor, 2015; Nicolas, Vacher, Martinent, & Mourot, 2016). Thus, and unless otherwise specified, all references to the RESTQ-Sport will imply use of the 76-item measure.

All items in the RESTQ-Sport typically begin with the stem of "In the past 3 days/nights", although Kallus and Kellmann (2016) recently suggested that adequate scale reliability is maintained with stems that range from "3 days/nights" to "4 weeks." All items are scored on a 7-point Likert scale ranging from *never* (0) to *always* (6), with item responses representing interval data. The measure is hierarchical in nature, whereby general stress, general recovery, sport-specific stress, and sport-specific recovery represent four latent variables comprised of 19 discrete 1st order factors (Table 1). From this point forward, each of the 1st order factors will be referred to as scales. Scoring can be performed using four methods: (a) mean scores for each of the 19 scales; (b) mean or sum scores for general stress, general recovery, sport-specific stress, and sport-specific recovery; (c) sum scores for total stress and total recovery; or (d) stress-recovery states calculated as total recovery minus total stress (Kallus & Kellmann, 2016; Kellmann & Kallus, 2001;). Due to the nonlinear and nonsymmetrical covariance between stress and recovery, calculations of a single sum score to represent stress and recovery are not permitted, and constructs may be treated as orthogonal (Kallus, 1995; Kellmann & Kallus, 2001).

Construction of the RESTQ-Sport measure was informed by principles of Classical Test Theory (CTT), a foundational psychometric theory for standardized test development (Guttman, 1945; Lord & Novick, 1968; Spearman, 1904; Thurstone, 1932). During initial development, Kellmann and Kallus systematically examined the psychometric properties of the measure over a period of 10 years, involving athlete participants from Germany, Canada, and the United States (U.S.). Since the RESTQ-Sport Manual was published (Kellmann & Kallus, 2001), 11 independent studies have examined various psychometric properties of the measure. In the paragraphs below, the research findings on the reliability, criterion validity, and construct validity of the RESTQ-Sport are reviewed.

Reliability. For self-report psychological measures like the RESTQ-Sport, evidence of reliability demonstrates the consistency and reproducibility of item responses across multiple administrations of the measure (Crocker & Algina, 1986). In Kellmann and Kallus' original work (2001), reliability of the RESTQ-Sport was examined using computations of Cronbach's alpha (α) for internal consistency within testing sessions and Pearson's *r* for test-retest reliability between testing sessions. Although there are no definitive rules for interpretation, Cronbach's alpha values of 0.70 or higher are generally acceptable (Bland & Altman, 1997; Kellmann & Kallus, 2001; Nunnally & Bernstein, 1994), and Pearson's *r* values of 0.70 or higher indicate temporal stability in user responses across the designated period of time between administrations (Crocker & Algina, 1986).

Internal consistency results were reported in a total of nine studies, seven of which reported Cronbach's alpha values for each of the 19 scales (Table 2). Across all studies, 12 of the 19 scales failed to meet standards of acceptability in at least one study. Of particular note, the C/P and S scales failed to reach standards of acceptability in five of the nine studies (56%), and the LE, PC, PR, and PA scales failed to reach standards of acceptability in three of the nine studies (33%). Overall, evidence points to a subpar internal consistency of items in the C/P, S, LE, PC, PR, and PA scales within testing sessions.

By contrast, test-retest reliability results were reported in three studies (Kellmann and Kallus, 2001; Mäetsu, Jürimäe, Kreegipuu, & Jürimäe, 2006; Nederhof, Brink, & Lemmink, 2008). Based on Pearson's *r*, Kellmann and Kallus' reported adequate test-retest reliability for 15 of the 19 scales within a 72-hour period (r = 0.70 – 0.82). Only the LE (r = 0.68), GWB (r = 0.61), DB (r = 0.64), and I (r = 0.59) scales failed to reach the recommended 0.70 cutoff for test-retest reliability. Similarly, results of Mäetsu and colleagues' research demonstrated adequate 24-hour test-retest reliability for all scales (r = 0.74 – 0.84) except the DB scales (r = 0.63). Using a different method of evaluating absolute test-retest reliability, intraclass correlation coefficients, Nederhof et al. (2008) reported test-retest bias in the PC, S, and SQ scales. Taken together, evidence points to adequate test-retest reliability for 12 of the 19 scales, while questions remain around the test-retest reliability of the LE, PC, S, GWB, SQ, DB, and I scales within a 72-hour window of measure administration.

In summarizing the research on the reliability of the RESTQ-Sport scales, minor questions have emerged regarding the internal consistency and test-retest reliability of the C/P, LE, PC, S, GWB PR, SQ, I, and PA scales (Costa & Samulski, 2005; Kellmann & Kallus, 2001; Nederhof et al., 2008). One explanation for the inconsistent demonstrations of reliability may be the computations employed by researchers. Specifically, although Cronbach's alpha remains one of the most commonly used computations for internal consistency in psychological research, recent literature has highlighted the limitations of Cronbach's alpha for determining reliability of a psychological measure (Dunn, Baguley, & Brunsden, 2014; Schmitt, 1996; Sijtsma, 2009; Yang & Green, 2011). Dunn et al. (2014) suggest that assumptions of alpha computations are rarely met, violations of assumptions lead to inflated bias in alpha, and point estimates of alpha without confidence intervals are insufficient and provide false confidence regarding the internal consistency of the variable. Dunn et al. (2014) proposed that McDonald's omega (ω) is an appropriate alternative to Cronbach's alpha, as omega performs better than alpha when assumptions are violated, is less sensitive than alpha to inflated bias, and provides a greater degree of confidence than alpha when reported in point estimates or confidence intervals. Since it is rare that psychological scales meet all assumptions for alpha, it is possible that computations of omega would provide contrasting information regarding the internal consistency of the RESTQ-Sport scales. However, and given the evidence available to date, it is apparent that both the internal consistency and test-retest reliability of RESTQ-Sport scales require further examination, particularly in English-speaking populations of athletes.

Criterion validity. The criterion validity of a psychological measure provides information on the relation between observed scores and other variables of practical importance (Crocker & Algina, 1986). Over the past 15 years, criterion validity of the RESTQ-Sport has been examined using Pearson's correlations (*r*) between individual RESTQ-Sport scales and the scales of four other measures: Multidimensional Physical Symptom List (MPSL; Erdmann & Janke, 1981), POMS (McNair et al., 1971, 1992), Volitional Control Questionnaire (VCQ; Kuhl & Fuhrmann, 1998), and Athlete Burnout Questionnaire (ABQ; Isoard-Gautheur, Oger, Guillet, & Martin-Krumm, 2010). A correlation coefficient value of less than 0.30 generally indicates a weak relationship between two variables, a coefficient of greater than 0.30 but less than 0.70 generally indicates a moderate relationship, and a coefficient greater than 0.70 generally indicates a strong relationship between two variables (Huck, 2008).

Criterion validity of the RESTQ-Sport has been examined in four studies (Table 3). Stress scores were positively related to physical symptom scores (MPSL), moods other than vigor (POMS), negative volitional components (VCQ), and all three facets of burnout (ABQ). Stress scales were also negatively related to vigor (POMS) and positive volitional components (VCQ). By contrast, evidence demonstrates weak to moderate criterion validity of the general and sport-specific recovery scales. In their seminal work, Kellmann and Kallus (2001) reported that recovery scales were negatively related to physical symptom scores (MPSL), moods other than vigor (POMS), negative volitional components (VCQ), and two of the three facets of burnout (ABQ). Recovery scales were positively related to vigor (POMS) and positive volitional components (VCQ). Based on directionality alone, the S and SR scales were repeatedly correlated with constructs that did not support criterion validity (Kellmann & Kallus, 2001; Martinent, Decret, Isoard-Gautheur, Filaire, & Ferrand, 2014; Nederhof et al., 2008). Martinent et al. (2014) also found positive correlations between three of the four sport-specific recovery scales (PA, SE, S-R) and the emotional and physical exhaustion scales of burnout (ABQ).

To summarize the criterion validity defined by Kellmann and Kallus (2001), research findings demonstrate stronger criterion validity for the stress scales than the recovery scales, with specific concerns around the S, SR, PA, SE, and S-R scales. Broadly, the general and sport-specific stress scales of the RESTQ-Sport are more strongly associated with MPSL physical symptoms than the general and sport-specific recovery scales, which is consistent with the theoretical underpinnings of the RESTQ-Sport (Janke & Wolfgramm, 1995; Kellmann & Kallus, 2001). The repeatedly identified relationships between recovery and mood scales are inconsistent with the theoretical underpinnings of the RESTQ-Sport, as Kellmann and Kallus (2001) suggested that the POMS does not sufficiently account for recovery processes. This inconsistency with the theoretical underpinnings of the RESTQ-Sport warrants additional research examining the relationships between mood states and stress and recovery responses. Despite evidence existing to demonstrate correlations between stress and recovery scales and other theoretically similar scales, it is perceivable that the original conceptualization of criterion validity by Kellmann and Kallus no longer fits within the overtraining literature. More specifically, of the criterion reference measures used in previous research, only the POMS continues to be used in overtraining research to date. Thus, the classification of the MPSL, ABQ, and VCQ as criterion references in overtraining research is not appropriate. Furthermore, previous researchers have only considered correlations between variables in isolation, as opposed to in combination, to determine criterion validity. For example, stress and recovery demonstrate weak to moderate relationships with each of the moods included in the POMS, yet no studies have determined relationships between stress-recovery state and mood profiles. Given that inconsistent evidence has emerged for the relationships between RESTQ-Sport variables and physiological markers of overtraining (Saw et al., 2016), the limitations of previous research prompts a need for inquiry that expands on the current understanding of the RESTQ-Sport in relation to other criterion references of overtraining.

Construct validity. The construct validity of a psychological measure provides information regarding how accurately the measure estimates the actual construct (Huck, 2008). Construct validity of the RESTQ-Sport has been examined in terms of convergent validity (i.e., correlations to similar construct measures), divergent validity (i.e., correlations to opposing construct measures), and factorial validity (i.e., evidence for the hypothesized factor structure). Both convergent and divergent validity have been examined using intercorrelations of measure scales (Pearson's r), while factorial validity has been examined using principal components analysis (PCA), exploratory factor analysis (EFA), and confirmatory factor analysis (CFA).

Convergent and divergent validity. The convergent and divergent validity of the RESTQ-Sport scales have been examined in four studies. In support of the convergent validity of the measure, Kellmann and Kallus (2001) reported positive correlations between general and sport-specific stress scales (r = 0.05 – 0.80), as well as between general and sport-specific recovery scales (r = 0.19 – 0.86). Several studies confirmed the convergent validity results reported by Kellmann and Kallus (2001), with positive correlations identified between general and sport-specific stress scales (r = 0.32 – 0.62, Costa & Samulski, 2005; r = 0.13 – 0.69, Filho et al., 2015; r = 0.56, González-Boto, Salguero, Tuero, Márquez, & Kellmann, 2008) as well as between general and sport-specific recovery scales (*r* = 0.12 – 0.55, Costa & Samulski, 2005; *r* = 0.10 – 0.68, Filho et al., 2015; *r* = 0.76, González-Boto et al., 2008).

For divergent validity, Kellmann and Kallus (2001) reported that several general recovery (i.e., S, SR) and sport-specific stress (i.e., DB, I) scales failed to demonstrate divergent validity. Other studies provided support for the divergent validity of the general scales, as negative correlations were identified between general stress and recovery (*r* = -0.63 – .05, Costa & Samulski, 2005; *r* = -0.59, Davis, Orzeck, & Keelan, 2007; *r* = -0.45 – -0.01, Filho et al., 2015; *r* = -0.52, González-Boto et al., 2008). Less support has been observed for the divergent validity of the sport-specific scales, with only weak correlations observed between sport-specific stress and recovery (*r* = -0.35 – -0.09, Costa & Samulski, 2005; *r* = -0.19 – 0.25, Filho et al., 2015; *r* = -0.34, Davis et al., 2007; *r* = -0.34, González-Boto et al., 2008). It is worth noting here, that although divergent validity is assumed by a strong negative correlation between stress and recovery scales, a strong relationship of any direction demonstrates substantial measurement overlap between constructs. Thus, divergent validity may be better examined using structural equation modeling (SEM) procedures, as opposed to correlation procedures.

Factorial validity. Factorial validity of the RESTQ-Sport has been examined in five studies (Table 4) and of these, factorial validity concerns consistently emerged around the S, SR, PR, GWB, SQ, and S-R scales. However, the lack of consistency in methods used makes it difficult to determine which scales are truly problematic within the overall factor structure. Although the methods used by the five studies are similar in that all are designed for variable reduction, PCA, EFA, and CFA methods address very different research questions. In-depth discussions of PCA, EFA, and CFA are beyond the scope of the current paper, yet it is important to recognize that PCA and EFA are data-driven procedures intended for initial exploratory work, while CFA is a theory-driven procedure intended for hypothesis testing of an *a priori* factor structure (Kline, 2011; Tabachnick & Fidell, 2013). As an example of this distinction, Davis et al. (2007) noted a dissatisfaction with the *a priori* model, thereby supporting their decision to examine the RESTQ-Sport factor structure using EFA as opposed to CFA methods. Since the concerns noted by Davis et al. (2007) and others have not been resolved, additional item-level analysis may be warranted prior to future CFA research on the RESTQ-Sport factor structure.

The results of all construct validity studies support the convergent validity of RESTQ-Sport scales, yet prompt questions about the divergent validity of several general recovery (S, SR) and all sport-specific scales. Results also demonstrate consistent concerns about the factorial validity of all general recovery scales (i.e., S, SR, PR, GWB, SQ), and one sport-specific recovery scale (i.e., S-R). Taken together, research findings provide better support for the construct validity of the RESTQ-Sport stress scales than the recovery scales. The weak divergent validity between the sport-specific scales may be explained by a lack of theoretical coherence underpinning scale and item construction, whereby the sport-specific scales were incorporated after the general scales and were based on several supplemental theories from the sport psychology literature. The inconsistencies around the construct validity of the general recovery scales may be explained by the fact that Kellmann and Kallus (2001) developed both general stress and recovery items based on Janke's (1976) classification of stressors, suggesting possible theoretical overlap between stress and recovery items. Similarly, the lack of consistent support for the overall recovery scales construct validity may be explained by the fact that athlete training methods are progressing at a rate faster than that of psychological recovery research and theory development.

Psychometric properties summary. In review of the literature on the psychometric properties of the RESTQ-Sport, major concerns emerged around the reliability and validity of the S and SR scales. Across the 11 studies, partial evidence supports the psychometric properties of 11 of 19 scales (C/P, LE, PC, PR, GWB, SQ, I, DB, PA, SE, S-R). No concerns emerged regarding the psychometric properties of the GS, ES, SS, F, EE, and BIS scales. Although partial evidence exists to support use of the measure in research and practice, there remains substantial room for improvement to the psychometric properties of the measure overall, prompting the need for research employing advanced methods of psychometric evaluation. Furthermore, there are repeated concerns expressed in the literature regarding the validity of the recovery scales specifically, demonstrating a need for research on the theory and measurement of recovery as a psychological construct.

Responsiveness to Training Load, Illness/Injury, & Performance

Training load. Currently, 22 studies have examined the responsiveness of RESTQ-Sport scales to training load across athletes in various sports (see Table 5). Of these 22 studies, 16 utilized experimental or intervention methodology while six utilized longitudinal and observational methodology. For the purposes of this review, and informed by the criteria outlined by Saw et al. (2016), each study was assigned a *risk of bias* score indicating methodological rigor (see Table 5). Risk of bias scores range from 0 to 8, with 8 indicating the lowest risk of bias. Each of the 22 studies included in Table 5 met the minimum cutoff score of 4 out of 8 (Saw et al., 2016).

Increases. A total of eight studies examined the responsiveness of the RESTQ-Sport scales to acute training overload protocols (Table 5), which involve two weeks or less of training overload (Saw et al., 2016). Across the eight studies, only one study reported that acute increases in training load were associated with increased perceptions of total stress and decreased perceptions of total recovery (Mäetsu et al., 2006). With regard to individual RESTQ-Sport scales, the F and PC scales consistently increased following acute training loads in six (75%) and five (63%) of the eight studies, respectively. Similarly, PR and BIS consistently decreased following acute training loads in five (63%) and four (50%) of the eight studies, respectively. Only partial support has been found for the responsiveness of the I and SQ scales to increases in acute training load, with significant findings observed in three of the eight studies for each scale (38%). For all other RESTQ-Sport scales, significant responses to acute training load were observed in two or fewer of the eight studies (25%).

In contrast to the studies reviewed above, 14 of the 22 studies examined the responsiveness of the RESTQ-Sport to chronic training overload protocols, which involve more than two weeks of training (Table 5). Overall, perceptions of total stress increase and perceptions of total recovery decrease in response to increases in chronic training load. Of the stress scales, only four of 14 studies (29%) supported the responsiveness of the F scale to increases in chronic training load. Few significant findings, observed in three or fewer of the 14 studies (< 21%), supported the consistent responsiveness of any other stress scale to increases in chronic training load. In contrast, the recovery scales, PR and BIS responses consistently decreased after chronic training loads in seven of the 14 studies (50%). Partial support has also been reported for the responsiveness of the GWB and S scales to increases in chronic training load, with significant findings observed in four (29%) and three (21%) of the eight studies, respectively. For all other recovery scales, significant responses to chronic increases in training load were observed in two or fewer of the 14 studies (14%).

Decreases (Tapers). To date, 10 studies have examined the responsiveness of the RESTQ-Sport scales to reductions in training load, commonly referred to as tapers or recovery periods (Table 5). In terms of training load reduction dosage, one study utilized a 72-hour period, five studies utilized a 1-week period, three studies utilized a 2-week period, and one study utilized a 3-week period. However, it should be noted that none of the experimental designs used examined deliberate training load reductions within a cycle ending in actual competition (e.g., tapering for performance). Thus, the results of previous research do not account for psychological responses during and after a true taper, as the thoughts and beliefs about forthcoming competitions would perceivably influence perceptions of stress and recovery.

The RESTQ-Sport responsiveness to training load reductions after an acute training overload was examined in four of the 10 studies. In three of the four studies (75%), researchers found that training load reductions after acute training overloads yielded significant decreases in the F and PC scales (Dupuy et al., 2012; Kölling et al., 2015; Mäetsu et al., 2006). Concomitantly, in two of the four studies (50%), training load reductions after acute training overloads yielded significant increases in the PR and BIS scales (Dupuy et al., 2012; Kölling et al., 2015). Kölling et al. (2015) noted decreases in F and PC, as well as increases in PR and BIS, after only 72 hours of rest from an acute training bout, indicating that it is possible to rapidly reestablish baseline levels of these scales with minimal intervention. This is a particularly interesting finding, as these same scales demonstrated consistent responsiveness to acute increases in training load. No consistent evidence emerged across the six studies which examined the responsiveness of RESTQ-Sport scales to decreased training load after chronic training overload. In fact, the I scale was the only scale that significantly decreased in two of the six studies (33%), and no other scale significantly changed in more than one study (Bresciani et al., 2010; Coutts, Wallace, & Slattery, 2007).

Training load summary. At present, there is no evidence to support that total stress and total recovery will change consistently in response to increased acute training load. However, research findings do indicate that disturbances in the F, PC, PR, and BIS scales would be expected when increases in acute training load are imposed. In turn, restoration of the F, PC, PR, and BIS scales to baseline are expected when training load reductions are implemented following acute training overloads. Collectively these findings are consistent with the notion of FOR and/or sympathetic overtraining, in which physiological symptoms are observed in the absence of other psychological or mood-related symptoms, and performance is restored or enhanced within two weeks after decreasing training load (Carfagno et al., 2014; Meeusen et al., 2013).

Unlike the research on acute training load responses, much evidence supports the responsiveness of total stress and recovery to increases in chronic training load. Conversely, there is no consistent evidence for the responsiveness of any individual stress scale, and only partial evidence for the responsiveness of PR and BIS recovery scales to increases in chronic training load. No consistent evidence emerged for the responsiveness of any RESTQ-Sport scales to training load reductions following chronic training overload. The inconsistent stress and recovery responses to chronic training overloads and reductions in the literature mirror the challenges associated with athlete monitoring generally, and variability in athletes’ responses to chronic stress specifically (Gabbett, 2016).

Illness/injury. Three studies have examined the link between the RESTQ-Sport scales and injury (Brink et al., 2010; Laux et al., 2015; van der Does, Brink, Otter, Visscher, & Lemmink, 2017), and only one study has examined the link between RESTQ-Sport scales and illness (Brink et al., 2010). All studies employed a prospective, longitudinal research design, in which athletes completed the RESTQ-Sport multiple times throughout the study, and perceptions of stress and recovery were examined in relation to injuries incurred. All three studies included in the following summary met the minimum risk of bias criteria outlined by Saw et al. (2016), with Brink et al. (2010) scored as a 7, Laux et al. (2015) as a 6, and van der Does et al. (2017) with a 7. Injury or illness was utilized as the dependent or outcome variable in all studies, and odds ratios (OR) with 95% confidence intervals (CI) were reported for all statistically significant independent variables (i.e., RESTQ-Sport scales). Two of the studies utilized the RESTQ-Sport stem of "In the past four weeks" (Laux et al., 2015; van der Does et al., 2017), and one study utilized the stem of "In the past 3 days/nights" (Brink et al., 2010).

Brink et al. (2010) studied elite Dutch male soccer players participating in the 2006-2007 and 2007-2008 competitive seasons (*N* =53, *age* = 15-18 years) who completed the RESTQ-Sport monthly. Injury was defined as "any physical complaint sustained by a player that results from a soccer match or soccer training, irrespective of the need for medical attention or time loss from soccer activities" (Brink et al., 2010, p. 810). Injuries were further sub-categorized as traumatic, in which the injury was caused by an acute identifiable event, or overuse, in which the injury was not caused by acute identifiable event. Illness was defined as any "circumstance in which the subject – after consulting with the medical staff – was withdrawn from training or match because he did not feel well and was limited or unable to perform athletic activities due to flu and common cold-related symptoms" (Brink et al., 2010, p. 810). Results of a multinomial regression analysis revealed that of the 19 scales, only the I scale was significantly associated with traumatic (OR 1.29, 95% CI = 1.01-1.66) and overuse injury (OR 1.46, 95% CI = 1.09-1.96). In contrast, 13 of the 19 scales were significantly associated with illness, with the ES (OR

2.27, 95% CI = 1.43-3.61), SS (OR 2.07, 95% CI = 1.37-3.13), LE (OR 1.92, 95% CI = 1.27-2.91), and PC (OR 1.88, 95% CI = 1.24-2.83) demonstrating the highest ORs. Overall, stress demonstrated a stronger association with illness than recovery, with nine out of the 10 stress scales significantly associated with illness (OR = 1.47-2.27), as compared to the four of nine recovery scales associated with illness (OR = 0.56-0.66).

Laux et al. (2015) investigated associations in 22 professional German football players participating in the 2009-2010 and 2010-2011 seasons (M_{age} = 28.5 years, *SD* = 5.0 years) who completed the 52-item version of the RESTQ-Sport monthly. Injury was defined as an event that "occurred during a football match or during training and led to an absence of the next training session or match (time loss injury)" (p. 3). General linear modeling results indicated that F (OR 1.70, 95% CI = 1.15-2.51), SQ (OR 0.53, 95% CI = 0.33-0.86), DB (OR 1.84, 95% CI = 1.01-3.39), and I (OR 1.77, 95% CI = 1.31-2.36) were significantly associated with injury. Again only the I scale findings were consistent with those presented by Brink et al. (2010), and differences between the findings of these two studies may be explained by the different RESTQ-Sport versions as well as the different data analysis procedures utilized.

Finally, van der Does et al. (2017) investigated male (*n* = 58, M_{age} = 22.1 years, *SD* = 3.8 years) and female (*n* = 28, M_{age} = 21.5 years, *SD* = 2.5 years) Dutch indoor sport players' responses to the RESTQ-Sport every three weeks. The authors utilized the same definition of injury as Brink et al. (2010), with acute and overuse injuries corresponding to the previously described traumatic and overuse injuries. Results of a multinomial regression analysis indicated that 3-week changes in RESTQ-Sport scales were not significantly associated with acute injury, yet also indicated that 6-week changes in SR (OR 0.59, 95% CI = 0.35-0.99), GWB (OR 0.61, 95% CI = 0.37-1.00), and DB (OR 0.55, 95% CI = 0.33-0.91) were significantly associated with acute injury. Only 3-week changes in PA (OR 0.59, 95% CI = 0.44-1.30) were significantly associated with overuse injury, and no 6-week changes in RESTQ-Sport scales were significantly associated with overuse injury. Overall, results were inconsistent with those of Brink et al. (2010) and Laux et al. (2015). Discrepancies between study findings may be attributed to differences in how the RESTQ-Sport scores were computed during data analysis, with van der Does et al. (2017) even suggesting that reliability of the data may have been compromised in their method of RESTQ-Sport scoring.

Illness/injury summary. With regard to illness risk, results of the only study conducted indicated that athletes who experienced increases in the stress scales of the RESTQ-Sport had significantly greater odds of becoming ill than healthy players. With regard to injury risk, results of the three studies conducted demonstrated that athletes who experienced increases in the DB and I scales had significantly greater odds of incurring an acute injury than healthy athletes, and athletes who experienced increases in I had significantly greater odds of incurring an overuse injury than healthy athletes (Brink et al., 2010; Laux et al., 2015; van der Does et al., 2017). No other RESTQ-Sport scales were consistently associated with acute or overuse injury, yet this could be explained by the variation in item stems utilized across the three studies. Overall, the stress scales, both general and sport-specific, were more responsive to illness/injury than the recovery scales. A possible explanation for the effects found for the recovery scales may be the different item stems utilized, and therefore contrasting assumptions regarding timelines of perceptions of stress and recovery in relation to acute and chronic injury risk.

Performance. To date, a total of eight studies have examined the responsiveness of the RESTQ-Sport to performance across athletes in various sports (see Table 6). Of these eight studies, two utilized an experimental or intervention methodology while six utilized longitudinal and observational methodology. All included studies met the minimum risk of bias criteria (Saw et al., 2016).

The two studies examining the responsiveness of the RESTQ-Sport to laboratory tests of performance utilized different methods of RESTQ-Sport scoring. Otter et al. (2016) calculated latent variable as well as individual RESTQ-Sport scale scores, reporting that general stress, sport-specific recovery, stress-recovery state, ES, F, PC, and SE were significantly related to peak power output during a submaximal cycling test. They also reported that ES, SS, I, and SE were significantly related to heart rate recovery after a submaximal cycling test. Alternatively, van der Does et al. (2015) calculated 2nd order latent variable scores and identified that general stress, sport-specific stress, general recovery, and sport-specific recovery were all associated with performance during a heart rate interval monitoring test. The results of these two studies suggest that the RESTQ-Sport latent variables may be predictive of physical performance during laboratory tests.

In contrast to the laboratory-based experiments, the majority of performance-related studies (*n* = 6) have examined the RESTQ-Sport responsiveness to actual competitive events. In these studies, results consistently demonstrated the responsiveness of ES, SS, LE, PC, F, PR, SQ, I, EE, BIS, SE, and S-R scales to competitive events. The fact that emotional (i.e., ES, EE), physical (i.e., LE, PC, F, PR, SQ, BIS), and psychological (i.e., SE, S-R) dimensions of the RESTQ-Sport were related to performance is not altogether surprising in the context of other sport performance literature (Cook & Beaven, 2013; Durand-Bush & Salmela, 2002; Lazarus, 2000; McCarthy, 2011). It is interesting that a consistent lack of support was observed for C/P, S, DB, and PA scale responsiveness to competitive events, with three of those four scales sharing a theoretical commonality around pleasure and enjoyment in completing obligatory, work-related tasks. While it is possible that external factors accounted for by the RESTQ-Sport (e.g., issues with teammates, unresolved conflicts, allotment of breaks) are not consistently related to performance outcomes, previous research indicates that external factors can detract focus from training and competition (Gould, Greenleaf, Guinan, Dieffenbach, & McCann, 2001; Greenleaf, Gould, & Dieffenbach, 2001). It is possible that the discrepancies in study findings may be attributed to differences in the timing of RESTQ-Sport administration (e.g., prior to or *around* competitive events) as well as differences in the type of athletes sampled (e.g., team sport vs. individual sport vs. recreational physical activity).

Two studies compared the RESTQ-Sport profile of one athlete who performed successfully (i.e., 1st place in the competition) to that of another athlete who performed less successfully during a competitive event (Kalda, Jürimäe, & Jürimäe, 2004; Kellmann & Günther, 2000). Both studies indicated that prior to competition, the more successful athlete had substantially higher scores in sport-specific recovery (i.e., BIS, SE, S-R) than the less successful athlete. Overall, it appears that athletes have varying RESTQ-Sport responses to actual competitive events, yet the emotional and physical stress scales as well as sport-specific recovery scales may be of particular importance leading up to competitive events.

Performance summary. Lack of consistent methodology across studies, particularly in the timing of the RESTQ-Sport administrations relative to competitive events, makes it difficult to ascertain the true responsiveness of the RESTQ-Sport scales to performance. That said, results of the eight studies consistently indicated that perceptions of total stress increase and perceptions of total recovery decrease prior to and during performances. With regard to individual RESTQ-Sport scales, results from over 50% of the reviewed studies demonstrated the responsiveness of the ES, PC, F, I, EE, BIS, and SE scales to upcoming or ongoing performance.

Evidence was found in three of the eight studies (38%) for the responsiveness of the SS, PR, SQ, and S-R scales to upcoming or ongoing performance. For all other scales, responsiveness to upcoming or ongoing performance was only identified in two or fewer of the eight studies (< 25%).

Literature Review Conclusions

Studies utilizing item and factor analysis to establish the psychometric properties of the original RESTQ-Sport measure have generated conflicting results over the past 15 years (Davis et al., 2007; Kallus & Kellmann, 2016; Kellmann & Kallus, 2001; Martinent et al., 2014). Due to discrepant findings, it remains unclear if the RESTQ-Sport as a measurement model is as reliable and valid as assumed in previous research (Saw et al., 2016). The lack of clarity and consistency in the literature emanate from inconsistencies in the methods used in previous research examining the psychometric properties of the RESTQ-Sport. Advanced methods of psychometric evaluation, such as item response theory or exploratory structural equation modeling, may be useful in achieving clarity regarding the psychometric properties of the RESTQ-Sport.

Studies examining athlete RESTQ-Sport responses surrounding changes in training load, illness/injury, and performance have demonstrated a responsiveness of the total stress, total recovery, F, PC, I, PR, and BIS subscales. Several scales (i.e., GS, SS, C/P, GS, ES, PA, SE, S-R) have consistently failed to respond to changes in training load, illness/injury, or performance. Little is known about the utility of general and sport-specific variable distinctions in terms of training load management. Previously unaddressed issues with the measurement model may serve as a one explanation for the lack of scale responsiveness to various sport situations observed in previous studies. In order to improve the practical utility of the RESTQ-Sport, and therefore improve the specificity of interventions informed by the measure, attending to questions surrounding the measurement model is of critical importance. If measurement concerns surrounding the RESTQ-Sport are not addressed, any explanations for the responsiveness or non-responsiveness of the measure in actual sport settings are inherently flawed.

Rationale for Dissertation Research

Research Problem #1: Previous studies on the psychometric properties of the RESTQ-Sport have generated inconsistent results. In addition, researchers have noted practical concerns regarding the measure length, scoring procedures, and utility of RESTQ-Sport data to inform interventions aimed at overtraining prevention (Saw et al., 2015a; Taylor, Chapman, Cronin, Newton, & Gill, 2012).

Dissertation Statement of Purpose: One purpose of the current dissertation research was to utilize advanced methods of psychometric evaluation to identify poor performing items as well as to confirm the most valid factor structure (i.e., measurement model parsimony) of the RESTQ-Sport.

Research Problem #2: Although both the POMS and RESTQ-Sport are recommended for use in monitoring athletes' responses to training load (Saw et al., 2016), little research has been conducted to understand the measurement overlap between the two measures. This lack of measurement distinction between the POMS and RESTQ-Sport makes it difficult for practitioners to select a measure that best fits the athlete and environment.

Dissertation Statement of Purpose: Another purpose of the current dissertation research was to understand the measurement overlap between the POMS and RESTQ-Sport.

Research Problem #3: Despite evidence to support the responsiveness of the RESTQ-Sport to training load, illness/injury, and performance, there remains a large proportion of unexplained intraindividual and interindividual variability in stress and recovery responses. This unexplained variability in responses makes it difficult for practitioners to use RESTQ-Sport data to inform specific and effective interventions.

> *Dissertation Statement of Purpose:* The final purpose of the current dissertation research was to advance the understanding of previously uninvestigated psychological variables (i.e., exercise tolerance, perceived susceptibility to sport injury, pain catastrophizing, chronic psychological stress) that contribute to the intraindividual and interindividual variability in RESTQ-Sport responses.

Tables

Table 1

RESTQ-Sport Scale Descriptions

General Stress Scales	General Recovery Scales
General Stress (GS): frequency of mental stress, depression, imbalances, and listlessness	Success (S): frequency of pleasure at work, success, and creativity
Emotional Stress (ES): frequency of irritation, aggression, anxiety, or inhibition	Social Recovery (SR): frequency of pleasurable social contacts, relaxation, and amusement
Social Stress (SS): frequency of arguments, irritations concerning others, fights, lack of humor, and upset	Physical Recovery (PR): frequency of physical recovery, physical well-being, and fitness
Conflicts/Pressure (C/P): frequency of unreached goals, ruminating thoughts, and unpleasant yet obligatory tasks to be done	General Well-Being (GWB): frequency of good moods, high well-being, relaxation, and contentment
Fatigue (F): frequency of time pressures, training, school, disturbances in work, over-fatigue, and loss of sleep	Sleep Quality (SQ): frequency of sleep disorders and sleepless nights
Lack of Energy (LE): frequency of inability to concentrate, make decisions, or lacking energy	
Physical Complaints (PC): frequency of whole body physical indispositions or complaints	
Sport-Specific Stress Scales	**Sport-Specific Recovery Scales**
Disturbed Breaks (DB): frequency of interruptions in recovery, situational aspects that impede recovery, and other recovery deficits	Being in Shape (BIS): frequency of feeling fit, efficient, and vital
Emotional Exhaustion (EE): frequency of feelings of burnout or wanting to discontinue sport	Personal Accomplishment (PA): frequency of communicating well with teammates, enjoyment of sport, and feeling integrated in a team
Injury (I): frequency of perceived acute injury risk or vulnerability	Self-Efficacy (SE): frequency of feeling optimally prepared and convinced of proper training
	Self-Regulation (S-R): frequency of mental skills use for preparation, motivation, and goal setting

Table 2

RESTQ-Sport Scale Reliability

Study	Population	*N*	Age (years)	α
Kellmann & Günther (2000)	German national rowers	11 male & female	25.6 – 26.2	0.67 – 0.89
Kellmann & Kallus (2001)	American, Canadian, & German athletes	87 – 149 male & female	13.0 – 23.0	< 0.50 – 0.93
Costa & Samulski (2005)	Portuguese athletes	134 male & female	17.8 ± 4.11	0.58 – 0.85
Mäetsu et al. (2006)	Estonian rowers	12 male	20.5 ± 3.0	0.72 – 0.95
González-Boto et al. (2008)	Spanish athletes	294 male & female	21.0 ± 2.0	0.54 –0 .91
Nederhof et al. (2008)	Dutch athletes	116 male & female	23.1 ± 3.6	0.47 – 0.91
Nicolas et al. (2011)	French ultra-marathoners	14 male	43.8 ± 10.2	0.73 – 0.88
Martinent et al. (2014)	French table tennis players	148 male & female	14.2 ± 2.1	0.65 – 0.85
Elbe et al. (2016)	Danish national swimmers	41 male & female	18.27 ± 2.8	0.60 – 0.85

Table 3

RESTQ-Sport Scale Criterion Validity

Scales	General Stress	Sport-Specific Stress	General Recovery	Sport-Specific Recovery	*N*	Citation
MPSL	-0.01 – 0.78	0.06 – 0.79	-0.36 – 0.11	-0.50 – 0.17	42	Kellmann & Kallus (2001)
POMS – Without Vigor	0.33 – 0.75	0.35 – 0.58	-0.67 – -0.09	-0.38 – -0.05	65	Kellmann & Kallus (2001)
	0.25 – 0.73	0.29 – 0.65	-0.63 – -0.06	-0.63 – -0.20	134	Costa & Samulski (2005)
	0.29 – 0.78	0.11 – 0.53	-0.69 – 0.06	-0.49 – 0.17	116	Nederhof et al. (2008)
POMS – Vigor Only	-0.38 – -0.19	-0.31 – -0.23	0.37 – 0.60	0.29 – 0.61	65	Kellmann & Kallus (2001)
	-0.52 – -0.21	-0.47 – -0.29	0.42 – 0.60	0.24 – 0.46	134	Costa & Samulski (2005)
	-0.56 – -0.20	-0.42 – -0.13	0.26 – 0.69	0.16 – 0.60	116	Nederhof et al. (2008)
VCQ – Positive	-0.48 – 0.00	-0.29 – -0.04	0.14 – 0.65	0.36 – 0.63	71	Kellmann & Kallus (2001)
VCQ – Negative	-0.34 – 0.53	-0.01 – 0.44	-0.36 – -0.01	-0.41 – -0.04	71	Kellmann & Kallus (2001)
ABQ – PA	0.32 – 0.49		-0.52 – -0.10		148	Martinent et al. (2014)
ABQ – SD	0.32 – 0.49		-0.33 – -0.06		148	Martinent et al. (2014)
ABQ – E/P Ex	0.15 – 0.58		-0.26 – 0.25		148	Martinent et al. (2014)

Note. MPSL = Multidimensional Physical Symptom List; POMS = Profile of Mood States; VCQ = Volitional Components Questionnaire; ABQ = Athlete Burnout Questionnaire.

Table 4

RESTQ-Sport Factorial Validity

Study	**Method**	**Results**
Kellmann & Kallus (2001)	PCA, maximum likelihood procedure with Varimax rotation, factor-level analysis	• 19 factors loaded on 4 hierarchical factors (general stress, general recovery, sport-specific stress, sport-specific recovery) • Cross loadings for general recovery scales
Davis IV et al. (2007)	EFA, maximum likelihood procedure with Promax rotation, factor-level analysis	• 19 factors loaded on 4 hierarchical factors • Sleep quality subscale cross-loaded on stress factor
	EFA, maximum likelihood procedure with Promax rotation, item-level analysis	• 76 items loaded on 14 unique factors • Sleep quality item cross-loadings
Nederhof et al. (2008)	EFA, maximum likelihood procedure with oblique rotation, factor-level analysis	• Cross loadings for the general and sport-specific recovery scales
	EFA, modified 13 items, factor-level analysis	• Cross loadings for general recovery items • Concerns arising in factor analysis likely a product of inherent measurement issues as opposed to translation issues
González-Boto et al. (2008)	PCA, factor-level analysis	• 19 factors loaded on 4 hierarchical factors
	CFA, maximum likelihood procedures	• Poor fit of 4-factor hierarchical model • Modification indices revealed 55 items which could be removed to improve model fit • Recursive model demonstrated good model fit
Martinent et al. (2014)	CFA, maximum likelihood procedures	• No support for the model proposed by Davis IV et al. (2007) • Good fit of the general and sport-specific 1st order models • Fair fit of general hierarchical model • Fair fit of sport-specific hierarchical model • Fair fit of 67-item, 17-factor hierarchical model (success and social recovery factors omitted)
Kallus & Kellmann (2016)	SEM (undefined procedures), factor-level analysis	• Good fit of general and sport-specific models, use of 19 subscales as indicators

Table 5

Responsiveness of the RESTQ-Sport to Training Load

Study	**Population**	***N***	**Age (years)**	**Training Protocol**	**RESTQ-Sport Administration**	**Results**	**Risk of Bias**
Kellmann & Günther (2000)	German Olympic rowers	6 female, 5 male	25-26	INT: 3 weeks high-altitude training camp	T1: arrival at camp T2 – T3: training T4: prior to traveling to Olympic site	Sig. quadratic trend T1 – T4: PC, LE, I, BIS Sig. linear trend T1 – T4: C/P, SR	6
Jürimäe et al. (2002)	Estonian junior rowers	10 male	16.6 ± 0.7	INT: 6-day training period of increased training load (100%)	T1: baseline T2: post-training	F sig. increased & SR sig. decreased from T1 to T2 C/P, SQ, & PA sig. correlated with training load	6
Jürimäe et al. (2004)	National rowers	21 male	19.6 ± 2.0	INT: 6-day training camp (100% increased training load)	T1: baseline T2: post-training	F, PC, I sig. increased from T1 to T2 S, SR, SQ, BIS, SE sig. decreased from T1 to T2 Training load sig. correlated with F, PC, SQ Resting cortisol sig. correlated with F, SS	7
Bouget et al. (2006)	French national cyclists	12 male	21.7 ± 5.5	INT: 4-day camp, 122% training load increase	T1: baseline T2: post-training	From T1 – T2: ES, SS, F, sig. increase & GWB, BIS, PA, sig. decrease Resting cortisol sig. related to PC DHEA-S/C ratio sig. related to SS, LE	7
Mäetsu et al. (2006)	Estonian national rowers	12 male	20.5 ± 3.0	INT: 6-day training camp	T1: regular training baseline T2 – T4: HVT (25% volume increase) T5 – T6: 1-week recovery (90% volume reduction)	GS, ES, SS, F, PC, EE, I sig. increased from T1 to T3 & T4 PR, GWB, BIS sig. decreased from T1 to T3 & T4 GS, ES, SS, F, PC sig. decreased from T4 to T6 S sig. increased from T4 to T6	7
Coutts et al. (2007)	Well-trained triathletes, IT & NT groups	16 male	IT: 33.4 ± 5.0 NT: 27.7 ± 7.6	INT: 4 weeks of 290% increased training load for IT	T1: Week 1 of training T2: Week 4 of training T3: Week 6 – 2nd week of taper/rest	LE, PC, I sig. higher in IT than NT at T4 PR, GW, BIS sig. lower in IT than NT at T4 LE, PC, I sig. decrease from T4 to T6, BIS sig. increase from T4 to T6 IT & NT group performance not sig. different after taper/rest.	7

Coutts & Reaburn (2008)	Semi-professional Australian rugby players, IT & NT groups	20 unspecified	23.7 ± 3.6	INT: 6-week progressive overload	T1: baseline T2: Week 2 of training T3: Week 4 of training T4: Week 6 of training T5: after 1-week taper	GS, F, DB sig. increase by T4, & F, DB sig. decrease by T5 S, PR, GWB, SQ, BIS sig. decrease by T4, & PR, GWB sig. increase by T5	6
González-Boto et al. (2008)	Well-trained swimmers	3 male 6 female	15.5 ± 7.5	INT: 6-week overload	T1: low training load T2: increased training load T3: 25% less load than T2 but > than T1 T4: after 1-week taper	Stress-recovery state sig. effect of time EE, I sig. increase across T1 – T3 S, PR, BIS, SE sig. decrease across T1 – T3 Only S sig. increase after taper	7
Hartwig et al. (2009)	Rugby union players	106 male	14-18	MON: 3 groups: low training (< 357 min/week), moderate training (358 – 542 min/week), high (> 543 min/week)	One time	GS, ES, SS, PC, DB, EE lowest in high training group, & S-R was highest in high training.	7
Bresciani et al. (2010)	Handball players	14 male	20.1 ± 2.5	MON: 40-week season broken into PP & CP	T1: end of PP I T2: end of PP II T3: end of CP I T4: end of CP II T5: after 1 week recovery period	Training load sig. related to I, PR, & BIS SS & BIS sig. increased at T4 I & S-R sig. decreased at T5	7
Bresciani et al. (2011)	Healthy, active young adults	9 male	22.3 ± 1.4	INT: 9-week intensified aerobic training overload with recovery	T1: baseline T2: intermediate load T3: maximum load T4: after 3-week recovery	Total, general, & sport-specific stress sig. increased from T1 – T3 No sig. changes from T3 to T4	6
Garatachea et al. (2011)	Spanish junior sprint kayakers	8 male	16.8 ± 2.1	MON: 42- week season	T1: November 12 T2: March 12 T2: June 17	No sig. changes for any RESTQ-Sport scales Lack of changes attributed to well-balanced training.	6
Dupuy et al. (2012)	Endurance athletes	11 male	29.5 ± 9.3	INT: 2-week overload	T1: Week 1 T2: Week 2 T3: after 1-week taper	F, LE sig. increased from T1 – T2, then sig. decreased from T2 – T3 PR, BIS sig. decreased from T1 – T2, then sig. increased from T2 – T3	5

Brink et al. (2012)	Dutch soccer players	94 male	15 – 18	MON: 1 full season; grouped by healthy & OR	Monthly	OR sig. higher in GS, ES & sig. lower in PR, GW, SQ, BIS, PA than healthy. Disturbances in ES, PR, GWB, & SQ noted 2 mo. prior to OR diagnosis F, PR, & BIS most affected in players who developed OR	8
di Fronso et al. (2013)	Italian amateur basketball players	33 male 27 female	23.5 ± 9.2	MON: 21-day training period	T1: pre-season T2: after training T3: post-season	Gender effect on PR, SQ, SE Time effect on ES, F No interaction effect	4
Filaire et al. (2013)	Adolescent tennis players	12 female	14.8 ± 0.6	MON: 16-week training & CP	T1: baseline T2: post-training	Total, general, & sport-specific stress sig. increased from T1 – T2 Sport-specific recovery sig. decreased from T1 – T2. GS, C/P, LE, F sig. increased from T1 – T2 S, GWB, PR, BIS, S-R sig. decreased from T1 – T2	6
Morales et al. (2014)	National-standard judokas	14 male	22.9 ± 1.7	INT: 4-week training overload, 2 groups: HTL & MTL	T1: baseline T2: post-training	HTL had higher general stress as well as lower general & sport-specific recovery than MTL	6
Nunes et al. (2014)	International-level basketball players	19 female	26.0 ± 5.0	INT: 2 training overload periods across 12 weeks	T1: after 3-week baseline T2: 3-week overload T3: 1-week taper T4: 2nd 3-week overload T5: 2-week taper	Stress-recovery balance disturbances at Weeks 8 & 10 from T2 By T5, stress-recovery balance resumed close to baseline	6
Freitas et al. (2014)	Brazilian volleyball players	16 male	23.4 ± 2.9	INT: 2 groups: IT & NT, 11-day overload for IT group	T1: baseline T2: after overload T3: after 2-week training load reduction	PC increased in IT group during overload & PR increased in IT group during training load reduction	6
Elbe et al. (2016)	Danish elite swimmers	19 male 11 female	18.3 ± 2.8	INT: 12-week high intensity training: 2 groups: HIT with reduced volume & NT	T1: baseline T2: post-training	Intervention yielded lower levels of general stress & higher levels of general recovery in HIT than the NT group, while controlling for baseline scores	7

Kölling et al. (2015)	German junior national field hockey players	25 female	19.1 ± 0.8	INT: 5-day training camp	T1: baseline T2: post-training	PC, I sig. increased from T1 to T2 PR sig. decreased from T1 to T2	6
Kölling et al. (2016)	Well-trained athletes	23 male 19 female	23.2 ± 2.4	INT: 6-day training camp, 2 groups strength & HT	T1: baseline T2: post-training (24 hours) T3: post-training (72 hours) *only F, PC, SQ, EE, I, BIS scales were administered	Strength: F, PC, EE, I sig. increased form T1 to T2; SQ, BIS sig. decreased from T1 to T2 HIT: F, PC, EE, I sig. increased form T1 to T2; BIS sig. decreased from T1 to T2 Strength & HIT post-72-hour rest: F, PC, EE, I sig. decreased from T2 to T3. BIS sig. increased from T2 to T3	6

Note. INT = intervention study; MON = monitoring/observational study; sig. = statistically significant; IT = intensified training; NT = normal training; HVT = high volume training; HTL = high training load; MTL = moderate training load; HIT = high intensity training; OR = overreached; PP = preparation period; CP = competitive period.

Table 6

Responsiveness of the RESTQ-Sport to Performance

Study	**Population**	***N***	**Age (years)**	**Performance Definition**	**RESTQ-Sport Administration**	**Results**	**Risk of Bias**
Kellmann & Günther (2000)	German Olympic rowers	4 female, 4 male	25-26	Finishing place in rowing	T1: prior to traveling to Olympic site T2: 2 days prior to Olympic Games preliminaries (9 days before finals)	ES sig. increased from T1 to T2 SR sig. decreased from T1 to T2 1st place rower had lower F, LE, PC, & higher BIS, PA, SE, & S-R than 13th place rower	6
Kalda et al. (2004)	Estonian sprinters & jumpers	4 male 7 female	17-24	International Amateur Athletic Federation (IAAF) points	T1: 1 day prior to indoor championships T2: 1 day prior to outdoor championships	F & EE sig. strong, negative correlations with IAFF points 1st place athlete had lower general stress scales, higher PR, GWB, SQ, lower sport-specific stress scales, & higher BIS, SE, & S-R than 12th place athlete	6
Hartwig et al. (2009)	Rugby union players	18 male	14-18	N/A	T1: Day 1 of a 5-day national championship competition T2: Day 4 of competition	From T1 – T2: 55.7% increase in GS (sig.) 34.9% increase in SS (sig.) 26.7% increase in LE (sig.) 32.0% increase in PC (sig.) 35.7% increase in EE (sig.) 11.3% decrease in SQ (sig.)	7
Nicolas et al. (2011)	Ultra-marathon runners	14 male	43.8 ± 10.2	Ultra-marathon race completion	T1: 2 hours before the race T2: 2 hours after the race T3 – T10: post-race recovery	T1 to T2: Sig. increase in total stress & sport-specific stress; sig. decrease in general recovery Restoration of physical stress dimension (PC, I) in 3 days Restoration of physical recovery dimension (PR, BIS) in 12 days Restoration of social dimensions (SS, SR, PA) in 6 days Restoration of emotional dimension (F, EE) in 9 days	6

Filho et al. (2013)	Girobio cyclists	67 unspecified	21.9 ± 1.6	N/A	T1: 1 day before race T2: 5 hours prior to starting the last stage of the 9-stage race	T1 to T2: Sig. increases in general & sport-specific stress; sig. decreases in general & sport-specific recovery All scales changed in the expected direction except C/P, S, SR, PA, SE	8
Filho et al. (2015)	Girobio cyclists	78 unspecified	21.9 ± 1.6	Race stage rankings (Stage 1 & 9)	T1: one day prior to race onset T2: one day prior to last stage of 9-stage race onset	T1 to T2: PR sig. positive predictor of subjective performance for Stage 1; I & GWB sig. negative predictor of subjective performance for Stage 1; C/P & LE sig. negative predictors of subjective final stage performance	8
Otter et al. (2016)	Cyclists, triathletes, ice-skaters	20 female	27±8	PPO test in a LSCT -2nd stage PPO -3rd stage PPO -HRR_{60}	8 times across 1 year	Sport-specific recovery & SE sig. related to 2nd stage PPO General stress, stress-recovery state, ES, F, PC, SE sig. related to 3rd stage PPO Sport-specific stress, stress-recovery state, ES, SS, I, SE sig. related to HRR_{60s}	7
van der Does et al. (2015)	Dutch floorball players	10 female	24.8±4.5	HIMS performance test	Tri-weekly across 7 months	General stress & sport-specific stress at 3 weeks pre-performance were predictive of increased HR_{submax} during test General recovery & sport-specific recovery at 3 & 6 weeks pre-performance were predictive of decreased HR_{submax} during test	6

Note. PPO = peak power output; LSCT = Lambert submaximal cycling test; HRR_{60s} = 60-second heart rate recovery after test; HIMS = heart rate interval monitoring system; HR_{submax} = submaximal heart rate.

Table 7

RESTQ-Sport Summary Table for Practitioners

Scales	**Psychometric Properties (*n* = 11)**	**Responsive to Acute Training Overload (*n* = 8)**	**Responsive to Chronic Training Overload (*n* = 14)**	**Responsive to Decreases in Training Load (*n* = 10)**	**Responsive to Performance (*n* = 8)**	**Responsive to Injury (*n* = 3)**	**Responsive to Illness (*n* = 1)**
General Stress	A	N	N	N	N	N	N
Emotional Stress	A	N	N	N	Y	N	Y
Social Stress	A	N	N	N	?	N	Y
Conflicts & Pressure	Q	N	N	N	N	N	Y
Fatigue	A	Y	?	Y	Y	?	Y
Lack of Energy	Q	N	N	N	Y	N	Y
Physical Complaints	Q	Y	N	Y	Y	N	Y
Success	U	N	N	N	N	N	N
Social Recovery	U	N	N	N	N	?	Y
Physical Recovery	Q	Y	Y	Y	?	N	N
General Well-Being	Q	N	?	N	?	?	Y
Sleep Quality	Q	?	N	N	?	?	Y
Injury	Q	?	N	?	Y	Y	Y
Disturbed Breaks	Q	N	N	N	N	Y	Y
Emotional Exhaustion	A	N	N	N	Y	N	Y
Being in Shape	A	Y	Y	Y	Y	N	Y
Personal Accomplishment	Q	N	N	N	N	?	N
Self-Efficacy	Q	N	N	N	Y	N	N
Self-Regulation	Q	N	N	N	?	N	N

Note. A = acceptable, no concerns about psychometric properties; Q = questionable, some concerns about psychometric properties; U = unacceptable, major concerns about psychometric properties; Y = consistent evidence that the scale does meet criterion (sig. findings in ≥ 50% studies), N = consistent evidence that the scale does not meet criterion (sig. findings in ≤ 25% studies), ? = inconsistent evidence, cannot determine if the scale meets the criterion

Chapter II: *Examining the psychometric properties of the RESTQ-Sport: A methods comparison*

Abstract

The RESTQ-Sport is a psychological measure of stress and recovery commonly used in sports medicine to detect the early symptoms of overtraining in elite sport athletes. Despite the popularity of the measure in sports medicine research and practice, the psychometric properties of the measure have been debated. The purpose of the current study was to examine the psychometric properties of the measure using methods of item analysis (i.e., classical test theory [CTT] and item response theory [IRT]) and factor analysis (i.e., confirmatory factor analysis [CFA] and exploratory structural equation modeling [ESEM]). Results of the item analysis indicated that the RESTQ-Sport stress items perform better among high-stress than low-stress athletes, while the recovery items perform better among low-recovery than high-recovery athletes. Results of the item analysis revealed potential item redundancy within stress and recovery items, as well as a number of poor performing items within individual subscales. Results of the CFA demonstrated superior model fit of a 1st order RESTQ-Sport measurement model in comparison with hierarchical models. Results of the ESEM demonstrated cross-loading concerns with the recovery items that were masked when using CFA procedures. Overall, the results of the study indicate that the RESTQ-Sport demonstrates superior responsiveness to symptoms of overtraining when used among athletes at high risk of overtraining. Results also broadly indicate that there is room for refinement in the RESTQ-Sport factor structure, particularly as it relates to the development of recovery as a distinct construct from stress.

Keywords: RESTQ-Sport, stress, recovery, reliability, validity

Overtraining remains one of the most rigorously studied areas in sport research, as well as one of the most elusive phenomena in sports medicine practice today. Over the past five years, sports medicine and International Olympic Committee (IOC) consensus statements have endorsed the importance of including psychological variables in the conceptualization of overtraining risk (Gabbett, 2016; Meeusen et al., 2013; Schwellnus et al., 2016; Soligard et al., 2016). As such, and to detect the early signs of overtraining, it has been recommended that subjective measures be used to monitor athletes' responses to training load (Carfagno & Hendrix, 2014; Meeusen et al., 2013; Saw, Main, & Gastin, 2016; Soligard et al., 2016).

The most commonly used subjective measure of athletes' responses to training load is the Recovery Stress Questionnaire for Athletes (RESTQ-Sport; Kallus & Kellmann, 2016; Kellmann & Kallus, 2001), which specifically captures athletes' perceptions of stress and recovery. The RESTQ-Sport is 76 items in length and involves a hierarchical factor structure. Within this hierarchical structure, the 76 items load onto 19 total 1st order latent variables – *general stress* (GS), *emotional stress* (ES), *social stress* (SS), *conflicts/pressure* (CP), *fatigue* (F), *lack of energy* (LE), *physical complaints* (PC), *disturbed breaks* (DB), *emotional exhaustion* (EE), *injury* (I), *success* (S), *social recovery* (SR), *physical recovery* (PR), *general well-being* (GWB), *sleep quality* (SQ), *being in shape* (BIS), *personal accomplishment* (PA), *self-efficacy* (SE), and *self-regulation* (S-R). The 1st order latent variables then load on to a set of 2nd order latent variables – general stress, general recovery, sport-specific stress, and sport-specific recovery. This organization of 1st order latent variables into general and sport-specific models represents the basis of the RESTQ-Sport modular construction, covering perceptions of stress and recovery in life and sport (Kallus & Kellmann, 2016). Finally, the 2nd order latent variables load on to the

3rd order latent variables of total stress and total recovery. A visual depiction of the RESTQ-Sport hierarchical measurement model structure is provided in Figure 1.

Since the development of the measure in 2001, the RESTQ-Sport (Kellmann & Kallus, 2001) has been utilized in many experimental and field research studies, with the majority of results suggesting that the measure is responsive to both acute and chronic changes in training load (Saw et al., 2016). Given evidence surrounding the measure's responsiveness to changes in training load, researchers have recommended continued use of the RESTQ-Sport in sports medicine research and practice (Meeusen et al., 2013; Saw et al., 2016; Soligard et al., 2016). Despite these recommendations, studies utilizing item and factor analysis to establish the psychometric properties of the original measure have generated conflicting results over the past 15 years (Davis, Orzeck, Keelan, 2007; Kallus & Kellmann, 2016; Kellmann & Kallus, 2001; Martinent, Decret, Isoard-Gautheur, Filaire, & Ferrand, 2014).

Item Analysis

The performance of individual RESTQ-Sport items has been examined in several studies utilizing methods underpinned by classical test theory (CTT; Crocker & Algina, 1986). In their initial development of the measure, Kellmann and Kallus (2001) concluded that the internal consistency and test-retest reliability of RESTQ-Sport items were supported by Cronbach's alpha (α) coefficient and test-retest correlation computations. Similar evidence for the internal consistency and test-retest reliability emerged from validation studies of translated versions of the RESTQ-Sport (Costa & Samulski, 2005; Nederhof, Brink, & Lemmink, 2008). Davis et al. (2007) utilized Cronbach's alpha computations and an exploratory factor analysis (EFA) to examine item performance. Their results reinforced support for the internal consistency of RESTQ-Sport items, but refuted the previously hypothesized item loading patterns (Kellmann and Kallus, 2001). Furthermore, no research has examined the item difficulty or item discrimination parameters within the RESTQ-Sport, which are essential features of CTT and other psychometric theories such as item response theory (IRT). Thus, despite claims regarding adequate internal consistency and test-retest reliability (Davis et al., 2007; Kellmann & Kallus, 2001), surprisingly little is known regarding item performance (e.g., difficulty, discrimination, information, factor loadings) beyond reliability metrics.

Factor Analysis

The RESTQ-Sport factor structure has been examined in six separate studies (summarized in Table 8), with repeated concerns expressed regarding cross-loadings of recovery items with stress factors (Davis et al., 2007; Kellmann & Kallus, 2001; Nederhof et al., 2008). With regard to hypothesis testing of the factor structure, previous research has both supported and refuted the 1st order latent factor structures of the general and sport-specific models (Davis et al., 2007; Martinent et al., 2014). Furthermore, only weak evidence supports the 2nd order hierarchical structure of the RESTQ-Sport (Kallus & Kellmann, 2016; Martinent et al., 2014), and no evidence is available for alternative RESTQ-Sport factor structures or the complete 3rd order hierarchical factor structure (Davis et al., 2007; Martinent et al., 2014). For half of the studies conducted, researchers concluded that modifications to the RESTQ-Sport measurement model, specifically item and/or subscale deletion, would improve model fit (Davis et al., 2007; González-Boto, Salguero, Tuero, Márquez, & Kellmann, 2008; Martinent et al., 2014). It is probable that the paucity of research conducted to examine item performance is related to the conflicting results generated across examinations of the RESTQ-Sport factor structure.

Inconsistent Methods Generate Inconsistent Results

Overall, the lack of clarity and consistency in the literature emanate from apparent inconsistencies in the methods used in previous research examining the psychometric properties of the RESTQ-Sport. Previous research involving item analysis has been limited to a few select methods informed by CTT, thereby providing an incomplete depiction of overall item performance. While CTT remains a commonly used framework to guide measure construction (DeVellis, 2017), IRT procedures offer several advantages over CTT procedures. Specifically, IRT is a scale-dependent analysis that involves strong assumptions, and CTT is a sample-dependent analysis that involves comparably weaker assumptions to IRT (de Ayala, 2009; Embretson, 1996). Additionally, IRT analysis allows for graphical evaluations of individual item performance that cannot be gleaned using other modeling procedures (de Ayala, 2009; Embretson & Reise, 2000). Given the limitations in previous studies using item analysis, as well as reported concerns about measure length by sports medicine professionals (Saw, Main, & Gastin, 2015a; Taylor, Chapman, Cronin, Newton, & Gill, 2012), results from IRT procedures would be beneficial in identifying poor performing RESTQ-Sport items.

For studies involving factor analysis, three different procedures have been utilized in previous research (i.e., PCA, EFA, CFA), none of which have generated convincing conclusions about the RESTQ-Sport factor structure. It is not surprising that consensus has yet to be reached on the factor structure of the RESTQ-Sport, given the disparate purpose of each factor analysis procedure implemented. Both PCA and EFA are data-driven, exploratory procedures which are appropriate for unveiling previously unknown factors that underlie a set of measured items or indicators (Tabachnick & Fidell, 2013). Although CFA is more appropriate than PCA or EFA for hypothesis testing of *a priori* specified model structures like the RESTQ-Sport, Marsh et al. (2009) posited that factor structures identified using PCA and EFA often fail to garner support from subsequent CFA procedures. Thus, given that the RESTQ-Sport measurement model was originally supported using PCA and EFA procedures, researchers may have been limited in their ability to replicate hypothesized factor structures due to the inherent limitations of CFA (Marsh et al., 2009). Since the RESTQ-Sport is presently represented by an established yet unsupported measurement model, exploratory structural equation modeling (ESEM) may be a preferable alternative to CFA procedures for hypothesis testing (Asparouhov & Müthen, 2009; Gucciardi & Zyphur, 2015). With ESEM, the best features of EFA (i.e., structure rotation, permissible item cross-loading) *and* CFA (i.e., *a priori* hypothesis testing) are combined to allow for flexibility in the representation of a complex measurement model like that of the RESTQ-Sport (Asparouhov & Müthen, 2009; Gucciardi & Zyphur, 2015; Marsh, Nagengast, & Morin, 2013; Marsh, Morin, Parker, & Kaur, 2014).

Study Purpose

In light of the advantages and disadvantages of previous methods used for item and factor analysis, research utilizing advanced methodological procedures is warranted to provide clarity regarding the psychometric properties of the RESTQ-Sport measurement model (summary provided in Table 9). Davis et al. (2007) suggested that "without an item analysis, the previously confirmed two factor (stress and recovery) structure is misleading, since the results of the item analysis suggest disconfirmation of this structure" (p. 932). Informed by their suggestion, the purpose of the current study was to examine the psychometric properties of the RESTQ-Sport using CTT and IRT methods of item analysis, in conjunction with CFA and ESEM methods of factor analysis. For the item analysis, CTT and IRT results were compared to provide a summary of poor performing items. For the factor analysis, CFA and ESEM results were compared to identify the most parsimonious factor structure and provide recommendations for future model refinement.

Methods

Participants and Procedure

After obtaining approval from the Institutional Review Board (IRB) of the authors' affiliate university, study recruitment occurred via e-mail recruitment flyers, word-of-mouth, and personal invitation through existing collaborations. Athletes (N = 555) from a variety of sports completed an online version of the RESTQ-Sport, which required approximately 5-10 minutes of each participant's time. Participants reported a mean of 11.05 (SD = 4.45) years of experience participating in their sport, and a mean of 2.22 (S*D* = 1.62) years of experience at their current competition level. All athletes were actively participating at the collegiate, professional, or international/Olympic levels of competition at the time of data collection. Additional demographic characteristics about the participants are provided in Table 10.

Measures

Recovery Stress Questionnaire for Athletes (RESTQ-Sport). To assess athlete perceptions of stress and recovery, the 76-item version of the RESTQ-Sport (Kallus & Kellmann, 2016; Kellmann & Kallus, 2001) was administered. All items were scored on a 7-point Likert scale ranging from 0 (*never*) to 6 (*always*), and reflect perceptions of stress and recovery over the previous three days and nights.

Data Analysis

Item analysis. Item analysis was conducted using procedures informed by both CTT and IRT. For the CTT analysis, measures of central tendency and variation were computed to examine item difficulty, item-total correlations (r) were computed to examine item discrimination, and Cronbach's alpha reliability coefficients (α) were computed to examine the internal consistency of items. In addition, an EFA was performed to examine the item loading patterns on stress and recovery factors in both the general and sport-specific models. From the item correlation matrix, fixed stress and recovery factors were extracted using the principal axis factoring (PAF) method with Varimax rotation. Results of the EFA were performed and reported per the procedures used by Davis et al. (2007). All CTT analyses were performed using IBM SPSS 22 software (IBM Corp., Armonk, NY). Missing data were considered to be missing completely at random (MCAR), and treated using the default procedure in SPSS.

For the IRT analysis, item responses were analyzed using a graded response two-parameter logistic (2-PL) model. Test information function (TIF) curves and category response curves (CRC) were generated for each item. Item difficulty (*b*) and discrimination (*a*) parameters were also evaluated for each item. To meet the assumption of unidimensionality, two separate 2-PL models were performed for stress and recovery items. All IRT analyses were performed using IRTPro 3 software (Scientific Software International Inc., Skokie, IL). Missing data were considered MCAR, and treated using the default procedure in IRTPro 3.

Factor analysis. Factor analysis was conducted using both CFA and ESEM procedures. For the CFA, three models of increasing structural complexity were tested to determine the most parsimonious factor structure. Model 1 represented the 1st order factor structure, whereby the 76 items load onto 19 latent variables. Model 2 represented the structure described in Model 1 in addition to the four 2nd order general and sport-specific latent variables. Model 3 represented the structure described in Model 2 in addition to the two 3rd order total stress and recovery latent variables. Model 3, a hierarchical structure, represents the complete factor structure as originally designed by Kellmann and Kallus (2001), which is depicted in Figure 1.

For the CFA, covariance matrices were analyzed using the maximum likelihood with robust standard errors (MLR) estimation procedure. For Model 1, the unstandardized loading of one item onto each 1st order latent variable was constrained to 1.0. For Models 2 and 3, a standardization approach was utilized in which the variance of the common factor (i.e., stress, recovery) was constrained to 1.0.

For the ESEM analysis, only the 1st order general (Model 4) and sport-specific (Model 5) models were tested, as ESEM cannot be applied to hierarchical model structures (Muthén & Muthén, 2011). The covariance matrix was analyzed using the maximum likelihood with robust standard errors (MLR) estimation procedure. A target (orthogonal) rotation was applied, which allows the procedure to identify a factor loadings matrix that most aligns with matrix B (i.e., the relationships between observed variables). In both Model 4 and 5, stress and recovery were treated as EFA factors, whereby items were allowed to load freely on both factors (i.e., cross-load). The unstandardized loading of one item onto each 1st order latent variable was constrained to 1.0.

All CFA and ESEM procedures were performed using Mplus 7.0 software (Muthén & Muthén, 2011). General (Model 4) and sport-specific (Model 5) models were also examined using CFA procedures to facilitate a comparison between ESEM and CFA results. From the standardized loadings and residual variances computed for Models 4 and 5, McDonald's omega were computed for all RESTQ-Sport scales (Dunn, Baguley, & Brunsden, 2014; Nunnally & Bernstein, 1994; Schmitt, 1996; Sijtsma, 2009; Yang & Green, 2011).

For both the CFA and ESEM analysis, all missing data were assumed MCAR and treated using full information maximum likelihood (FIML) estimation for incomplete data procedures (Enders & Bandalos, 2001; Kline, 2011), which is the default procedure in Mplus 7.0 (Muthén & Muthén, 2011). Model fit was evaluated using the χ^2 (chi-square) test of fit, residuals-based indices (i.e., RMSEA, SRMR), and incremental fit indices (i.e., CFI, TLI). All calculated model fit indices were compared with recommended cut-off values (Hu & Bentler, 1999; Jackson, Gillaspy, & Purc-Stephenson, 2009; Kenny & McCoach, 2003; Marsh, Hau, & Wen, 2004), and assessed collectively to qualitatively describe the goodness of the model fit. Specifically, a good fitting measurement model is expected to meet the following criteria: a small chi-square goodness of fit test statistic (χ^2), RMSEA ≤ .06, SRMR ≤ .05, CFI ≥ 0.95, TLI ≥ 0.95. Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) comparisons were also used to evaluate model fit, as good fitting models have lower AIC and BIC values than poor fitting models. A visual summary of the hypothesized models tested is provided in Figure 2.

Results

Item Analysis

Results of the CTT item analysis demonstrated that the item difficulty parameters were lower for stress items than recovery items, meaning stress items may perform poorly among low-stress individuals (Table 11). Overall, item discrimination was not better or worse between stress and recovery items; however, weak item total correlations ($r \leq 0.3$) emerged for two sleep quality items, and one self-regulation item. Similarly, six stress items and 11 recovery items demonstrated low squared multiple correlations ($r \leq 0.5$). The internal scale consistency for stress ($\alpha = 0.96$) and recovery items ($\alpha = 0.95$) were very high, likely due to item redundancy within the two factors (Streiner, 2003).

Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity confirmed the use of EFA for all models tested. For factor loading interpretation, magnitudes of < 0.400 were considered poor and magnitudes of > 0.700 were considered good or excellent (Enders & Bandalos, 2001; Kline, 2011). The EFA results presented in Table 12 revealed potential cross-loading patterns for the *physical recovery* subscale, and results presented in Table 13 revealed additional cross-loading patterns for the *being in shape* subscale. With regard to the general model (Table 14), cross-loading concerns emerged for some *physical recovery* and *sleep quality* items. With regard to the sport-specific model (Table 15), cross-loading concerns emerged for the *being in shape* items.

Standardized local dependence (LD) χ^2 test statistics indicated that no items demonstrated consistent violation of the local independence assumption for IRT analysis. An example of CRC interpretation is provided in Figure 3. Results of the IRT item analysis were similar to the CTT item analysis in that the TIF, CRC, and item difficulty results indicated that most of the stress items functioned better among high-stress than low-stress participants (Table 16). The TIF, CRC, and item difficulty results also indicated that most of the recovery items functioned better among low-recovery than high-recovery participants, a finding that was difficult to ascertain from the CTT results. Low item discrimination parameters were observed for several of the *disturbed breaks, emotional exhaustion, and injury* items within the stress model, as well as for several of the *success, social recovery, sleep quality, personal accomplishment, and self-regulation* items within the recovery model. In visually examining the CRC figures, a total of 46 items were identified as poor performing items.

Factor Analysis

Results of the CFA indicated that Model 1 demonstrated better model fit than Model 2 or 3 (Table 17). To that end, the underperforming incremental fit indices of CFI and TLI (< 0.95) for Model 1 concurrently demonstrate room for improvement in model fit. The unstandardized and standardized parameter estimates for Model 1 are presented in Table 18.

The results of the ESEM demonstrated slightly better model fit indices than the results of the CFA for both the general (Model 4) and sport-specific (Model 5) models tested (Tables 19 and 20). When computed using the standardized loadings and residual variances from the ESEM, omega coefficient computations revealed poor internal consistency for the *success, physical recovery, and sleep quality* scales. When computed using the standardized loadings and residual variances from the CFA, omega coefficient computations revealed poor internal consistency for the *success, sleep quality,* and *injury* scales. Computed omega coefficients are reported in Table 21. Results of the ESEM demonstrated substantial cross-loading concerns among general recovery (i.e., *success*, *social recovery, physical recovery, general well-being*) and sport-specific recovery (i.e., *being in shape*, *self-efficacy*) scale items (Tables 22 and 23). Cross-loading issues were not identified for general and sport-specific stress items. A total of 40 items were identified as poor performing items from the results of the ESEM, while no item performance concerns emerged from the results of the CFA.

Discussion

The purpose of the current study was to examine the psychometric properties of the RESTQ-Sport using CTT and IRT methods of item analysis, in conjunction with CFA and ESEM methods of factor analysis. In terms of the item analysis, results of the CTT and IRT analysis indicated that stress items of the RESTQ-Sport may perform better among high-stress athletes than low-stress athletes, and that recovery items may perform better among low-recovery athletes than high-recovery athletes. Thus, the RESTQ-Sport as a complete measure may provide more information about athletes who are at high risk of overtraining (i.e., very stressed and under-recovered), than athletes who are at low risk of overtraining (i.e., not at all stressed, properly recovered). The high alpha reliability coefficients from the CTT analysis, in conjunction with the CRC figure results from the IRT analysis, also demonstrated that there is substantial item redundancy within both the stress and recovery factors. In terms of the factor analysis, no support was identified for the hierarchical factor structure of the RESTQ-Sport (Figure 1). The most parsimonious measurement model identified was Model 1, which includes only the 76-items and 19 latent subscales. The results of the ESEM analysis further revealed substantial cross-loading issues with the general (Model 4) and sport-specific (Model 5) recovery scales, a finding which was masked in the current and likely previous CFA results. A summary of poor performing items, as identified by both IRT and ESEM, is provided in Table 24.

The item analysis results of the current study were generally consistent with the results of Davis et al. (2007), yet extended the current understanding regarding the performance of individual items across stress and recovery states. In practice, the RESTQ-Sport measure is purported to be a measure that can be used to detect the early symptoms of overtraining (Meeusen et al., 2013; Saw et al., 2016). In reviewing the results of the current study, the RESTQ-Sport may not perform consistently across the full continuum of overtraining, with low discriminating power among healthy or functionally overreached athletes and high discriminating power among non-functionally overreached or severely overtrained athletes. Given the desire to identify symptoms of overtraining as early as possible, practitioners might consider pairing the RESTQ-Sport measure with other measures designed to detect symptoms of functional overreaching (e.g., session ratings of perceived exertion; Gomes, Moreira, Lodo, Capitani, & Aoki, 2015; Veugelers, Young, Fahrner, & Harvey, 2016). Based on the current findings, it is also possible that item redundancies in the model reduce the total information gained from the RESTQ-Sport as a whole. Removing underperforming items and factors might improve the performance of the RESTQ-Sport across the continuum of overreached and overtrained states.

The results of the factor analysis performed in the current study were consistent with those of previous research, which also demonstrated better model fit for the 1^{st} order simple factor structures than for the hierarchical models (González-Boto et al., 2008; Martinent et al., 2014). A further finding was that CFI and TLI, incremental fit indices, underperformed in all models tested. Given that CFI and TLI are both robust to sample size, scale reliability, and estimation methods, it is possible the hypothesized models tested involve underlying model misspecifications (Hu & Bentler, 1998). Additionally, Kline (2011) described that model fit tends to increase with model complexity, making it more probable that a hierarchical model will demonstrate better fit than a simple model. Given Kline's suggestion, and the number of potentially poor performing items identified in the current study, the item and factor redundancies may be contributing to model complexity at the expense of overall model fit. The current data also suggest that some of the best performing recovery items identified in the IRT analysis (i.e., *general well-being, being in* shape) cross-load with stress factors, which in turn may be inadvertently contributing to unnecessary model complexity.

Limitations and Directions for Future Research

The contributions of the current study to the extant literature notwithstanding, there are a number of limitations of the current methodology that prompt specific directions for future research. First, a considerable number of statistical analyses were performed using the same sample. Future research should be conducted to replicate the findings in another large sample of individuals. Second, and despite the theorized relationship between stress and recovery latent constructs (Kellmann, 2002, 2010), orthogonal rotations were used in the CTT and ESEM procedures to intentionally minimize the cross-loading potential of items on non-hypothesized factors (Asparouhov & Müthen, 2009). While future research could be conducted to replicate the current procedures with oblique rotations, it is perhaps more important that future research is first aimed at empirical investigations of the interrelation between stress states and recovery demands (Kellmann, 2002, 2010). The questions that emerged regarding the validity of recovery items and scales in the current study, in conjunction with the burgeoning body of literature on the psychology of recovery in sport, further reinforce the need for empirical investigations of recovery theory. Third, and while the current findings expand on the psychometric properties of the RESTQ-Sport in English-speaking populations, the generalizability of the findings is limited to primarily white/Caucasian collegiate athletes. Future research is warranted to explore the psychometric properties of the RESTQ-Sport in more diverse groups of English-speaking athletes, and those who may be most likely to complete the RESTQ-Sport as part of their sport monitoring protocols (e.g., professional and international/Olympic level competitors).

Conclusions

The current study is the most comprehensive examination of the RESTQ-Sport psychometric properties to date. Evidence emerged for the 1st order model structure, thereby supporting the continued validity of profile analysis (Kellmann & Günther, 2000; Kellmann, 2010) in sports medicine practice. Despite this evidence, a number of concerns were identified regarding the performance and redundancy of RESTQ-Sport items, as well as the overall validity of the hierarchical factor structure. The current findings prompt caution in using only total stress and total recovery scores in sports medicine research and practice. Since shorter published versions of the RESTQ-Sport (e.g., 52-item, 36-item) have recently surfaced in the literature (Kuan & Kueh, 2015; Laux, Krumm, Diers, & Flor, 2015; Nicolas, Vacher, Martinent, & Mourot, 2016), it is recommended that examinations of the psychometric properties for these short versions be conducted.

Figures & Tables

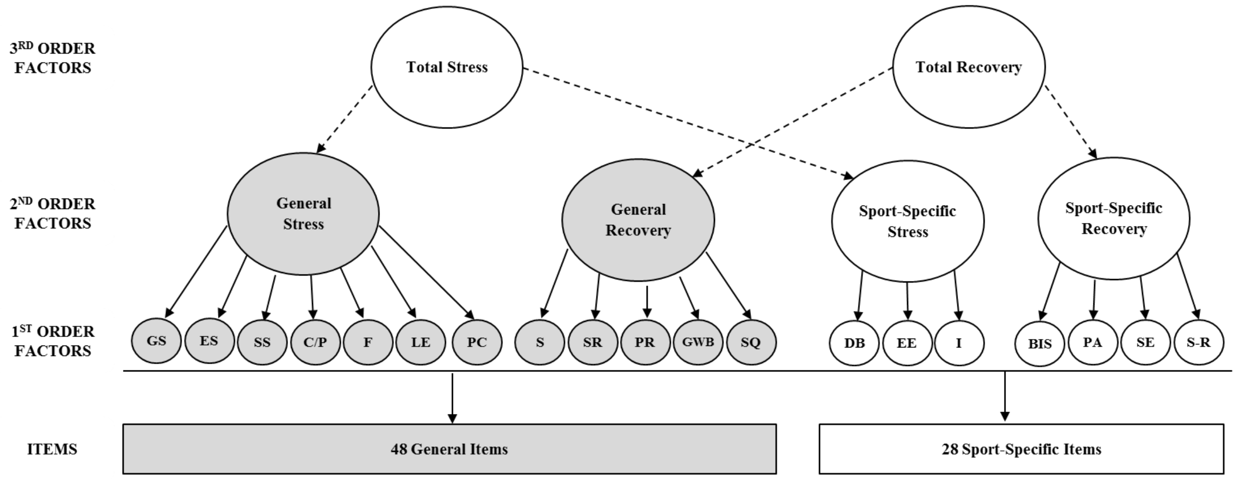

Figure 1. Hierarchical factor structure of the RESTQ-Sport. Items and latent variables associated with the general model are depicted in grey, while items and latent variables associated with the sport-specific model are depicted in white. Dotted lines represent previously untested relationships between 3rd order and 2nd order latent variables.

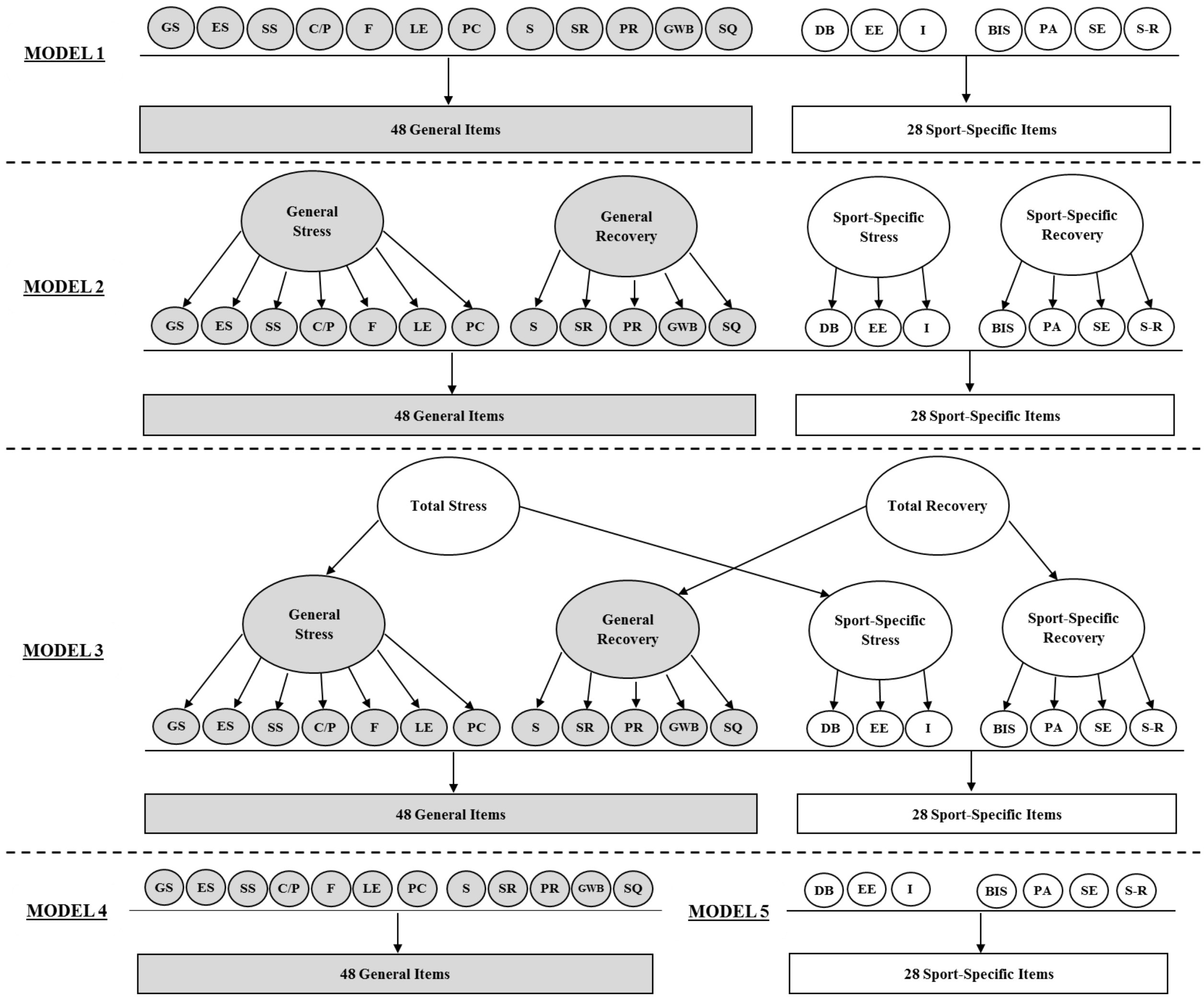

Figure 2. Hypothesized models tested.

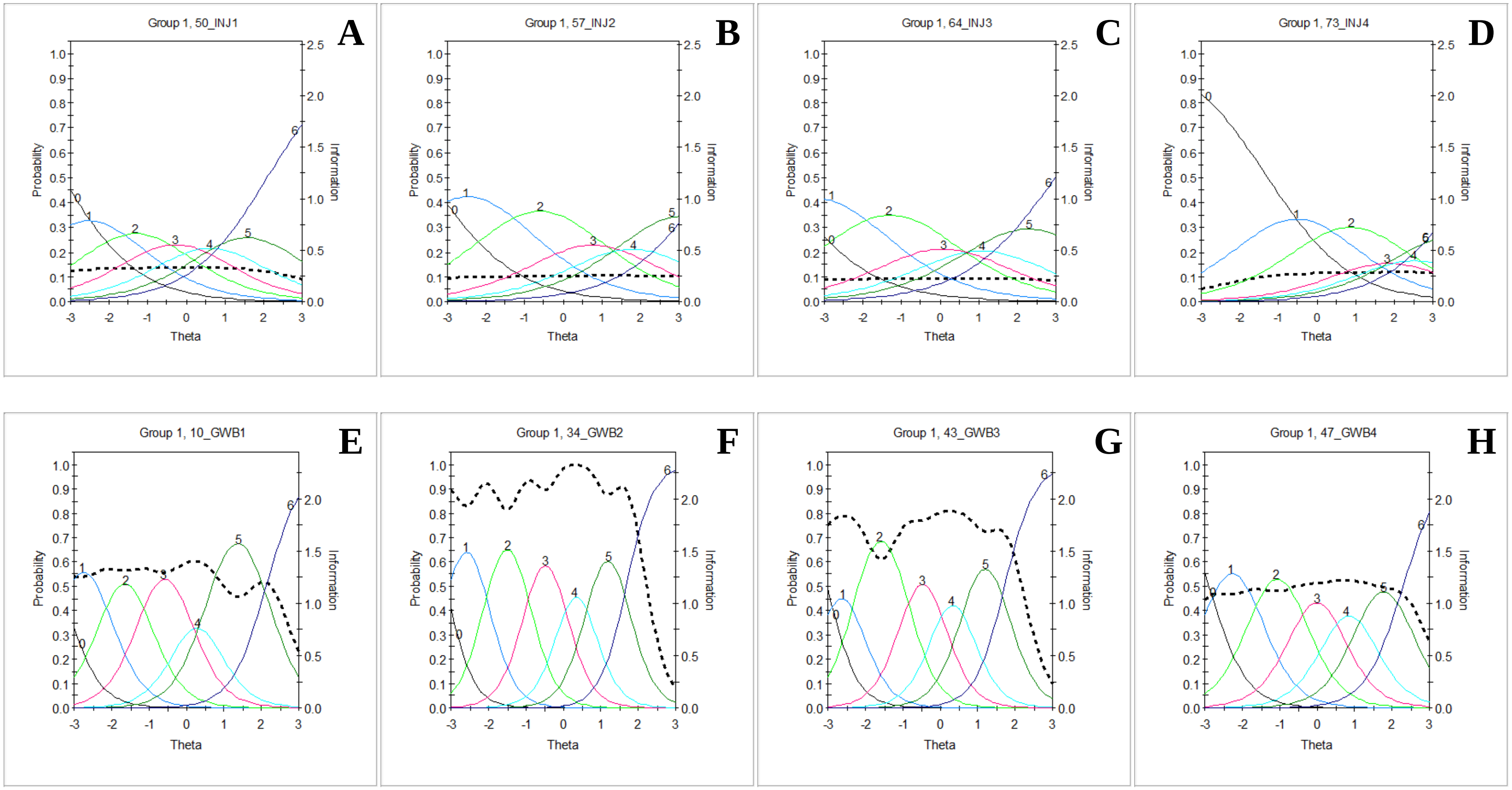

Figure 3. IRT category response curves (colored lines by response category) and total information curves (dotted line). Distributions labeled 0-6 (shown in color) correspond to the 7-point Likert scale of the RESTQ-Sport. For all curves, theta values on the x-axis correspond to the stress or recovery level needed to respond above a specific category response with 50% probability. Probability values on the y-axis correspond to the probability distribution of a category response. Injury items (A, B, C, D) are considered poor performing items, while general well-being items (E, F, G, H) are considered high performing items.

Table 8

Previous Factor Analysis Results

Study	Method	Results
Kellmann & Kallus (2001)	PCA, maximum likelihood procedure with Varimax rotation, factor-level analysis	• 19 factors loaded on 4 hierarchical factors (general stress, general recovery, sport-specific stress, sport-specific recovery) • Cross loadings for general recovery scales
Davis et al. (2007)	EFA, maximum likelihood procedure with Promax rotation, factor-level analysis	• 19 factors loaded on 4 hierarchical factors • Sleep quality subscale cross-loaded on stress factor
	EFA, maximum likelihood procedure with Promax rotation, item-level analysis	• 76 items loaded on 14 unique factors • Sleep quality item cross-loadings
Nederhof et al. (2008)	EFA, maximum likelihood procedure with oblique rotation, factor-level analysis	• Cross loadings for the general and sport-specific recovery scales
	EFA, modified 13 items, factor-level analysis	• Cross loadings for general recovery items • Concerns arising in factor analysis likely a product of inherent measurement issues as opposed to translation issues
González-Boto et al. (2008)	PCA, factor-level analysis	• 19 factors loaded on 4 hierarchical factors
	CFA, maximum likelihood procedures	• Poor fit of 4-factor hierarchical model • Modification indices revealed 55 items which could be removed to improve model fit • Recursive model demonstrated good model fit
Martinent et al. (2014)	CFA, maximum likelihood procedures	• No support for the model proposed by Davis et al. (2007) • Good fit of the general and sport-specific 1st order models • Fair fit of general hierarchical model • Fair fit of sport-specific hierarchical model • Fair fit of 67-item, 17-factor hierarchical model (success and social recovery factors omitted)
Kallus & Kellmann (2016)	SEM (undefined procedures), factor-level analysis	• Good fit of general and sport-specific models, use of 19 subscales as indicators

Note. PCA = principal components analysis, EFA = exploratory factor analysis, CFA = confirmatory factor analysis, SEM = structural equation modeling.

Table 9

Advantages and Disadvantages of Common Methods for Psychometric Evaluation

Method	Advantages	Disadvantages	Citation
Item Analysis			
CTT	• Readily accessible (software) • Item difficulty and discrimination parameters	• Sample-dependent analysis • Data-driven procedures • Results often difficult to replicate	Crocker & Algina (1986) De Ayala (2009)
IRT	• Scale-dependent analysis • Stronger assumptions than CTT • Item difficulty and discrimination parameters • Visual analysis of item performance	• Limited model fit interpretation	De Ayala (2009) Embretson & Reise (2000)
Factor Analysis			
PCA	• Data-driven procedure • Exploratory procedure • Cross-loading permitted • Rotations permitted	• Involves few assumptions • Not suitable for hypothesis testing • Results often difficult to replicate	Tabachnick & Fidell (2013)
EFA	• Data-driven procedure • Exploratory procedure • Cross-loading permitted • Rotations permitted	• Involves few assumptions • Not suitable for hypothesis testing • Results often difficult to replicate	Tabachnick & Fidell (2013)
CFA	• Confirmatory procedure for hypothesis testing • Stronger assumptions than PCA or EFA	• Cross-loading not permitted • Rotation not permitted • Rigid methods of parameter estimation	Gucciardi & Zyphur (2015) Tabachnick & Fidell (2013)

ESEM	• Combines the best features of EFA and CFA
	  • Cross-loadings
	  • Rotation
	  • Hypothesis testing
	  • Stronger assumptions than PCA or EFA
			Asparouhov & Múthen (2009)
			Gucciardi & Zyphur (2015)
			Marsh et al. (2014)

Note. CTT = classical test theory, IRT = item response theory, PCA = principal components analysis, EFA = exploratory factor analysis, CFA = confirmatory factor analysis, ESEM = exploratory structural equation modeling.

Table 10

Athlete Demographic Characteristics

Characteristic	Percent by Category (*N* = 555)
Gender	
Male	32.9%
Female	67.1%
Race/Ethnicity	
Caucasian/White	88.6%
Black/African American	4.0%
Latino/a or Hispanic	0.7%
Asian	3.8%
Native American	0.4%
Other	2.6%
Nationality	
American (USA)	87.4%
Canadian	6.7%
British or English	2.9%
Australian	0.5%
Other	2.5%
Season Status	
Pre-Season or Training Camp	11.7%
In-Season	66.1%
Off-Season	20.6%
Other	1.6%
Competition Level	
NCAA Division III	34.1%
NCAA Division II	14.1%
NCAA Division I	40.9%
CCAA	2.9%
BUCS	2.9%
Professional (NGB)	2.2%
International/Olympic	1.4%
Other	1.6%

Note. NCAA = National Collegiate Athletic Association, CCAA = Canadian Collegiate Athletic Association, BUCS = British Universities & Colleges Sport, NGB = National Governing Body.

Table 11

CTT Analysis of RESTQ-Sport Stress and Recovery Scales

Stress (α = .96)						
Item	Mean	Median	s^2	Item-Total r	Squared Multiple r	α if deleted
22_GS1	1.65	1.00	1.76	0.72	0.74	0.96
24_GS2	0.92	0.00	1.61	0.63	0.66	0.96
30_GS3	1.44	1.00	2.11	0.73	0.73	0.96
45_GS4	1.41	1.00	2.23	0.74	0.69	0.96
5_ES1	1.46	1.00	1.55	0.72	0.66	0.96
8_ES2	1.67	1.00	1.26	0.69	0.66	0.96
28_ES3	1.80	1.00	2.30	0.71	0.64	0.96
37_ES4	1.87	2.00	1.63	0.75	0.80	0.96
21_SS1	2.17	2.00	1.76	0.65	0.76	0.96
26_SS2	2.00	2.00	1.94	0.69	0.80	0.96
39_SS3	1.52	1.00	1.53	0.72	0.71	0.96
48_SS4	1.35	1.00	1.68	0.61	0.57	0.96
12_CP1	2.46	2.00	2.24	0.65	0.55	0.96
18_CP2	2.29	2.00	2.58	0.54	0.43	0.96
32_CP3	2.20	2.00	2.24	0.56	0.44	0.96
44_CP4	2.66	2.00	2.55	0.67	0.58	0.96
2_F1	2.53	2.00	2.61	0.51	0.44	0.96
16_F2	2.28	2.00	2.83	0.54	0.61	0.96
25_F3	1.77	1.00	2.98	0.62	0.67	0.96
35_F4	2.37	2.00	2.62	0.67	0.67	0.96
4_LE1	2.07	2.00	1.61	0.54	0.55	0.96
11_LE2	1.88	2.00	1.47	0.62	0.62	0.96
31_LE3	1.68	2.00	1.80	0.60	0.49	0.96
40_LE4	1.87	2.00	2.23	0.51	0.41	0.96
7_PC1	1.96	2.00	1.82	0.61	0.52	0.96
15_PC2	1.32	1.00	2.07	0.44	0.29	0.96
20_PC3	1.68	1.00	1.71	0.66	0.54	0.96
42_PC4	2.65	2.00	2.50	0.64	0.64	0.96
51_DB1	1.71	1.00	1.92	0.60	0.46	0.96
58_DB2	1.51	1.00	1.89	0.45	0.53	0.96
66_DB3	1.21	1.00	1.52	0.45	0.54	0.96
72_DB4	1.21	1.00	1.24	0.45	0.50	0.96
54_EE1	1.81	2.00	2.56	0.58	0.56	0.96
63_EE2	2.16	2.00	2.59	0.65	0.57	0.96
68_EE3	0.98	0.00	2.15	0.47	0.51	0.96
76_EE4	2.33	2.00	2.60	0.64	0.56	0.96

Item	Mean	Median	s^2	Item-Total *r*	Squared Multiple *r*	α if deleted
50_I1	3.33	3.00	3.08	0.52	0.54	0.96
57_I2	2.59	2.00	2.35	0.49	0.50	0.96
64_I3	3.09	3.00	2.68	0.45	0.53	0.96
73_I4	1.68	1.00	2.56	0.46	0.32	0.96
			Recovery (α = 95)			
3_SUC1	4.09	4.00	1.85	0.41	0.34	0.95
17_SUC2	3.48	3.00	1.43	0.61	0.49	0.95
41_SUC3	2.23	2.00	1.68	0.28	0.18	0.95
49_SUC4	2.94	3.00	1.56	0.54	0.43	0.95
6_SR1	4.28	5.00	1.92	0.57	0.60	0.95
14_SR2	3.82	4.00	2.03	0.65	0.70	0.94
23_SR3	2.60	3.00	3.17	0.41	0.37	0.95
33_SR4	3.74	4.00	1.95	0.69	0.77	0.94
9_PR1	2.37	2.00	1.65	0.51	0.50	0.95
13_PR2	2.71	2.00	1.79	0.61	0.60	0.95
29_PR3	3.57	4.00	2.19	0.65	0.54	0.94
38_PR4	2.47	2.00	2.26	0.56	0.45	0.95
10_GWB1	3.63	4.00	1.68	0.70	0.69	0.94
34_GWB2	3.60	3.00	1.75	0.76	0.80	0.94
43_GWB3	3.59	3.00	1.78	0.71	0.69	0.94
47_GWB4	3.05	3.00	1.91	0.65	0.57	0.94
19_SQ1	2.65	2.00	2.33	0.62	0.67	0.95
27_SQ2	2.75	3.00	2.37	0.56	0.60	0.95
36_SQ3	4.09	4.00	2.50	0.28	0.50	0.95
46_SQ4	4.43	5.00	2.62	0.31	0.46	0.95
53_BIS1	2.86	3.00	1.74	0.64	0.57	0.94
61_BIS2	3.38	3.00	2.05	0.64	0.57	0.94
69_BIS3	2.96	3.00	1.99	0.67	0.51	0.94
75_BIS4	3.28	3.00	2.04	0.72	0.67	0.94
55_PA1	2.95	3.00	1.99	0.59	0.55	0.95
60_PA2	2.88	3.00	1.94	0.53	0.45	0.95
70_PA3	3.03	3.00	2.08	0.42	0.35	0.95
77_PA4	3.15	3.00	2.32	0.42	0.30	0.95
52_SE1	3.14	3.00	2.00	0.71	0.59	0.94
59_SE2	2.74	2.00	2.02	0.64	0.54	0.94
65_SE3	3.06	3.00	2.13	0.66	0.63	0.94
71_SE4	3.38	3.00	2.18	0.69	0.68	0.94
56_S-R1	3.27	3.00	2.18	0.61	0.59	0.95
62_S-R2	4.39	5.00	1.92	0.53	0.52	0.95
67_S-R3	2.75	2.00	2.74	0.33	0.38	0.95
74_S-R4	3.28	3.00	2.68	0.55	0.53	0.95

Table 12

General Stress and Recovery Subscale Rotated Pattern Matrix

General Subscales	Communalities	Factor 1: Stress	Factor 2: Recovery
General Stress	.766	.806	-.341
Emotional Stress	.805	.855	-.274
Social Stress	.609	.753	-.203
Conflicts/Pressure	.684	.809	-.171
Fatigue	.512	.709	-.098
Lack of Energy	.530	.703	-.188
Physical Complaints	.672	.806	-.150
Success	.411	-.058	.638
Social Recovery	.598	-.138	.761
Physical Recovery	.677	-.417	.710
General Well-being	.855	-.342	.859
Sleep Quality	.512	-.608	.377
Variance (%)		54.498	12.092
Eigenvalues		6.180	1.451

Table 13

Sport-Specific Stress and Recovery Subscale Rotated Pattern Matrix

Sport-Specific Subscales	Communalities	Factor 2: Stress	Factor 1: Recovery
Disturbed Breaks	.548	.729	-.128
Emotional Exhaustion	.581	.725	-.234
Injury	.483	.695	.013
Being in Shape	.729	-.421	.743
Personal Accomplishment	.570	-.081	.750
Self-efficacy	.795	-.244	.857
Self-regulation	.663	.061	.812
Variance (%)		18.597	43.800
Eigenvalues		1.734	3.399

Table 14

General Stress and Recovery Item Rotated Pattern Matrix

Items	Communalities	Stress Factor	Recovery Factor
22_GS1	.645	.707	-.381
24_GS2	**.473**	**.615**	**-.306**
30_GS3	.624	.714	-.339
45_GS4	.589	.708	-.295
5_ES1	.567	.704	-.267
8_ES2	**.566**	**.660**	**-.361**
28_ES3	.574	.722	-.230
37_ES4	.642	.766	-.237
21_SS1	.493	.675	-.194
26_SS2	.549	.708	-.219
39_SS3	.570	.695	-.295
48_SS4	.412	.626	-.144
12_CP1	.470	.648	-.223
18_CP2	.334	.547	-.188
32_CP3	.331	.571	-.068
44_CP4	.461	.667	-.125
2_F1	.302	.549	-.027
16_F2	.328	.572	-.017
25_F3	.385	.616	-.077
35_F4	.477	.689	-.044
4_LE1	.332	.571	-.073
11_LE2	.410	.621	-.155
31_LE3	.383	.593	-.178
40_LE4	.288	.523	-.122
7_PC1	.365	.595	-.102
15_PC2	.226	.454	-.141
20_PC3	.489	.652	-.254
42_PC4	.436	.659	.037
3_SUC1	.174	-.038	.416
17_SUC2	.377	-.150	.595
41_SUC3	.111	.102	.317
49_SUC4	.273	-.080	.517
6_SR1	.505	-.055	.708
14_SR2	.633	-.125	.786
23_SR3	.250	-.051	.497
33_SR4	.723	-.183	.830
9_PR1	**.355**	**-.421**	**.421**
13_PR2	**.519**	**-.429**	**.579**
29_PR3	.374	-.167	.589
38_PR4	**.308**	**-.276**	**.482**
10_GWB1	.677	-.287	.771
34_GWB2	.793	-.315	.833
43_GWB3	.671	-.289	.766
47_GWB4	.517	-.295	.655
19_SQ1	.490	-.472	.517
27_SQ2	**.374**	**-.439**	**.426**
36_SQ3	**.370**	**-.600**	**.100**
46_SQ4	**.295**	**-.528**	**.129**
Variance (%)		35.831	8.979
Eigenvalues		17.703	4.820

Note. Bold indicates potential cross-loading or inappropriate factor loading.

Table 15

Sport-Specific Stress and Recovery Item Rotated Pattern Matrix

Items	Communalities	Stress Factor	Recovery Factor
51_DB1	.337	.567	-.125
58_DB2	.381	.610	-.095
66_DB3	.365	.600	-.070
72_DB4	.321	.558	-.098
54_EE1	.498	.693	-.133
63_EE2	.531	.717	-.133
68_EE3	.297	.467	-.282
76_EE4	.434	.620	-.222
50_I1	.323	.563	.078
57_I2	.440	.663	.025
64_I3	.399	.622	.113
73_I4	.217	.446	-.133
53_BIS1	**.479**	**-.458**	**.519**
61_BIS2	.446	-.237	.624
69_BIS3	.443	-.276	.606
75_BIS4	.641	-.305	.740
55_PA1	.482	-.090	.689
60_PA2	.333	.000	.577
70_PA3	.219	.018	.468
77_PA4	.210	-.101	.447
52_SE1	.502	-.230	.670
59_SE2	.520	-.227	.684
65_SE3	.573	-.203	.729
71_SE4	.642	-.141	.789
56_S-R1	.553	-.082	.739
62_S-R2	.526	.109	.717
67_S-R3	.297	.144	.525
74_S-R4	.466	-.006	.683
Variance (%)		13.364	29.057
Eigenvalues		4.327	8.662

Note. Bold indicates potential cross-loading or inappropriate factor loading.

Table 16

IRT Analysis of RESTQ-Sport Stress and Recovery Scales

Item	λ	*a* (*s.e.*)	b_1 (*s.e.*)	b_2 (*s.e.*)	b_3 (*s.e.*)	b_4 (*s.e.*)	b_5 (*s.e.*)	b_6 (*s.e.*)
				Stress				
22_GS1	0.82	2.48 (0.19)	-1.09 (0.12)	0.06 (0.07)	0.97 (0.06)	1.52 (0.09)	2.14 (0.13)	3.02 (0.27)
24_GS2	0.77	2.05 (0.18)	0.02 (0.07)	0.94 (0.07)	1.59 (0.10)	2.04 (0.13)	2.60 (0.19)	3.30 (0.32)
30_GS3	0.85	2.73 (0.21)	-0.61 (0.10)	0.42 (0.06)	0.98 (0.06)	1.46 (0.08)	1.86 (0.11)	2.97 (0.26)
45_GS4	0.82	2.47 (0.20)	-0.54 (0.10)	0.40 (0.06)	1.04 (0.06)	1.46 (0.08)	1.95 (0.11)	2.63 (0.19)
5_ES1	0.81	2.33 (0.18)	-1.01 (0.12)	0.31 (0.06)	1.26 (0.08)	1.75 (0.10)	2.25 (0.15)	3.41 (0.37)
8_ES2	0.80	2.29 (0.18)	-1.58 (0.16)	0.00 (0.07)	1.18 (0.07)	1.78 (0.11)	2.51 (0.18)	3.75 (0.50)
28_ES3	**0.81**	**2.32 (0.18)**	**-1.04 (0.12)**	**-0.01 (0.07)**	**0.78 (0.06)**	**1.27 (0.07)**	**1.87 (0.11)**	**2.59 (0.19)**
37_ES4	**0.86**	**2.81 (0.22)**	**-1.57 (0.15)**	**-0.12 (0.07)**	**0.82 (0.06)**	**1.42 (0.08)**	**2.00 (0.12)**	**2.99 (0.27)**
21_SS1	**0.74**	**1.88 (0.15)**	**-2.16 (0.20)**	**-0.60 (0.10)**	**0.71 (0.07)**	**1.35 (0.09)**	**2.00 (0.13)**	**3.00 (0.25)**
26_SS2	**0.78**	**2.15 (0.17)**	**-1.65 (0.16)**	**-0.26 (0.08)**	**0.74 (0.06)**	**1.38 (0.08)**	**1.98 (0.13)**	**2.67 (0.20)**
39_SS3	0.83	2.55 (0.20)	-1.10 (0.12)	0.24 (0.06)	1.19 (0.07)	1.66 (0.09)	2.31 (0.15)	2.98 (0.26)
48_SS4	0.70	1.67 (0.14)	-0.89 (0.13)	0.52 (0.07)	1.45 (0.10)	2.04 (0.15)	2.64 (0.21)	3.69 (0.38)
12_CP1	**0.70**	**1.67 (0.14)**	**-1.93 (0.19)**	**-0.84 (0.12)**	**0.19 (0.08)**	**1.01 (0.08)**	**1.78 (0.12)**	**2.88 (0.23)**
18_CP2	0.61	1.32 (0.12)	-2.10 (0.23)	-0.52 (0.11)	0.55 (0.08)	1.21 (0.11)	1.89 (0.15)	2.95 (0.26)
32_CP3	0.61	1.32 (0.12)	-1.87 (0.21)	-0.65 (0.12)	0.60 (0.08)	1.39 (0.12)	2.24 (0.18)	3.38 (0.31)
44_CP4	**0.69**	**1.64 (0.14)**	**-2.06 (0.21)**	**-0.96 (0.13)**	**0.02 (0.08)**	**0.77 (0.07)**	**1.48 (0.10)**	**2.50 (0.19)**
2_F1	0.53	1.05 (0.11)	-2.63 (0.30)	-0.99 (0.15)	0.26 (0.10)	1.14 (0.12)	1.92 (0.19)	3.46 (0.35)
16_F2	0.57	1.18 (0.12)	-1.51 (0.19)	-0.76 (0.13)	0.30 (0.09)	1.26 (0.12)	2.09 (0.19)	3.43 (0.34)
25_F3	0.66	1.48 (0.14)	-0.72 (0.12)	0.06 (0.08)	0.87 (0.08)	1.41 (0.11)	2.03 (0.16)	3.02 (0.27)
35_F4	0.68	1.59 (0.14)	-1.81 (0.19)	-0.61 (0.11)	0.40 (0.07)	0.98 (0.08)	1.66 (0.12)	2.70 (0.22)
4_LE1	0.63	1.37 (0.13)	-2.50 (0.26)	-0.57 (0.11)	0.99 (0.09)	1.72 (0.14)	2.48 (0.21)	4.18 (0.47)
11_LE2	0.68	1.56 (0.14)	-1.99 (0.20)	-0.34 (0.09)	1.12 (0.09)	1.81 (0.13)	2.59 (0.21)	4.01 (0.45)
31_LE3	0.65	1.45 (0.13)	-1.29 (0.16)	-0.05 (0.09)	1.24 (0.10)	1.88 (0.15)	2.85 (0.25)	4.06 (0.45)
40_LE4	0.58	1.21 (0.12)	-1.58 (0.19)	-0.15 (0.10)	1.03 (0.10)	1.86 (0.16)	2.57 (0.23)	3.36 (0.32)
7_PC1	0.65	1.44 (0.13)	-1.85 (0.20)	-0.40 (0.10)	1.02 (0.09)	1.71 (0.13)	2.37 (0.19)	3.77 (0.39)
15_PC2	0.52	1.04 (0.12)	-0.57 (0.13)	0.56 (0.10)	1.68 (0.17)	2.54 (0.25)	3.44 (0.36)	4.79 (0.59)
20_PC3	0.76	1.97 (0.17)	-1.30 (0.14)	0.04 (0.07)	1.09 (0.08)	1.71 (0.11)	2.31 (0.16)	3.23 (0.30)
42_PC4	**0.65**	**1.47 (0.13)**	**-2.44 (0.25)**	**-0.95 (0.13)**	**0.15 (0.08)**	**0.82 (0.08)**	**1.48 (0.11)**	**2.89 (0.25)**
51_DB1	0.67	1.52 (0.14)	-1.32 (0.16)	0.00 (0.08)	1.09 (0.09)	1.82 (0.14)	2.54 (0.20)	3.50 (0.34)
58_DB2	0.47	0.90 (0.11)	-1.32 (0.21)	0.33 (0.11)	1.81 (0.20)	2.79 (0.31)	3.82 (0.44)	5.20 (0.68)
66_DB3	0.50	0.97 (0.11)	-0.98 (0.17)	1.01 (0.13)	2.33 (0.25)	3.12 (0.34)	4.00 (0.46)	5.48 (0.75)
72_DB4	0.48	0.93 (0.11)	-1.14 (0.19)	0.88 (0.12)	2.50 (0.27)	3.77 (0.43)	4.79 (0.60)	7.18 (1.30)
54_EE1	0.58	1.21 (0.12)	-1.24 (0.17)	-0.05 (0.09)	1.06 (0.11)	1.76 (0.16)	2.35 (0.21)	3.31 (0.33)
63_EE2	0.68	1.58 (0.14)	-1.60 (0.18)	-0.41 (0.10)	0.56 (0.07)	1.18 (0.09)	1.79 (0.13)	2.71 (0.22)
68_EE3	0.49	0.95 (0.11)	0.30 (0.10)	1.24 (0.15)	2.33 (0.25)	2.85 (0.31)	3.45 (0.39)	4.51 (0.55)
76_EE4	0.64	1.42 (0.13)	-1.92 (0.20)	-0.68 (0.12)	0.52 (0.08)	1.14 (0.10)	1.80 (0.14)	2.59 (0.22)

Item	λ	*a* (*s.e.*)	b_1 (*s.e.*)	b_2 (*s.e.*)	b_3 (*s.e.*)	b_4 (*s.e.*)	b_5 (*s.e.*)	b_6 (*s.e.*)
50_I1	0.51	1.01 (0.11)	-3.20 (0.37)	-1.86 (0.23)	-0.74 (0.14)	0.18 (0.10)	1.05 (0.12)	2.09 (0.21)
57_I2	0.46	0.89 (0.11)	-3.48 (0.44)	-1.46 (0.21)	0.25 (0.11)	1.29 (0.16)	2.26 (0.25)	3.86 (0.45)
64_I3	0.45	0.85 (0.10)	-4.22 (0.54)	-2.14 (0.29)	-0.43 (0.13)	0.59 (0.12)	1.57 (0.19)	2.99 (0.35)
73_I4	0.48	0.94 (0.11)	-1.27 (0.19)	0.20 (0.10)	1.52 (0.17)	2.18 (0.24)	2.89 (0.32)	4.02 (0.47)
				Recovery				
3_SUC1	0.46	0.88 (0.09)	-6.76 (1.03)	-4.59 (0.53)	-2.40 (0.26)	-0.82 (0.13)	0.41 (0.11)	1.95 (0.22)
17_SUC2	**0.70**	**1.65 (0.12)**	**-3.88 (0.42)**	**-2.67 (0.21)**	**-1.19 (0.09)**	**0.07 (0.07)**	**1.19 (0.10)**	**2.50 (0.19)**
41_SUC3	0.26	0.46 (0.08)	-6.08 (1.10)	-2.02 (0.39)	1.26 (0.29)	3.70 (0.67)	6.14 (1.11)	9.10 (1.72)
49_SUC4	**0.58**	**1.21 (0.10)**	**-4.13 (0.43)**	**-2.16 (0.19)**	**-0.49 (0.09)**	**0.85 (0.10)**	**1.98 (0.18)**	**3.73 (0.36)**
6_SR1	0.65	1.47 (0.12)	-5.00 (0.77)	-3.06 (0.26)	-1.80 (0.14)	-0.73 (0.08)	-0.04 (0.07)	1.23 (0.11)
14_SR2	**0.75**	**1.90 (0.14)**	**-3.05 (0.25)**	**-2.21 (0.15)**	**-1.15 (0.09)**	**-0.31 (0.06)**	**0.45 (0.07)**	**1.66 (0.12)**
23_SR3	0.47	0.91 (0.09)	-2.15 (0.23)	-1.12 (0.14)	-0.13 (0.10)	0.95 (0.13)	1.96 (0.21)	3.34 (0.35)
33_SR4	**0.81**	**2.31 (0.16)**	**-3.43 (0.36)**	**-2.06 (0.13)**	**-1.03 (0.07)**	**-0.16 (0.05)**	**0.57 (0.06)**	**1.49 (0.10)**
9_PR1	0.57	1.17 (0.10)	-3.26 (0.30)	-1.13 (0.12)	0.39 (0.09)	1.55 (0.15)	2.64 (0.24)	4.17 (0.43)
13_PR2	**0.70**	**1.65 (0.12)**	**-3.02 (0.25)**	**-1.39 (0.11)**	**-0.05 (0.06)**	**0.80 (0.08)**	**1.67 (0.13)**	**3.12 (0.26)**
29_PR3	**0.70**	**1.68 (0.12)**	**-3.21 (0.28)**	**-1.98 (0.14)**	**-0.96 (0.08)**	**-0.06 (0.06)**	**0.73 (0.08)**	**1.83 (0.14)**
38_PR4	0.61	1.30 (0.11)	-2.45 (0.20)	-1.09 (0.13)	0.29 (0.0)	1.19 (0.12)	2.02 (0.17)	2.81 (0.24)
10_GWB1	**0.78**	**2.15 (0.15)**	**-3.33 (0.32)**	**-2.17 (0.14)**	**-1.13 (0.08)**	**-0.03 (0.05)**	**0.60 (0.07)**	**2.12 (0.14)**
34_GWB2	**0.86**	**2.82 (0.19)**	**-3.13 (0.30)**	**-2.06 (0.13)**	**-0.96 (0.06)**	**0.00 (0.05)**	**0.69 (0.06)**	**1.68 (0.11)**
43_GWB3	**0.83**	**2.51 (0.17)**	**-3.02 (0.26)**	**-2.25 (0.15)**	**-0.92 (0.07)**	**-0.03 (0.05)**	**0.69 (0.07)**	**1.72 (0.11)**
47_GWB4	**0.76**	**2.00 (0.14)**	**-2.89 (0.23)**	**-1.65 (0.11)**	**-0.47 (0.06)**	**0.45 (0.06)**	**1.25 (0.09)**	**2.29 (0.16)**
19_SQ1	**0.67**	**1.55 (0.12)**	**-2.76 (0.22)**	**-1.04 (0.09)**	**0.14 (0.07)**	**0.80 (0.09)**	**1.44 (0.12)**	**2.74 (0.22)**
27_SQ2	**0.61**	**1.31 (0.11)**	**-2.83 (0.24)**	**-1.25 (0.11)**	**-0.09 (0.08)**	**0.79 (0.10)**	**1.58 (0.14)**	**2.82 (0.24)**
36_SQ3	0.35	0.64 (0.09)	-5.66 (0.80)	-3.85 (0.52)	-2.67 (0.37)	-1.63 (0.25)	0.18 (0.14)	2.42 (0.34)
46_SQ4	0.39	0.72 (0.09)	-4.86 (0.63)	-3.69 (0.46)	-2.73(0.34)	-2.04 (0.26)	-0.62 (0.14)	1.24 (0.19)
53_BIS1	**0.69**	**1.61 (0.12)**	**-3.13 (0.26)**	**-1.62 (0.12)**	**-0.28 (0.07)**	**0.78 (0.08)**	**1.69 (0.13)**	**2.76 (0.22)**
61_BIS2	**0.70**	**1.65 (0.12)**	**-3.12 (0.26)**	**-2.03 (0.15)**	**-0.85 (0.08)**	**0.17 (0.07)**	**1.03 (0.09)**	**2.01 (0.15)**
69_BIS3	**0.71**	**1.70 (0.13)**	**-3.22 (0.28)**	**-1.65 (0.12)**	**-0.23 (0.06)**	**0.61 (0.07)**	**1.39 (0.11)**	**2.28 (0.17)**
75_BIS4	**0.76**	**1.97 (0.14)**	**-2.81 (0.22)**	**-1.70 (0.11)**	**-0.65 (0.07)**	**0.20 (0.06)**	**1.03 (0.09)**	**2.12 (0.15)**
55_PA1	**0.63**	**1.39 (0.11)**	**-3.13 (0.27)**	**-1.73 (0.14)**	**-0.35 (0.08)**	**0.61 (0.09)**	**1.61 (0.14)**	**2.90 (0.24)**
60_PA2	**0.57**	**1.19 (0.10)**	**-3.07 (0.28)**	**-1.94 (0.17)**	**-0.35 (0.08)**	**0.84 (0.10)**	**1.87 (0.17)**	**3.30 (0.30)**
70_PA3	0.48	0.92 (0.09)	-4.44 (0.50)	-2.39 (0.25)	-0.50 (0.11)	0.78 (0.12)	1.91 (0.21)	3.39 (0.35)
77_PA4	0.49	0.95 (0.09)	-4.12 (0.44)	-2.39 (0.24)	-0.6 (0.11)5	0.50 (0.11)	1.53 (0.17)	3.02 (0.31)
52_SE1	**0.75**	**1.92 (0.14)**	**-3.18 (0.28)**	**-1.64 (0.11)**	**-0.54 (0.06)**	**0.45 (0.07)**	**1.13 (0.09)**	**2.07 (0.15)**
59_SE2	**0.64**	**1.43 (0.11)**	**-3.20 (0.28)**	**-1.46 (0.12)**	**-0.03 (0.07)**	**0.83 (0.09)**	**1.70 (0.14)**	**2.63 (0.22)**
65_SE3	**0.68**	**1.58 (0.12)**	**-2.79 (0.23)**	**-1.64 (0.12)**	**-0.45 (0.07)**	**0.36 (0.07)**	**1.30 (0.11)**	**2.72 (0.21)**
71_SE4	**0.73**	**1.83 (0.13)**	**-2.75 (0.21)**	**-1.88 (0.13)**	**-0.73 (0.07)**	**0.20 (0.06)**	**0.91 (0.08)**	**1.93 (0.14)**
56_S-R1	**0.64**	**1.40 (0.11)**	**-2.96 (0.25)**	**-1.88 (0.15)**	**-0.84 (0.09)**	**0.27 (0.08)**	**1.21 (0.11)**	**2.44 (0.20)**
62_S-R2	0.56	1.14 (0.10)	-5.08 (0.64)	-3.47 (0.33)	-2.35 (0.21)	-0.97 (0.11)	-0.02 (0.08)	1.13 (0.13)
67_S-R3	0.30	0.54 (0.08)	-4.97 (0.78)	-2.35 (0.38)	-0.03 (0.16)	1.57 (0.28)	2.81 (0.45)	5.00 (0.78)
74_S-R4	0.55	1.12 (0.10)	-3.43 (0.33)	-1.90 (0.17)	-0.78 (0.10)	0.25 (0.09)	1.14 (0.13)	2.27 (0.21)

Note. Bold indicates the best performing items.

Table 17

CFA Model Comparisons by Fit Indices

	AIC	BIS	χ^2	*p*	RMSEA (90% CI)	SRMR	CFI	TLI
Model 1	114379	116051	5702.168	< .001	.049 (.048 – .051)	.066	.839	.823
Model 2	115353	116412	6809.153	< .001	.055 (.053 – .057)	.084	.789	.781
Model 3	115363	116419	22059.530	< .001	.055 (.053 – .057)	.085	.788	.780

Table 18

Model 1 CFA Standardized Parameter Estimate Comparisons

	Unstandardized Estimate (*S.E.*)	Standardized Estimate (*S.E.*)	R^2 (*S.E.*)
General Stress			
22_GS1	1.000 (0.000)	0.847 (0.018)	0.717 (0.030)
24_GS2	0.833 (0.046)	0.739 (0.027)	0.546 (0.040)
30_GS3	1.074 (0.060)	0.823 (0.020)	0.678 (0.032)
45_GS4	1.027 (0.057)	0.770 (0.023)	0.592 (0.035)
Emotional Stress			
5_ES1	1.000 (0.000)	0.747 (0.026)	0.558 (0.038)
8_ES2	0.980 (0.056)	0.778 (0.022)	0.605 (0.035)
28_ES3	1.079 (0.073)	0.676 (0.032)	0.457 (0.043)
37_ES4	1.197 (0.070)	0.862 (0.017)	0.743 (0.030)
Social Stress			
21_SS1	1.000 (0.000)	0.842 (0.025)	0.709 (0.042)
26_SS2	1.073 (0.035)	0.871 (0.019)	0.758 (0.034)
39_SS3	0.814 (0.066)	0.774 (0.030)	0.598 (0.046)
48_SS4	0.823 (0.057)	0.669 (0.035)	0.488 (0.049)
Conflicts/Pressure			
12_CP1	1.000 (0.000)	0.731 (0.029)	0.534 (0.042)
18_CP2	0.909 (0.060)	0.631 (0.035)	0.398 (0.044)
32_CP3	0.820 (0.068)	0.595 (0.035)	0.354 (0.042)
44_CP4	0.996 (0.068)	0.690 (0.029)	0.476 (0.041)
Fatigue			
2_F1	1.000 (0.000)	0.665 (0.037)	0.422 (0.050)
16_F2	1.116 (0.104)	0.718 (0.034)	0.516 (0.048)
25_F3	1.236 (0.116)	0.774 (0.031)	0.599 (0.048)
35_F4	1.197 (0.081)	0.805 (0.027)	0.647 (0.043)
Lack of Energy			
4_LE1	1.000 (0.000)	0.705 (0.046)	0.497 (0.065)
11_LE2	1.058 (0.059)	0.775 (0.032)	0.601 (0.050)
31_LE3	1.042 (0.111)	0.682 (0.037)	0.465 (0.051)
40_LE4	1.067 (0.121)	0.626 (0.040)	0.391 (0.050)
Physical Complaints			
7_PC1	1.000 (0.000)	0.628 (0.035)	0.394 (0.044)
15_PC2	0.703 (0.087)	0.411 (0.039)	0.169 (0.032)
20_PC3	0.978 (0.089)	0.609 (0.039)	0.371 (0.047)
42_PC4	1.262 (0.090)	0.674 (0.033)	0.454 (0.045)
Success			
3_SUC1	1.000 (0.000)	0.544 (0.046)	0.296 (0.050)
17_SUC2	1.081 (0.104)	0.639 (0.042)	0.409 (0.054)
41_SUC3	0.733 (0.120)	0.392 (0.048)	0.153 (0.038)
49_SUC4	0.989 (0.130)	0.560 (0.040)	0.314 (0.045)
Social Recovery			
6_SR1	1.000 (0.000)	0.737 (0.027)	0.543 (0.040)
14_SR2	1.214 (0.058)	0.831 (0.022)	0.690 (0.037)
23_SR3	0.899 (0.082)	0.515 (0.040)	0.265 (0.042)
33_SR4	1.269 (0.068)	0.889 (0.017)	0.314 (0.045)
Physical Recovery			
9_PR1	1.000 (0.000)	0.668 (0.039)	0.446 (0.052)
13_PR2	1.101 (0.078)	0.705 (0.037)	0.497 (0.052)
29_PR3	1.023 (0.127)	0.599 (0.043)	0.359 (0.052)
38_PR4	1.112 (0.090)	0.642 (0.038)	0.412 (0.049)
General Well-being			
10_GWB1	1.000 (0.000)	0.828 (0.017)	0.686 (0.029)
34_GWB2	1.082 (0.040)	0.888 (0.013)	0.788 (0.024)
43_GWB3	1.058 (0.048)	0.827 (0.028)	0.684 (0.047)
47_GWB4	0.945 (0.052)	0.721 (0.033)	0.519 (0.048)

Sleep Quality			
19_SQ1	1.000 (0.000)	0.842 (0.017)	0.709 (0.040)
27_SQ2	0.960 (0.043)	0.888 (0.013)	0.623 (0.042)
36_SQ3	0.711 (0.077)	0.827 (0.028)	0.345 (0.052)
46_SQ4	0.620 (0.076)	0.721 (0.033)	0.250 (0.046)
Disturbed Breaks			
51_DB1	1.000 (0.000)	0.549 (0.049)	0.302 (0.054)
58_DB2	1.397 (0.157)	0.747 (0.031)	0.559 (0.046)
66_DB3	1.170 (0.146)	0.710 (0.036)	0.504 (0.052)
72_DB4	1.104 (0.125)	0.709 (0.037)	0.502 (0.052)
Emotional Exhaustion			
54_EE1	1.000 (0.000)	0.781 (0.036)	0.610 (0.056)
63_EE2	0.829 (0.069)	0.653 (0.039)	0.426 (0.051)
68_EE3	0.801 (0.067)	0.655 (0.041)	0.429 (0.053)
76_EE4	0.970 (0.070)	0.738 (0.031)	0.544 (0.046)
Injury			
50_I1	1.000 (0.000)	0.739 (0.032)	0.547 (0.047)
57_I2	0.863 (0.070)	0.714 (0.034)	0.509 (0.049)
64_I3	0.924 (0.058)	0.709 (0.036)	0.503 (0.051)
73_I4	0.563 (0.075)	0.426 (0.051)	0.181 (0.043)
Being in Shape			
53_BIS1	1.000 (0.000)	0.728 (0.027)	0.530 (0.040)
61_BIS2	1.012 (0.064)	0.698 (0.029)	0.487 (0.041)
69_BIS3	0.998 (0.068)	0.702 (0.026)	0.493 (0.037)
75_BIS4	1.161 (0.077)	0.793 (0.023)	0.629 (0.036)
Personal Accomplishment			
55_PA1	1.000 (0.000)	0.670 (0.033)	0.448 (0.044)
60_PA2	0.879 (0.093)	0.600 (0.047)	0.359 (0.049)
70_PA3	0.730 (0.096)	0.486 (0.050)	0.236 (0.049)
77_PA4	0.754 (0.090)	0.483 (0.046)	0.233 (0.045)
Self-efficacy			
52_SE1	1.000 (0.000)	0.721 (0.031)	0.520 (0.045)
59_SE2	1.066 (0.067)	0.745 (0.029)	0.555 (0.043)
65_SE3	1.170 (0.074)	0.799 (0.022)	0.639 (0.034)
71_SE4	1.185 (0.074)	0.821 (0.025)	0.675 (0.042)
Self-regulation			
56_S-R1	1.000 (0.000)	0.734 (0.029)	0.539 (0.042)
62_S-R2	0.948 (0.071)	0.706 (0.032)	0.499 (0.045)
67_S-R3	0.855 (0.074)	0.572 (0.039)	0.328 (0.044)
74_S-R4	0.978 (0.080)	0.640 (0.039)	0.410 (0.050)

Table 19

Model 4 CFA and ESEM Comparisons by Fit Indices

	AIC	BIS	χ^2	*p*	RMSEA (90% CI)	SRMR	CFI	TLI
CFA	72440	73048	4321.421	< .001	.079 (.076 – .081)	.088	.731	.718
ESEM	72073	72873	3944.380	< .001	.076 (.074 – .079)	.061	.758	.736

Table 20

Model 5 CFA and ESEM Comparisons by Fit Indices

	AIC	BIS	χ^2	*p*	RMSEA (90% CI)	SRMR	CFI	TLI
CFA	44978	45334	1378.607	< .001	.078 (.074 – .082)	.081	.791	.774
ESEM	44781	45246	1172.885	<.001	.074 (.069 – .078)	.055	.828	.798

Table 21

Reliability Estimates for RESTQ-Sport Scales

Scale	CTT (α)	CFA (ω)	ESEM (ω)
GS	0.879	0.853	0.849
ES	0.858	0.852	0.846
SS	0.883	0.822	0.807
C/P	0.764	0.689	0.688
F	0.828	0.630	0.640
LE	0.784	0.645	0.642
PC	0.694	0.646	0.651
S	0.636	0.456	0.386
SR	0.843	0.779	0.734
PR	0.754	0.681	0.369
GWB	0.897	0.882	0.771
SQ	0.819	0.524	0.097
DB	0.767	0.701	0.690
EE	0.822	0.765	0.740
I	0.759	0.573	0.630
BIS	0.822	0.787	0.735
PA	0.665	0.603	0.605
SE	0.844	0.842	0.819
S-R	0.787	0.668	0.712

Table 22

Model 4 CFA ESEM Standardized Parameter Estimate Comparisons

	Stress Estimate (*S.E.*)		Recovery Estimate (*S.E.*)		R^2	
Items	CFA	ESEM	CFA	ESEM	CFA	ESEM
22_GS1	0.814 (0.019)	0.807 (0.019)		**0.018 (0.054)**	0.663 (0.031)	0.652 (0.031)
24_GS2	0.701 (0.026)	0.692 (0.026)		**0.020 (0.063)**	0.492 (0.037)	0.480 (0.036)
30_GS3	0.804 (0.020)	0.795 (0.021)		**0.058 (0.069)**	0.646 (0.033)	0.636 (0.033)
45_GS4	0.756 (0.023)	0.755 (0.022)		**0.054 (0.084)**	0.572 (0.034)	0.573 (0.033)
5_ES1	0.764 (0.022)	0.749 (0.026)		**0.108 (0.075)**	0.584 (0.034)	0.573 (0.035)
8_ES2	0.768 (0.023)	0.762 (0.023)		**0.018 (0.059)**	0.589 (0.035)	0.582 (0.034)
28_ES3	0.724 (0.028)	0.714 (0.031)		**0.123 (0.081)**	0.524 (0.041)	0.525 (0.041)
37_ES4	0.815 (0.020)	0.790 (0.032)		0.185 (0.072)	0.664 (0.033)	0.659 (0.038)
21_SS1	0.730 (0.027)	0.695 (0.038)		0.205 (0.064)	0.533 (0.040)	0.525 (0.046)
26_SS2	0.771 (0.023)	0.739 (0.035)		0.196 (0.066)	0.595 (0.036)	0.585 (0.042)
39_SS3	0.785 (0.024)	0.766 (0.026)		**0.083 (0.060)**	0.616 (0.037)	0.594 (0.038)
48_SS4	0.638 (0.034)	0.608 (0.043)		0.190 (0.066)	0.406 (0.044)	0.406 (0.047)
12_CP1	0.655 (0.030)	0.657 (0.030)		**0.077 (0.086)**	0.428 (0.039)	0.437 (0.040)
18_CP2	0.540 (0.037)	0.544 (0.037)		**0.086 (0.078)**	0.292 (0.040)	0.304 (0.040)
32_CP3	0.599 (0.035)	0.539 (0.038)		0.186 (0.073)	0.312 (0.039)	0.325 (0.040)
44_CP4	0.630 (0.030)	0.621 (0.033)		**0.157 (0.083)**	0.397 (0.037)	0.411 (0.038)
2_F1	0.476 (0.041)	0.484 (0.042)		**0.168 (0.090)**	0.227 (0.039)	0.262 (0.044)
16_F2	0.502 (0.038)	0.491 (0.041)		0.203 (0.079)	0.252 (0.039)	0.283 (0.042)
25_F3	0.587 (0.038)	0.581 (0.039)		**0.154 (0.082)**	0.345 (0.044)	0.361 (0.044)
35_F4	0.617 (0.035)	0.621 (0.036)		0.202 (0.096)	0.381 (0.043)	0.426 (0.048)
4_LE1	0.550 (0.039)	0.543 (0.042)		**0.149 (0.080)**	0.302 (0.043)	0.317 (0.045)
11_LE2	0.601 (0.033)	0.594 (0.035)		**0.149 (0.087)**	0.361 (0.040)	0.375 (0.042)
31_LE3	0.571 (0.037)	0.569 (0.036)		**0.089 (0.083)**	0.326 (0.043)	0.332 (0.043)
40_LE4	0.512 (0.043)	0.501 (0.042)		**0.105 (0.076)**	0.262 (0.044)	0.262 (0.044)
7_PC1	0.569 (0.033)	0.563 (0.036)		0.180 (0.074)	0.324 (0.037)	0.349 (0.038)
15_PC2	0.444 (0.040)	0.446 (0.040)		**0.056 (0.071)**	0.197 (0.036)	0.202 (0.036)
20_PC3	0.685 (0.031)	0.686 (0.031)		**0.029 (0.075)**	0.469 (0.043)	0.471 (0.042)
42_PC4	0.531 (0.039)	0.522 (0.044)		0.267 (0.089)	0.282 (0.041)	0.344 (0.049)
3_SUC1		-0.213 (0.059)	0.376 (0.044)	0.328 (0.054)	0.141 (0.033)	0.153 (0.035)
17_SUC2		-0.387 (0.060)	0.577 (0.038)	0.408 (0.049)	0.310 (0.043)	0.316 (0.041)
41_SUC3		**-0.083 (0.055)**	0.251 (0.045)	0.286 (0.059)	0.063 (0.023)	0.089 (0.028)
49_SUC4		-0.265 (0.065)	0.478 (0.039)	0.399 (0.059)	0.229 (0.037)	0.230 (0.039)
6_SR1		-0.380 (0.072)	0.667 (0.031)	0.616 (0.044)	0.445 (0.041)	0.523 (0.039)
14_SR2		-0.468 (0.071)	0.748 (0.029)	0.629 (0.052)	0.560 (0.043)	0.614 (0.040)
23_SR3		-0.279 (0.061)	0.492 (0.039)	0.433 (0.051)	0.243 (0.039)	0.265 (0.040)
33_SR4		-0.537 (0.070)	0.810 (0.022)	0.640 (0.060)	0.656 (0.036)	0.698 (0.035)
9_PR1		-0.530 (0.044)	0.566 (0.036)	0.202 (0.092)	0.321 (0.041)	0.321 (0.037)
13_PR2		-0.553 (0.048)	0.629 (0.036)	0.286 (0.084)	0.395 (0.045)	0.388 (0.042)
29_PR3		-0.440 (0.057)	0.615 (0.032)	0.434 (0.064)	0.379 (0.039)	0.382 (0.040)
38_PR4		-0.423 (0.056)	0.548 (0.038)	0.318 (0.077)	0.300 (0.041)	0.280 (0.042)
10_GWB1		-0.630 (0.055)	0.813 (0.018)	0.527 (0.060)	0.661 (0.029)	0.675 (0.029)
34_GWB2		-0.641 (0.060)	0.869 (0.015)	0.595 (0.061)	0.755 (0.027)	0.765 (0.026)
43_GWB3		-0.601 (0.062)	0.812 (0.029)	0.551 (0.064)	0.660 (0.047)	0.665 (0.047)
47_GWB4		-0.535 (0.062)	0.731 (0.032)	0.481 (0.068)	0.535 (0.047)	0.518 (0.047)
19_SQ1		-0.590 (0.048)	0.640 (0.034)	0.242 (0.098)	0.410 (0.044)	0.407 (0.040)
27_SQ2		-0.517 (0.045)	0.523 (0.043)	**0.145 (0.096)**	0.274 (0.045)	0.288 (0.040)
36_SQ3		-0.527 (0.039)	0.338 (0.050)	**-0.131 (0.093)**	0.114 (0.034)	0.295 (0.045)
46_SQ4		-0.454 (0.040)	0.341 (0.046)	**-0.032 (0.095)**	0.117 (0.032)	0.208 (0.038)

Note. Bold indicates non-significant results ($p > .05$)

Table 23

Model 5 CFA ESEM Standardized Parameter Estimate Comparisons

	Stress Estimate (*S.E.*)		Recovery Estimate (*S.E.*)		R^2	
Items	CFA	ESEM	CFA	ESEM	CFA	ESEM
51_DB1	0.561 (0.037)	0.574 (0.036)		-0.114 (0.034)	0.315 (0.041)	0.343 (0.040)
58_DB2	0.633 (0.632)	0.627 (0.040)		**-0.001 (0.054)**	0.401 (0.048)	0.394 (0.051)
66_DB3	0.632 (0.038)	0.604 (0.044)		**0.005 (0.061)**	0.399 (0.048)	0.364 (0.053)
72_DB4	0.606 (0.038)	0.581 (0.041)		**-0.052 (0.053)**	0.367 (0.046)	0.341 (0.047)
54_EE1	0.736 (0.038)	0.707 (0.042)		**-0.025 (0.057)**	0.542 (0.055)	0.500 (0.059)
63_EE2	0.660 (0.035)	0.675 (0.034)		**-0.042 (0.056)**	0.436 (0.046)	0.458 (0.045)
68_EE3	0.593 (0.043)	0.521 (0.052)		-0.190 (0.052)	0.352 (0.051)	0.307 (0.050)
76_EE4	0.688 (0.032)	0.654 (0.036)		**-0.094 (0.051)**	0.474 (0.045)	0.436 (0.046)
50_I1	0.468 (0.048)	0.531 (0.049)		0.122 (0.051)	0.219 (0.045)	0.296 (0.054)
57_I2	0.606 (0.042)	0.649 (0.040)		**0.104 (0.060)**	0.367 (0.051)	0.432 (0.052)
64_I3	0.473 (0.050)	0.548 (0.050)		0.140 (0.055)	0.223 (0.048)	0.320 (0.058)
73_I4	0.455 (0.045)	0.439 (0.046)		**-0.087 (0.047)**	0.207 (0.041)	0.200 (0.041)
53_BIS1		-0.507 (0.049)	0.639 (0.034)	0.475 (0.049)	0.408 (0.043)	0.483 (0.039)
61_BIS2		-0.296 (0.055)	0.668 (0.031)	0.596 (0.039)	0.446 (0.041)	0.443 (0.041)
69_BIS3		-0.360 (0.048)	0.667 (0.028)	0.572 (0.037)	0.444 (0.037)	0.457 (0.036)
75_BIS4		-0.391 (0.048)	0.794 (0.022)	0.699 (0.034)	0.631 (0.035)	0.642 (0.033)
55_PA1		-0.179 (0.052)	0.668 (0.030)	0.650 (0.032)	0.446 (0.041)	0.454 (0.040)
60_PA2		**-0.084 (0.056)**	0.541 (0.039)	0.553 (0.040)	0.293 (0.042)	0.313 (0.043)
70_PA3		**-0.050 (0.056)**	0.430 (0.044)	0.449 (0.042)	0.185 (0.037)	0.204 (0.038)
77_PA4		-0.148 (0.056)	0.449 (0.045)	0.428 (0.044)	0.202 (0.041)	0.205 (0.040)
52_SE1		-0.305 (0.050)	0.706 (0.030)	0.638 (0.033)	0.498 (0.043)	0.499 (0.042)
59_SE2		-0.268 (0.057)	0.731 (0.029)	0.669 (0.034)	0.534 (0.042)	0.520 (0.043)
65_SE3		-0.300 (0.053)	0.779 (0.020)	0.713 (0.029)	0.606 (0.031)	0.599 (0.032)
71_SE4		-0.225 (0.056)	0.807 (0.025)	0.778 (0.025)	0.652 (0.040)	0.656 (0.038)
56_S-R1		-0.147 (0.056)	0.699 (0.027)	0.696 (0.029)	0.488 (0.038)	0.506 (0.037)
62_S-R2		**0.015 (0.048)**	0.585 (0.037)	0.655 (0.037)	0.342 (0.043)	0.429 (0.048)
67_S-R3		**0.063 (0.048)**	0.463 (0.042)	0.532 (0.037)	0.214 (0.039)	0.288 (0.039)
74_S-R4		-0.114 (0.033)	0.559 (0.039)	0.571 (0.040)	0.312 (0.043)	0.339 (0.044)

Note. Bold indicates non-significant results ($p > .05$)

Table 24

Summary of Potential Problematic Items

	IRT	ESEM
General Stress		
22_GS1	X	X
24_GS2	X	X
30_GS3	X	X
45_GS4	X	X
Emotional Stress		
5_ES1	X	X
8_ES2	X	X
28_ES3		X
37_ES4		
Social Stress		
21_SS1		
26_SS2		
39_SS3	X	X
48_SS4	X	
Conflicts/Pressure		
12_CP1		
18_CP2	X	
32_CP3	X	X
44_CP4		
Fatigue		
2_F1	X	X
16_F2	X	
25_F3	X	X
35_F4	X	
Lack of Energy		
4_LE1	X	X
11_LE2	X	X
31_LE3	X	X
40_LE4	X	X
Physical Complaints		
7_PC1	X	
15_PC2	X	X
20_PC3	X	X
42_PC4		
Success		
3_SUC1	X	X
17_SUC2		X
41_SUC3	X	
49_SUC4		X
Social Recovery		
6_SR1	X	X
14_SR2		X
23_SR3	X	X
33_SR4		X
Physical Recovery		
9_PR1	X	X
13_PR2		X
29_PR3		X
38_PR4	X	X

	IRT	ESEM
General Well-being		
10_GWB1		X
34_GWB2		X
43_GWB3		X
47_GWB4		X
Sleep Quality		
19_SQ1		X
27_SQ2		X
36_SQ3	X	X
46_SQ4	X	X
Disturbed Breaks		
51_DB1	X	
58_DB2	X	
66_DB3	X	
72_DB4	X	
Emotional Exhaustion		
54_EE1	X	
63_EE2	X	
68_EE3	X	
76_EE4	X	
Injury		
50_I1	X	
57_I2	X	
64_I3	X	
73_I4	X	
Being in Shape		
53_BIS1		X
61_BIS2		X
69_BIS3		X
75_BIS4		X
Personal Accomplishment		
55_PA1		
60_PA2		
70_PA3	X	
77_PA4	X	
Self-efficacy		
52_SE1		
59_SE2		
65_SE3		
71_SE4		
Self-regulation		
56_S-R1		
62_S-R2	X	
67_S-R3	X	
74_S-R4	X	

Chapter III: *Subjective measures of training load response: Revisiting the relation between the POMS and the RESTQ-Sport*

Abstract

The purpose of the study was to understand the measurement overlap in the Profile of Mood States (POMS) and Recovery Stress Questionnaire for Athletes (RESTQ-Sport) by examining the proportion of variance in perceived stress and recovery explained by mood states (i.e., tension, anger, fatigue, vigor, depression, confusion). Athletes (*N* = 500) currently competing in collegiate, professional, and Olympic level sports volunteered to complete the online measures. In partial support for the hypothesis, the current results revealed that mood states explained 63% of the variance in perceived stress, 54% of the variance in perceived recovery, and 71% of the variance in stress-recovery state. The direction of the relationships between mood states and perceived stress and recovery were consistent with those reported in previous research. While the results of the current study demonstrated theoretical overlap between the POMS and RESTQ-Sport measures, the results also indicated that the RESTQ-Sport may capture more information than mood states alone. Results of the study can be used to inform interventions aimed at managing specific moods (e.g., anger, tension, fatigue, vigor) which appear to influence stress-recovery state more so than other moods (e.g., depression, confusion).

Keywords: mood, perceived stress and recovery, overtraining

In competitive sport, athletes must often endure frequent and strenuous bouts of training to facilitate necessary adaptations for the achievement and maintenance of peak performance. There has been substantial debate around the proper management of training load in competitive sport, as the process of overtraining typically yields a high risk of illness, injury, and suboptimal performance for athletes (Gabbett, 2016; Meeusen et al., 2013; Schwellnus et al., 2016; Soligard et al., 2016). As such, it has been recommended that coaches and sport organizations proactively monitor athletes' responses to training to detect the early signs of overtraining (Kenttä & Hassmén, 1998; Meeusen et al., 2013). While there is no consistent evidence for immunological, biochemical, or physiological predictors of overtraining (Meeusen et al., 2013), there is consistent evidence for psychological predictors of overtraining (Carfagno & Hendrix, 2014; Meeusen et al., 2013; Saw, Main, & Gastin, 2016). The inclusion of psychological variables in the conceptualization of training load has been reinforced in recent International Olympic Committee (IOC) consensus statements on training load management, and the use of subjective measures to monitor athletes' responses to training load has been encouraged (Carfagno & Hendrix, 2014; Meeusen et al., 2013; Saw et al., 2016; Soligard et al., 2016).

The Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1971) was one of the first measures used to study athletes' psychological responses to training load (Morgan, Brown, Raglin, O'Connor, & Ellickson, 1987), and various derivatives of the measure continue to be used in overtraining research to this day (Bresciani et al., 2011; Kenttä, Hassmén, & Raglin, 2006; Killer, Svendsen, Jeukendrup, & Gleeson, 2015; Merrigan, Tynan, Oliver, Jagim, & Jones, 2017). According to Lane (2007), mood is operationalized as a state of collective emotions or feelings, which in turn may influence thoughts and behaviors. Previous research has demonstrated a dose-response relationship between mood states (i.e., tension, anger, fatigue, vigor, depression, confusion) and training load, whereby disturbances to the *iceberg profile* (Morgan, 1985) are observed following increased training load, and mood restoration to baseline occurs following decreased training load (Saw et al., 2016). A recent systematic review indicates that mood states are a reliable indicator of acute changes in training load, but may not be a reliable indicator of chronic training load (Saw et al., 2016). Other research has also demonstrated a link between mood states and injury occurrence (Galambos, Terry, Moyle, & Locke, 2005; Wiese-Bjornstal et al., 2012).

Since 1999, the Recovery Stress Questionnaire for Athletes (RESTQ-Sport; Kallus & Kellmann, 2016; Kellmann & Kallus, 2001), a measure of perceived stress and recovery, has gradually emerged as the most commonly used measure to study athletes' psychological responses to training load. According to Kellmann and Kallus (2001), stress is operationalized as an imbalance in psychophysical state that prompts central and autonomic nervous system responses to meet stress demands, while recovery is operationalized as a process of restoring psychophysical balance after stressful experiences. Several researchers have also studied the concept of a stress-recovery state, or the difference between perceived recovery scores and perceived stress scores, as a marker of psychological balance between stress and recovery demands (González-Boto, Salguero, Tuero, González-Gallego, & Márquez, 2008; Hartwig, Naughton, & Searl, 2009; Nunes et al., 2014). Previous research has demonstrated a consistent dose-response relationship between stress-recovery state and training load, whereby increases in training load yield increased levels of perceived stress and decreased levels of perceived recovery, and decreases in training load yield restorations of perceived stress and recovery to baseline (Saw et al., 2016). Saw et al. (2016) suggest that the RESTQ-Sport is responsive to changes in acute training load, and may be more responsive to changes in chronic training load than the POMS. In addition to research on the responsiveness of the RESTQ-Sport to training load fluctuations, changes in perceived stress and recovery have been shown to precede illness and injury occurrence in athletes (Brink et al., 2010; Laux, Krumm, Diers, & Flor, 2015; van der Does, Brink, Otter, Visscher, Lemmink, 2017).

Although both the POMS and RESTQ-Sport are recommended for use in monitoring athletes' responses to training load, little research has been conducted to understand the relation between the two measures, making it difficult for practitioners to ascertain which measure to implement in practice. Early research on the RESTQ-Sport demonstrates significant relationships between mood states measured by the POMS and stress-recovery states measured by the RESTQ-Sport (Kellmann & Kallus, 1999). In their summary of prior findings, Kellmann and Kallus (2001) reported that perceived stress scores were positively related (r = 0.33 – 0.75) to tension, anger, fatigue, depression, and confusion mood states, and negatively related to the mood state of vigor (r = -0.19 – -0.38). In contrast, perceived recovery scores were negatively related (r = -0.05 – 0.67) to tension, anger, fatigue, depression, and confusion mood states, and positively related to the mood state of vigor (r = 0.29 – 0.61). Similar findings have emerged during criterion validity examinations of translated RESTQ-Sport measures (Costa & Samulski, 2005; Nederhof, Brink, & Lemmink, 2008). Despite the relationships observed between POMS and RESTQ-Sport responses, no research has been conducted to determine the proportion of variance in RESTQ-Sport responses collectively explained by all six moods.

Beyond the lack of research on the response overlap between POMS and RESTQ-Sport measures, the majority of the sport research to date has been conducted under the assumption that mood disturbance is a consequence of stress imposed during training or competition (Bresciani et al., 2011; Chennaoui et al., 2016; West et al., 2014). In contrast, very little research has been conducted to understand mood states as antecedents of perceived stress and recovery. Kellmann and Kallus (1999) suggested that “it also has to be considered that mood might affect the scoring of the [stress-recovery] state or the way the questionnaire is answered. It seems very likely that stress-recovery state and mood are interdependent organismic states” (pp. 113-114). In developing the RESTQ-Sport, it was further theorized that mood states were more indicative of stress than recovery, thereby demonstrating the utility of the RESTQ-Sport over the POMS in practice (Kellmann & Kallus, 2001). However, results of studies on perceived recovery in occupational settings indicates that mood repair is actually a primary function of psychological recovery from work (Fuller et al., 2003; Sonnentag & Fritz, 2007). Thus, mood states may be theoretical antecedents of perceived stress and recovery, as well as stress-recovery state, yet these theoretical links have never been examined in sport research.

Study Purpose

The purpose of the study was to better understand the measurement overlap in the POMS and RESTQ-Sport by examining the proportions of variance in perceived stress, perceived recovery, and stress-recovery state explained by mood states (i.e., tension, anger, fatigue, vigor, depression, confusion). It was hypothesized that mood states would account for more of the variance in perceived stress than in perceived recovery or stress-recovery state. It was also hypothesized that all mood states except vigor would be positive predictors of perceived stress and negative predictors of perceived recovery, while vigor would be a negative predictor of perceived stress and a positive predictor of perceived recovery.

Methods

Participants and Procedure

Approval was obtained from the Institutional Review Board (IRB) of the authors' affiliate university prior to data collection. Study recruitment occurred via e-mail recruitment flyers, word-of-mouth, and personal invitation through existing collaborations. Athletes (N = 500; M_{age} = 20.06 years; SD = 2.24 years) currently participating in a variety of competitive sports volunteered to participate in the study. All athletes were competing at the collegiate, professional, or Olympic levels of sport at the time of data collection. Participants had a mean of 10.96 years (SD = 4.53 years) of experience participating in their respective sports and 2.18 years (SD = 1.49 years) of experience participating at their current competition level (e.g., collegiate, professional, etc.). In Table 25, additional demographic characteristics of the sample are presented. All participants completed the online measures outlined below, which required approximately 10-15 minutes of each participant's time.

Measures

Brief Profile of Mood States. To assess athlete mood states (i.e., tension, anger, fatigue, vigor, depression, confusion), the Brief POMS was administered (McNair, Lorr, & Droppleman, 1992). The Brief POMS is a 30-item measure, with items scored on a 5-point Likert scale ranging from 0 (*not at all*) to 4 (*extremely*). All items reflect descriptions of feelings over the past week. The reliability and validity of the measure for use in adult populations has been established in previous research (Bourgeois, LeUnes, Meyers, 2010; McNair et al., 1992). Calculated as the sum of all items, each mood state score ranged from 0 to 20.

Recovery Stress Questionnaire for Athletes (RESTQ-Sport). To assess athlete perceptions of stress and recovery, the 36-item version of the RESTQ-Sport (Kallus &

Kellmann, 2016) was administered. All items are scored on a 7-point Likert scale ranging from 0 (*never*) to 6 (*always*). All items reflect perceptions of stress and recovery over the previous three days and nights. The reliability and validity of the measure for use in athlete populations has been established in previous research (Kallus & Kellman, 2016; Nicolas, Vacher, Martinent, & Mourot, 2016). Calculated as the sum of individual subscale means, reported perceived stress and recovery scores ranged from 0 to 36. Calculated as the difference between perceived recovery and stress scores, stress-recovery state scores ranged from -36 (*extremely stressed and not at all recovered*) to 36 (*not at all stressed and fully recovered*).

Data Analysis

All statistical tests were computed using IBM SPSS 22 software (IBM Corp., Armonk, NY). In Table 26, descriptive statistics for all variables are presented. Multiple regression model testing was performed to identify significant predictors of perceived stress, perceived recovery, and stress-recovery state. In each regression analysis, two prediction models were tested. In Model 1, gender, age, years of experience in sport, and years of experience at current competitive level were included as independent variables. In Model 2, tension, anger, fatigue, vigor, depression, and confusion were included, in addition to all Model 1 independent variables. An alpha level of 0.05 was used to determine statistical significance for all tests performed.

Results

Perceived Stress

Model 1 was not significant, indicating that gender, age, years of experience in sport, and years of experience at competition level were not significant predictors of perceived stress. Model 2 was significant (R^2 = 0.640), with years of experience at competition level, tension, anger, and fatigue emerging as significant predictors of perceived stress ($p < 0.05$). The model summary is presented in Table 27, and significance test results for regression coefficients are presented in Table 28.

Perceived Recovery

Model 1 was not significant, indicating that gender, age, years of experience in sport, and years of experience at competition level were not significant predictors of perceived recovery. Model 2 was significant ($R^2 = 0.536$), with anger, vigor, and confusion emerging as significant predictors of perceived recovery ($p < 0.05$). The model summary is presented in Table 27, and significance test results for regression coefficients are presented in Table 29.

Stress-Recovery State

Model 1 was not significant, indicating that gender, age, years of experience in sport, and years of experience at competition level were not significant predictors of stress-recovery state. Model 2 was significant ($R^2 = 0.717$), with tension, anger, fatigue, and vigor emerging as significant predictors of stress-recovery state. The model summary is presented in Table 27, and significance test results for regression coefficients are presented in Table 30. Prompted by these findings, Figure 4 was generated to compare the mood state profiles for athletes with low stress-recovery state scores (i.e., $\leq 25^{th}$ percentile) and high stress-recovery state scores (i.e., $\geq 75^{th}$ percentile).

Discussion

The purpose of the study was to better understand the measurement overlap in the POMS and RESTQ-Sport by examining the proportion of variance in perceived stress and recovery explained by mood states (i.e., tension, anger, fatigue, vigor, depression, confusion). In partial support for the *a priori* hypothesis, the current results revealed that mood states explained more of the variance in perceived stress (63%) than perceived recovery (54%), and explained more of the variance in stress-recovery state (71%) than perceived stress or recovery. Also in support of the *a priori* hypothesis, the regression coefficients and zero-order correlations reported in Tables 28-30 indicated that the mood states of tension, anger, fatigue, depression, and confusion were positively related to perceived stress and negatively related to perceived recovery. Similarly, the regression coefficients and zero-order correlations indicated that vigor was negatively related to perceived stress and positively related to perceived recovery.

The current findings demonstrated that 54-71% of the variance in RESTQ-Sport responses was explained by mood states, which suggests that while there is considerable overlap between the two measures, 29-46% of the variance in RESTQ-Sport responses is likely explained by variables other than those included in the current study. This supports previous claims that the POMS and RESTQ-Sport are related measures, yet the RESTQ-Sport may capture more information than mood states alone (Kellmann & Kallus, 2001; Saw et al., 2016). In addition, the large R^2 values emerging from all models tested reinforce Kellmann and Kallus' (1999) suggestion that mood states may affect athlete responses to the RESTQ-Sport. In support of this finding, cognitive psychologists have concluded that mood and emotions play a role in the regulation of thoughts, information processing, and memory (Clore & Huntsinger, 2007; Storbeck & Clore, 2008). Similarly, sport psychologists have long established that moods and emotions influence cognitive processes involved in performance (Eysenck, Derakshan, Santos, & Calvo, 2007; Lane & Terry, 2000; Vast, Young, & Thomas, 2010). Thus, the influence of mood states on perceived stress and recovery identified in the current study may be explained by the influence of mood on cognitive processes involved in responding to situation-specific questionnaires (e.g., memory, attention, etc.).

An interesting finding in the current study was that even though mood states explained more of the variance in perceived stress than in perceived recovery, mood states still explained over half of the variance in perceived recovery and explained the more variance in stress-recovery state than any other dependent variable. Taken together, the current findings refute the previous contention that the POMS serves as a better indicator of stress than recovery (Kellmann & Kallus, 2001). By contrast, the current findings correspond to those which have revealed mood repair as a primary function of psychological recovery in occupational settings (Fuller et al., 2003; Sonnentag & Fritz, 2007). Drawing on the occupational literature further, the conservation of resources theory (Hobfoll, 1998) posits that day-to-day recovery typically revolves around the restoration of internal resources such as mood. Thus, and since the RESTQ-Sport measures perceived recovery in the short-term (i.e., "in the past 3 days/nights"), it makes sense that mood states may be more related to recovery-specific questionnaire responses than previously thought.

With regard to the specific mood state predictors, anger was the only mood state that emerged as a significant predictor of perceived stress, perceived recovery, and stress-recovery state. This finding is interesting given the previous relationship identified between anger and injury risk (Williams & Andersen, 1998), as well as between anger and sport performance (Lazarus, 2000; Ruiz & Hanin, 2011; Woodman et al., 2009). The literature on anger in sport also indicates that the direction of anger (i.e., inward vs. outward) has a role in determining whether anger has a positive or negative effect on performance (Lazarus, 2000; Williams & Andersen, 1998). As such, and given the current findings, practitioners should dedicate particular attention to the magnitudes and directions of athlete anger when developing and delivering interventions aimed at optimizing stress-recovery states.

In addition, tension and fatigue emerged as significant predictors of perceived stress and stress-recovery state, while vigor emerged as a significant predictor of perceived recovery and stress-recovery state. Taken together, the findings collectively indicate that athletes' negative feelings around physical and mental fatigue (e.g., perception of effort) more closely align with perceived stress, and positive feelings around energy (e.g., enjoyment of sport and training) more closely align with perceived recovery. The current findings are consistent with previous sport research which demonstrated the importance of conserving energy and minimizing energy demands (e.g., media requests) to optimize performance (Gould, Dieffenbach, & Moffett, 2002; Gould, Greenleaf, Chung, & Guinan, 2002; Greenleaf, Gould, & Dieffenbach, 2001). In the occupational literature, the effort-recovery model posits that mental effort expenditure at work elicits stress reactions such as fatigue and physiological activation, and that a precondition for recovery is that the functional systems taxed during work cannot be called upon during recovery activities (Meijman & Mulder, 1998). Thus, in terms of enhancing intervention specificity in practice, managing symptoms of physical fatigue while concurrently identifying ways for athletes to feel mentally energized despite feelings of fatigue may be crucial to maximizing overall stress-recovery state.

Finally, and although not associated with an *a priori* hypothesis, the current results indicated that years of experience at the competitive level was a significant predictor of perceived stress. While it is true that organizational and life stressors experienced by athletes are substantial at elite levels of competition (Hanton, Fletcher, & Coughlan, 2005; Mellalieu, Neil, Hanton, & Fletcher, 2009; Rice et al., 2016), the current finding should be interpreted with caution. In this study, the data for years of experience at competitive level were treated as ratio level data, yet less experienced athletes were more specific in their time estimates than were more experienced athletes (e.g., “1 year and 2 months” vs. “about 10 years”). Furthermore, over 96% of the participants had four or fewer years of experience at the competitive level. As such, researchers are encouraged to explore alternative methods of measuring competitive experience in future studies.

Limitations and Directions for Future Research

In terms of study strengths, the results of the current study provided novel information regarding the overlap between the POMS and RESTQ-Sport measures, as well as clarity regarding the potential influence of mood states on RESTQ-Sport responses. These strengths notwithstanding, there are a few limitations of the work, prompting specific directions for future research. First, the generalizability of the findings to more diverse groups of athletes (e.g., race, competition level) is limited. Future research should be conducted to examine the influence of moods on RESTQ-Sport responses among larger samples of athletes varying by race, ethnicities, nationalities, and competition levels. Second, many overtraining, burnout, and injury models in sport psychology place particular emphasis on the role of cognitive appraisal of situations as well as of automatic responses such as mood or physiological activation (Gould & Whitley, 2009; Gustafsson, Kenttä, & Hassmén, 2011; Lemyre, Treasure, Roberts, 2006; Williams & Andersen, 1998). As such, future research should be conducted to understand the moderating role of cognitive appraisal on the relation between mood states and perceived stress and recovery. Finally, the current study methods did not account for the phenomenon of mood or emotional contagion which has been shown to play a prominent role in team functioning, group behavior, and performance (Moll, Jordet, & Pepping, 2010; Totterdell, 2000). Since the RESTQ-Sport involves items related to social stress and social recovery, future research might explore the influence of group moods on individual RESTQ-Sport responses, as athletes are often in close contact with others (e.g., coaches, staff, teammates).

Conclusions

The current study was conducted in response to the recent recommendations to implement subjective measures of athletes' responses to training load (Carfagno & Hendrix, 2014; Meeusen et al., 2013; Saw et al., Gastin, 2016; Soligard et al., 2016). The current findings indicated that while the POMS and RESTQ-Sport demonstrate measurement overlap, the RESTQ-Sport may offer additional information beyond mood states. Findings also indicated that athlete mood states may be more predictive of perceived recovery than previously assumed (Kellmann, 2010). In addition, some moods (e.g., anger, tension, fatigue, vigor) appear to influence RESTQ-Sport responses more so than others (e.g., depression, confusion). Based on the collective findings of the study, practitioners are should be mindful that athlete mood states will significantly influence responses to the RESTQ-Sport. Thus, practitioners might consider administration of the RESTQ-Sport at consistent times of the day (e.g., one hour after waking) to minimize individual mood fluctuations.

Figures & Tables

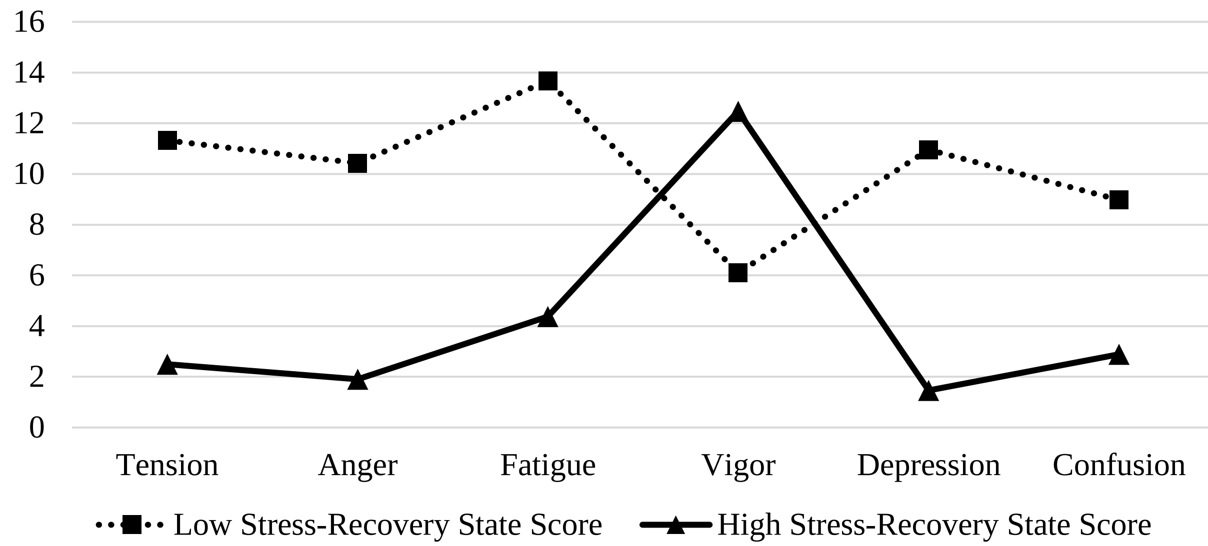

Figure 4. Mood profiles of athletes with low and high stress-recovery scores.

Table 25

Athlete Demographic Characteristics

Characteristic	Percent by Category (*N* = 500)
Gender	
Male	32.9%
Female	67.1%
Race/Ethnicity	
Caucasian/White	89.0%
Black/African American	3.6%
Latino/a or Hispanic	3.6%
Asian	0.8%
Native American	0.2%
Other	2.6%
Nationality	
American (USA)	86.6%
Canadian	7.2%
British or English	2.8%
Australian	0.6%
Other	2.6%
Sport Type	
Non-Contact	54.4%
Contact	44.4%
Season Status	
Pre-Season or Training Camp	12.6%
In-Season	66.4%
Off-Season	19.0%
Other	1.8%
Competition Level	
NCAA Division III	33.6%
NCAA Division II	14.4%
NCAA Division I	40.2%
CCAA	3.2%
BUCS	2.8%
Professional (NGB)	2.4%
International/Olympic	1.6%
Other	1.8%

Note. NCAA = National Collegiate Athletic Association, CCAA = Canadian Collegiate Athletic Association, BUCS = British Universities & Colleges Sport, NGB = National Governing Body.

Table 26

Descriptive Statistics

Variable	Overall (*N* = 494)
Tension	6.15 ± 4.40 (5.70 – 6.59)
Anger	4.51 ± 4.01 (4.10 – 4.91)
Fatigue	8.47 ± 4.85 (7.98 – 8.97)
Vigor	9.68 ± 3.75 (9.30 – 10.06)
Depression	4.93 ± 4.75 (4.46 – 5.40)
Confusion	5.33 ± 3.39 (4.98 – 5.67)
Perceived Stress	11.09 ± 5.65 (10.51 – 11.66)
Perceived Recovery	19.43 ± 5.61 (18.86 – 20.00)
Stress-Recovery State	8.35 ± 9.75 (7.35 – 9.34)

Note. All descriptive statistics reported as *M* ± *SD* (95% lower bound and upper bound confidence intervals).

Table 27

Model Summary

Dependent Variable	R^2	*Adj.* R^2	SEE	F	df	p	ΔR^2
Perceived Stress							
Model 1	.020	.009	5.622	1.849	4, 371	.119	.020
Model 2	.650	.640	3.390	66.909	10, 371	< .001	.630*
Perceived Recovery							
Model 1	.006	-.004	5.619	0.592	4, 371	.592	.006
Model 2	.548	.536	3.819	43.848	10, 371	< .001	.542*
Stress-Recovery State							
Model 1	.014	.004	9.732	1.331	4, 371	.258	.014
Model 2	.724	.717	5.189	94.877	10, 371	< .001	.710*

Note. SEE = standard error of estimate.

* Significant ΔF ($p < .001$)

Table 28

Significance Tests Results for Perceived Stress Regression Coefficients

Variable	*B*	*SE B*	β	*T*	*p*	Zero	Partial	Part
Model 1 (Constant)	15.153	3.189		4.751	.000			
Gender	.658	.647	.053	1.017	.310	.042	.053	.053
Age	-.301	.172	-.119	-1.755	.080	-.008	-.091	-.091
Years of Experience in Sport	.005	.066	.004	.072	.943	.026	.004	.004
Years of Experience at Competition Level	.669	.262	.176	2.551	.011	.094	.132	.132
Model 2 (Constant)	7.154	2.039		3.509	.001			
Gender	.076	.395	.006	.191	.848	.042	.010	.006
Age	-.205	.104	-.081	-1.978	.049	-.008	-.104	-.062
Years of Experience in Sport	-.005	.040	-.004	-.123	.902	.026	-.006	-.004
Years of Experience at Competition Level	**.350**	**.159**	**.092**	**2.203**	**.028**	**.094**	**.115**	**.069**
Tension	**.206**	**.069**	**.161**	**3.007**	**.003**	**.674**	**.156**	**.094**
Anger	**.332**	**.063**	**.236**	**5.256**	**.000**	**.626**	**.267**	**.164**
Fatigue	**.540**	**.052**	**.464**	**10.310**	**.000**	**.738**	**.477**	**.321**
Vigor	-.033	.052	-.022	-.624	.533	-.354	-.033	-.019
Depression	.085	.061	.072	1.403	.161	.618	.074	.044
Confusion	-.029	.078	-.018	-.378	.706	.561	-.020	-.012

Table 29

Significance Tests Results for Perceived Recovery Regression Coefficients

Variable	*B*	*SE B*	β	*T*	*p*	Zero	Partial	Part
Model 1 (Constant)	20.383	3.187		6.395	.000			
Gender	-.687	.647	-.056	-1.062	.289	-.051	-.055	-.055
Age	.013	.172	.005	.078	.938	-.032	.004	.004
Years of Experience in Sport	-.023	.066	-.019	-.348	.728	-.034	-.018	-.018
Years of Experience at Competition Level	-.220	.262	-.058	-.840	.401	-.053	-.044	-.044
Model 2 (Constant)	19.660	2.297		8.559	.000			
Gender	-.274	.445	-.022	-.616	.538	-.051	-.032	-.022
Age	-.112	.117	-.045	-.957	.339	-.032	-.050	-.034
Years of Experience in Sport	-.019	.045	-.016	-.427	.670	-.034	-.022	-.015
Years of Experience at Competition Level	.030	.179	.008	.169	.866	-.053	.009	.006
Tension	-.107	.077	-.084	-1.380	.168	-.530	-.072	-.049
Anger	**-.276**	**.071**	**-.197**	**-3.879**	**.000**	**-.526**	**-.200**	**-.137**
Fatigue	-.072	.059	-.063	-1.229	.220	-.504	-.065	-.043
Vigor	**.652**	**.059**	**.436**	**11.068**	**.000**	**.614**	**.503**	**.391**
Depression	-.074	.069	-.063	-1.075	.283	-.536	-.057	-.038
Confusion	**-.202**	**.088**	**-.122**	**-2.299**	**.022**	**-.530**	**-.120**	**-.081**

Table 30

Significance Tests Results for Stress-Recovery State Regression Coefficients

Variable	*B*	*SE B*	β	*T*	*p*	Zero	Partial	Part
Model 1 (Constant)	5.230	5.520		.947	.344			
Gender	-1.345	1.120	-.063	-1.201	.231	-.054	-.063	-.062
Age	.314	.297	.072	1.059	.290	-.014	.055	.055
Years of Experience in Sport	-.028	.115	-.013	-.243	.808	-.034	-.013	-.013
Years of Experience at Competition Level	-.889	.454	-.135	-1.959	.051	-.085	-.102	-.102
Model 2 (Constant)	12.507	3.121		4.007	.000			
Gender	-.350	.604	-.016	-.579	.563	-.054	-.030	-.016
Age	.093	.159	.021	.588	.557	-.014	.031	.016
Years of Experience in Sport	-.014	.061	-.007	-.234	.815	-.034	-.012	-.006
Years of Experience at Competition Level	-.320	.243	-.049	-1.314	.190	-.085	-.069	-.036
Tension	**-.313**	**.105**	**-.141**	**-2.980**	**.003**	**-.695**	**-.155**	**-.082**
Anger	**-.608**	**.097**	**-.250**	**-6.288**	**.000**	**-.665**	**-.314**	**-.174**
Fatigue	**-.612**	**.080**	**-.305**	**-7.640**	**.000**	**-.718**	**-.373**	**-.211**
Vigor	**.685**	**.080**	**.263**	**8.554**	**.000**	**.558**	**.411**	**.236**
Depression	-.159	.093	-.078	-1.708	.089	-.666	-.090	-.047
Confusion	-.172	.119	-.060	-1.445	.149	-.630	-.076	-.040

Chapter IV: *Psychological predictors of perceived stress and recovery in sport*

Abstract

The purpose of the current study was to identify psychological predictors (i.e., exercise intensity tolerance, pain catastrophizing, perceived susceptibility to sport injury, chronic psychological stress) of perceived acute stress and recovery responses. Athletes (N = 494, 55% non-contact sport, 45% contact sport) completed a battery of online psychological questionnaires, and multiple regression models were tested to identify significant predictors of perceived stress and recovery. Results of the study indicated that exercise intensity tolerance, pain catastrophizing, perceived susceptibility to sport injury, and chronic psychological stress were significant predictors of both perceived stress and recovery in non-contact sport athletes. Results also indicated that years of experience at competition level, perceived susceptibility to injury risk, and chronic psychological stress were significant predictors of perceived stress in contact sport athletes. Only perceived susceptibility to sport injury and chronic psychological stress were significant predictors of perceived recovery in contact sport athletes. Overall, findings indicate that predictors of perceived stress and recovery differ between non-contact and contact athletes, and that chronic psychological stress emerged as a predominant indicator of perceived stress and recovery regardless of sport type. The current findings expand on previous overtraining and burnout literature, and provide evidence to inform specificity in future training load management interventions.

Keywords: perceived stress and recovery, overtraining, burnout

To prevent the health and performance consequences of overtraining, researchers have recommended that coaches and sports medicine staff proactively monitor athletes' responses to training load (Drew & Finch, 2016; Kenttä & Hassmén, 1998; Meeusen et al., 2013). In recent International Olympic Committee (IOC) consensus statements (Schwellnus et al., 2016; Soligard et al., 2016), the training-injury prevention paradox is proposed as a framework to inform the management of athlete training load (Gabbett, 2016). According to the training-injury prevention paradox, there is a theoretical *sweet spot* of training load for every athlete, and sport injury risk is highest when acute:chronic training load ratio is too low (i.e., athlete is not training enough relative to previous load) or too high (i.e., athlete is training too much relative to previous load). As informed by Gabbett's (2016) framework, the importance of monitoring psychological aspects of training load is emphasized, and the use of subjective measures in monitoring athletes' responses to training load is therefore encouraged (Carfagno & Hendrix, 2014; Meeusen et al., 2013; Saw, Main, & Gastin, 2016; Soligard et al., 2016).

To date, the Recovery Stress Questionnaire for Athletes (RESTQ-Sport; Kallus & Kellmann, 2016; Kellmann & Kallus, 2001), a measure of perceived acute stress and recovery in sport, is the most commonly used subjective measure in overtraining research. In this measure, stress is operationalized as a deviation from psychophysical balance that elicits central and autonomic nervous system responses to meet imposed demands, while recovery is operationalized as a passive or active process of restoring psychophysical balance after experiencing stress. The majority of research conducted using the RESTQ-Sport has revolved around understanding psychological consequences of training load, with results consistently demonstrating that increases in physical training load elicit increases in perceived stress and decreases in perceived recovery (Bouget, Rouviex, Michaux, Pequignot, & Filaire, 2006; Brink, Visscher, Coutts, & Lemmink, 2012; Coutts, Wallace, & Slattery, 2007; Elbe, Rasmussen, Nielsen, & Nordsburg, 2016; Kölling et al., 2015; Kölling et al., 2016). More recently research has also demonstrated a responsiveness of the RESTQ-Sport measure to the early signs of illness and injury risk in athletes (Brink et al., 2010; Laux, Krumm, Diers, & Flor, 2015; van der Does, Brink, Otter, Visscher, & Lemmink, 2017).

Despite the popularity of the RESTQ-Sport in overtraining research, barriers have been reported regarding translation of the measure from research to practice (Saw, Main, & Gastin, 2015a, 2015b; Taylor, Chapman, Cronin, Newton, & Gill, 2012). For example, one challenge commonly reported is the interindividual variability observed in perceived stress and recovery responses to standardized training loads (Saw, Kellmann, Main, & Gastin, 2016), which in turn generates confusion around how to use RESTQ-Sport data to inform individualized interventions (Saw et al., 2015a; Taylor et al., 2012). Confusion regarding the sources of variability in RESTQ-Sport responses, in turn, makes it difficult to implement and sustain the decision-making process recommended by the IOC for training load management (Schwellnus et al., 2016; Soligard et al., 2016).

The challenges associated with the translation of the RESTQ-Sport measure from research to practice are not surprising, as little research has been conducted to identify predictors of perceived acute stress and recovery. To the extent of the current authors' knowledge, only two studies have examined the psychological correlates of perceived stress and recovery in their effort to establish the criterion validity of the measure. Although the analyses demonstrated that perceived stress and recovery scores were moderately related to mood, physical symptoms, facets of burnout, motivation, trait and state anxiety (Beckmann & Kellmann, 2004; Kellmann & Kallus, 2001), no further research has been conducted to identify additional variables which may explain interindividual variability in RESTQ-Sport responses. The IOC consensus statements suggest that variables such as stress susceptibility (e.g., tolerance for training load), appraisal of somatosensory feedback (e.g., pain), perceived susceptibility to injury risk, and chronic psychological stress likely contribute to psychological load (Soligard et al., 2016), yet no research has been conducted to examine these variables as predictors of psychological load. The study of psychological antecedents to perceived stress and recovery is consistent with previous, and now commonly overlooked, approaches to understanding the psychological constructs involved in the processes of stress and burnout in athlete populations (Lazarus & Folkman, 1984; McGrath, 1970; Smith, 1986; Williams & Andersen, 1998). As such, and informed by the IOC consensus statements (Schwellnus et al., 2016; Soligard et al., 2016), the current study involves an examination of previously unconsidered predictors of perceived stress and recovery: exercise intensity tolerance, pain catastrophizing, perceived susceptibility to sport injury, and chronic psychological stress.

Hypothesized Predictors of Perceived Stress and Recovery

Exercise intensity tolerance. Exercise intensity tolerance is operationalized as a dispositional trait that facilitates cognitive processes necessary to regulate affective responses to exercise, thus enabling individuals to persist during strenuous exercise despite feelings of displeasure or discomfort (Ekkekakis, Hall, & Petruzzello, 2005; Hall, Petruzello, Ekkekakis, Miller, & Bixby, 2014; Tempest & Parfitt, 2016). Research has indicated that exercise intensity tolerance explains significant proportions of variance (20-31%) in performance times during exhaustive fitness tests (i.e., 1.5-mile run; Hall et al., 2014), as well as significant proportions of the variance (i.e., 19-29%) in affective responses to exercise when the intensity level equals or exceeds a defined physiological limit (i.e., ventilatory threshold; Ekkekakis et al., 2005). In theory, the relationship identified between exercise intensity tolerance and affective responses to exercise may be explained by central regulatory mechanisms such as stress-induced analgesia (Ekkekakis et al., 2005). Tempest and Parfitt (2016) also theorized that individuals with low tolerance (i.e., unable to cognitively regulate affective responses elicited during intense exercise) have difficulty maintaining high intensity exercise due to the downregulation of physiological (e.g., central nervous system activation, hemodynamic response) and motivational processes required during physical performance. Given that affective responses to training load in sport are expected (Saw et al., 2016), and that exercise intensity tolerance influences the cognitive processing of induced affective responses (Ekkekakis et al., 2005), exercise intensity tolerance may be related to athletes' perceived stress and recovery.

Pain catastrophizing. Pain catastrophizing is operationalized as a relative inability to suppress thoughts about pain (i.e., helplessness, rumination, magnification) in anticipation of, during, and after experiencing painful stimuli (Quartana, Campbell, & Edwards, 2009; Turner & Aaron, 2001). Exercise research indicates that pain catastrophizing explained nearly 28% of the variance in determining healthy individuals' time to recover from an exercise-induced bout of shoulder pain, and that individuals with higher scores in pain catastrophizing at 48 hours post-exercise were significantly more likely to experience continued pain at 96 hours post-exercise (Parr et al., 2014). Within the general population, Sullivan et al. (2002) also reported that participants' levels of pain catastrophizing after experiencing exercise-induced muscle soreness were significantly associated with subsequent exercise intolerance, even after controlling for negative mood and pain. In their study on pain perception in athletes, Sullivan et al. (2001) reported that pain catastrophizing was a significant predictor of perceived pain intensity, and that athletes had lower pain catastrophizing responses than sedentary individuals. Similarly, Deroche et al. (2011) identified that pain catastrophizing explained a significant proportion of variance in sport-related pain behaviors (i.e., unwillingness to play through pain). A review of the literature provides evidence of central nervous system (i.e., diffuse noxious inhibitory controls) and other physiological mechanisms (i.e., alterations in muscle activation, hypothalamic-pituitary axis response to stress) that explain the role of pain catastrophizing in pain modulation (Quartana et al., 2009). Since researchers have suggested that interventions targeting pain catastrophizing might aid in the reduction of pain and facilitation of recovery in athlete populations (Sullivan, Tripp, Rodgers, & Stanish, 2000), pain catastrophizing may be predictive of athletes' perceived stress and recovery.

Perceived susceptibility to sport injury. Perceived susceptibility to sport injury is operationalized as one's belief about the probability of incurring a sport injury (Deroche, Stephan, Brewer, & Le Scanff, 2007), and is viewed as a psychological antecedent to sport injury within the framework of the Health Belief Model (HBM; Janz & Becker, 1984) and the Protection Motivation Theory (PMT; Brewer et al., 2003a; Maddux & Rogers, 1983; Prentice-Dunn & Rogers, 1986). Research indicates that athletes who have experienced injuries report higher levels of perceived susceptibility than athletes who have never been injured (Deroche et al., 2007; Reuter & Short, 2005; Short, Reuter, Brandt, Short, & Kontos, 2004; Stephan, Deroche, Brewer, Caudroit, & Le Scanff, 2009). In his prospective injury study, Kontos (2004) demonstrated that low to average scores in perceived susceptibility to sport injury were associated with high odds ratios of incurring a future injury. In a study on running injuries, weak positive correlations were identified between perceived susceptibility to sport injury and the number of training sessions per week, as well as obsessive passion (Stephan et al., 2009). Given the established influence of history of stressors on athletes' cognitive appraisals of stress

(Williams & Andersen, 1998), perceived susceptibility to sport injury may influence subsequent RESTQ-Sport responses.

Chronic psychological stress. Recent research findings suggest that chronic psychological stress, experienced in both sport and non-sport settings, must be accounted for in monitoring athletes' vulnerability to overtraining (Gabbett, 2016; Schwellnus et al., 2016; Soligard et al., 2016). This recent suggestion is consistent with historical perspectives, whereby chronic psychological stress is considered the primary antecedent to athlete burnout (Gould & Whitley, 2009; Gustafsson, Kenttä, & Hassmén, 2011). Previous research has indicated that chronic psychological stress not only impedes the recovery of muscle function following strenuous bouts of exercise (Stults-Kolehmainen & Bartholomew, 2012; Stults-Kolehmainen, Bartholomew, & Sinha, 2014), but also influences affective (i.e., less pleasure) and psychophysiological responses (i.e., less arousal) to exercise (Stults-Kolemainen, Lu, Ciccolo, Bartholomew, Brotnow, & Sinha, 2016). Kellmann (2010) further suggests that under-recovery during periods of elevated stress states can exacerbate the stress reactions already experienced, leading to unexplained performance declines and other symptoms of overtraining. Concomitantly, extreme levels of stress are thought to inhibit an athlete's ability to select and execute necessary recovery strategies, furthering their vulnerability to overtraining (Kellmann, 2010). In the context of previous literature, it makes sense that chronic psychological stress may influence athletes' responses to training, thereby influencing their perceived stress and recovery as measured by the RESTQ-Sport.

Study Purpose

In theory, exercise intensity tolerance, pain catastrophizing, perceived susceptibility to sport injury, and chronic psychological stress may influence an athlete's cognitive appraisal of the demands, resources, and consequences of sport training (Gould & Whitley, 2009; Hollander, Meyers, & LeUnes, 1995; Lazarus & Folkman, 1984; Smith, 1986). As such it is perceivable that these constructs may be antecedents of an athletes' acute psychological response to training, and may thereby explain the commonly cited interindividual variability observed in perceived stress and recovery responses (Kallus & Kellmann, 2016; Kellmann, 2010; Saw, Kellmann, et al., 2016). As such, the purpose of the current study was to identify psychological predictors (i.e., exercise intensity tolerance, pain catastrophizing, perceived susceptibility to sport injury, chronic psychological stress) of perceived acute stress and recovery responses. The *a priori* hypotheses were as follows: (a) exercise tolerance would be a negative predictor of perceived stress and a positive predictor of perceived recovery; (b) pain catastrophizing, perceived susceptibility to sport injury, and chronic psychological stress would be positive predictors of perceived stress and negative predictors of perceived recovery.

Methods

Participants and Procedure

Prior to data collection, approval was obtained from the Institutional Review Board (IRB) of the authors' affiliate university. After obtaining IRB approval, study recruitment occurred via e-mail recruitment flyers, word-of-mouth, and personal invitation through existing collaborations. Athletes (N = 494; M_{age} = 20.02 years; SD = 2.11 years) currently participating in their respective sports volunteered to take part in the study. All athletes were competing at the collegiate level of sport or higher at the time of data collection. As a sample, participants had a mean of 11.10 years (SD = 4.50 years) of experience participating in their respective sports and 2.21 years (SD = 1.59 years) of experience participating at their current competition level (e.g., collegiate, professional, etc.). Additional demographic characteristics of the sample are presented in Table 31 and Figure 5. After providing their online informed consent, all participants completed the measures identified and described below. Completion of all online measures required approximately 10-15 minutes.

Measures

Recovery Stress Questionnaire for Athletes (RESTQ-Sport). To assess athlete perceptions of stress and recovery, the 36-item version of the RESTQ-Sport (Kallus & Kellmann, 2016) was administered. All items are scored on a 7-point Likert scale ranging from 0 (*never*) to 6 (*always*). The most recent RESTQ-Sport Manual indicates that the 36-item version of the RESTQ-Sport is as reliable and valid for use in athlete populations as the original 76-item version (Kallus & Kellman, 2016). Calculated as the sum of individual subscale means, reported perceived stress and recovery scores ranged from 0 to 36.

Tolerance of Exercise Intensity Questionnaire (PRETIE-Q). To assess athlete tolerance to exercise intensity, the tolerance scale of the PRETIE-Q (Ekkekakis et al., 2005) was administered. The PRETIE-Q is an 8-item measure, and all items are scored on a 5-point Likert scale ranging from 1 (*totally disagree*) to 5 (*strongly agree*). The reliability and validity of the measure for use in adult populations has been established in previous research (Ekkekakis et al., 2005; Ekkekakis, Lind, Hall, & Petruzzello, 2007). Calculated as the sum of all item responses, reported exercise intensity tolerance scores ranged from 8 to 40.

Pain Catastrophizing Scale (PCS-EN). To assess athlete level of catastrophizing pain experienced, the PCS-EN (Sullivan, Bishop, & Pivik, 1995) was administered. The PCS-EN is a 13-item measure, with all items being scored on a 5-point Likert scale ranging from 0 (*not at all*) to 4 (*all the time*). The reliability and validity of the measure for use in adult populations has been established in previous research (Osman et al., 2000; Sullivan et al., 1995; Walton, Wideman, & Sullivan, 2013). Calculated as the sum of all item responses, reported pain catastrophizing scores ranged from 0 to 52.

Perceived Susceptibility to Sport Injury (PSSI). To assess athlete perceived susceptibility to sport injury, the PSSI (Deroche et al., 2007) was administered. The PSSI is a 4-item measure, with all items scored on a 5-point Likert scale (see Gnacinski, Arvinen-Barrow, Brewer, & Meyer, 2016 for scoring procedure). The reliability and validity of the measure for use in adult athlete populations has been established in previous research (Gnacinski et al., 2016). Calculated as the mean of item responses, reported perceived susceptibility to sport injury scores ranged from 1 to 5.

Perceived Stress Scale (PSS). To assess athlete chronic psychological stress, the PSS (Cohen & Williamson, 1988; Taylor, 2015) was administered. The PSS is a 10-item measure, and all items are scored on a 5-point Likert scale ranging from 1 (*never*) to 5 (*very often*). The reliability and validity of the measure for use in adult populations has been established in previous research (Roberti, Hartington, & Storch, 2006; Taylor, 2015). Calculated as the sum of item responses, reported chronic psychological stress scores ranged from 10 to 50.

Data Analysis

Missing data were considered missing completely at random, and were consequently treated using listwise deletion within respective statistical tests. All statistical tests were performed using IBM SPSS 22 software (IBM Corp., Armonk, NY). Descriptive statistics for all variables are reported in Table 32. Systematic multiple regression model testing was performed to identify significant predictors of perceived stress and perceived recovery. In each regression analysis, three prediction models were tested. In Model 1, gender, age, years of experience in sport, and years of experience at current competitive level were included as independent variables. In Model 2, exercise intensity tolerance, pain catastrophizing, and perceived susceptibility were included in addition to all Model 1 independent variables. In Model 3, chronic psychological stress was included in addition to all Model 2 independent variables. Multiple regression models were tested separately for non-contact and contact sport athletes, as previous research has indicated possible sport type differences in several of the independent variables (Raudenbush et al., 2012; Reuter & Short, 2005; Short et al., 2004; Kontos, 2004). No significant sport type differences were identified for any of the independent or dependent variables ($p > 0.05$; data not shown). An alpha level of 0.05 was utilized to determine statistical significance for all analyses performed.

Results

Non-Contact Sport Athletes

Stress. Model 1 was not significant, indicating that gender, age, years of experience in sport, and years of experience at competition level were not significant predictors of perceived stress. Model 2 was significant ($R^2 = 0.320$), with exercise intensity tolerance, pain catastrophizing and perceived susceptibility to sport injury emerging as significant predictors ($p < 0.05$). Model 3 was significant ($R^2 = 0.540$) and explained 22% more of the variance in perceived stress than Model 2, with exercise intensity tolerance, pain catastrophizing, perceived susceptibility to sport injury, and chronic psychological stress emerging as significant predictors ($p < 0.05$). The model summary is presented in Table 33, and significance test results for regression coefficients are presented in Table 34.

Recovery. Model 1 was not significant, indicating that gender, age, years of experience in sport, and years of experience at competition level were not significant predictors of perceived recovery. Model 2 was significant ($R^2 = 0.236$), with pain catastrophizing and perceived susceptibility to sport injury emerging as significant predictors ($p < 0.05$). Model 3 was significant (R^2 = 0.465) and explained an 23% more of the variance in perceived recovery than Model 2, with exercise intensity tolerance, pain catastrophizing, perceived susceptibility to sport injury, and chronic psychological stress emerging as significant predictors ($p < 0.05$). The model summary is presented in Table 33, and significance test results for regression coefficients are presented in Table 35.

Contact Sport Athletes

Stress. Model 1 was not significant, indicating that gender, age, years of experience in sport, and years of experience at competition level were not significant predictors of perceived stress. Model 2 was significant (R^2 = 0.188), with years of experience at competition level, pain catastrophizing, and perceived susceptibility to sport injury emerging as significant predictors ($p < 0.05$). Model 3 was significant (R^2 = 0.487) and explained 30% more of the variance in perceived stress than Model 2, with years of experience at competition level, perceived susceptibility to sport injury and chronic psychological stress emerging as significant predictors ($p < 0.05$). The model summary is presented in Table 36, and significance test results for regression coefficients are presented in Table 37.

Recovery. Model 1 was not significant, indicating that gender, age, years of experience in sport, and years of experience at competition level were not significant predictors of perceived recovery. Model 2 was significant (R^2 = 0.132), with perceived susceptibility to sport injury emerging as a significant predictor ($p < 0.05$). Model 3 was significant (R^2 = 0.345) and explained 21% more of the variance in perceived recovery than Model 2, with perceived susceptibility to sport injury and chronic psychological stress emerging as significant predictors ($p < 0.05$). The model summary is presented in Table 36, and significance test results for regression coefficients are presented in Table 38.

Discussion

The purpose of the current study was to identify psychological predictors (i.e., exercise intensity tolerance, pain catastrophizing, perceived susceptibility to sport injury, chronic psychological stress) of perceived acute stress and recovery responses. In partial support of the *a priori* hypothesis, exercise intensity tolerance was a significant positive predictor of perceived stress and recovery among non-contact sport athletes, yet was not a significant of predictor of perceived stress or recovery among contact sport athletes. Also in partial support of the *a priori* hypothesis, pain catastrophizing was a significant positive predictor of perceived stress and negative predictor of perceived recovery among non-contact sport athletes, yet was not a significant positive predictor of perceived stress or recovery among contact sport athletes. Perceived susceptibility to sport injury was a significant positive predictor of perceived stress and negative predictor of perceived recovery in both non-contact and contact sport athletes, which fully supported the *a priori* hypothesis. Similarly, chronic psychological stress was a significant positive predictor of perceived stress and a negative predictor of perceived recovery in both non-contact and contact sport athletes. It was further observed that chronic psychological stress explained an additional 22-30% of the variance in perceived stress and an additional 21-23% of the variance in perceived recovery over and above all other predictors. Finally, and although not explicitly linked to a research hypothesis, years of experience at competition level emerged as a significant positive predictor of perceived stress in contact sport athletes. A summary of the significant predictors of perceived stress and perceived recovery by sport type is presented in Figure 6.

Contrary to the authors' *a priori* hypothesis, exercise intensity tolerance was a positive predictor of perceived stress among non-contact sport athletes, and was not a significant predictor of perceived stress or recovery among contact sport athletes. These unexpected results may be explained by the use of an exercise-focused measure in a competitive sport population, as the majority of the research on exercise intensity tolerance has been conducted in the general population (Ekkekakis, Lind, & Joens-Matre, 2006; Ekkekakis, Parfitt, & Petruzzello, 2011). Furthermore, the construct of exercise intensity tolerance has only recently surfaced in the sport and exercise psychology literature (Ekkekakis et al., 2005), warranting a need for theoretical advancement regarding the nuances of the construct in all domains. Based on the current findings, practitioners should be aware that exercise intensity tolerance, or an athlete's propensity to "push through" the tough workouts, may not be a reliable predictor of their psychological responses to training load.

The current results indicated that pain catastrophizing was a significant positive predictor of perceived stress and a significant negative predictor of perceived recovery in non-contact sport athletes, yet was not a significant predictor of perceived stress or recovery in contact sport athletes. Previous research indicates that contact sport athletes may have higher pain tolerance than non-contact sport athletes, and that physical contact may desensitize athletes to pain (Raudenbush et al., 2012). Both Deroche et al. (2011) and Raudenbush et al. (2012) further suggest that athletes who are more willing to exercise through pain often underestimate the need for proper healing time after exercise, which consequently elevates injury risk. Given the current findings, practitioners might anticipate that for every one standard deviation increase in pain catastrophizing, predicted perceived stress scores will increase by 0.172 standard deviations, and predicted perceived recovery scores will decrease by 0.156 standard deviations. In looking at RESTQ-Sport profiles over time, it appears non-contact sport athletes who catastrophize pain may have more drastic responses in their RESTQ-Sport data during stressful conditions (e.g., training load peaks, competitions) than would non-contact sport athletes who do not catastrophize pain. By contrast, pain catastrophizing does not appear to influence contact sport athletes' responses to the RESTQ-Sport.

The current results indicated that perceived susceptibility to sport injury was a significant positive predictor of perceived stress and negative predictor of perceived recovery, regardless of sport type. The current results are consistent with a previously mentioned stress-injury model (Williams & Andersen, 1998), reinforcing that history of injury stressors (i.e., perceived susceptibility to sport injury) may influence subsequent perceptions of stress and recovery. In practice, a one standard deviation increase in perceived susceptibility to sport injury will yield an approximate 0.157 – 0.179 standard deviation increase in predicted perceived stress and 0.095 – 0.177 standard deviation decrease in predicted perceived recovery. In both non-contact and contact sports, athletes who have high levels of perceived susceptibility to sport injury may have more drastic responses in their RESTQ-Sport data during stressful conditions than would athletes who have low levels of perceived susceptibility to sport injury.

The current results indicated that chronic psychological stress was a significant positive predictor of perceived stress and negative predictor of perceived recovery regardless of sport type, and was the strongest predictor in all models tested. More specifically, for every one standard deviation increase in chronic psychological stress, an approximate 0.537 – 0.584 standard deviation increase in predicted perceived stress and a 0.492 – 0.547 standard deviation decrease in predicted perceived recovery is expected. These data reinforce previous findings from the burnout literature (Gould & Whitley, 2009; Gustafsson et al., 2011), as well as current recommendations for training load monitoring (Soligard et al., 2016), which collectively demonstrate that chronic psychological stress may be an important variable when considering overall psychological load in any given sport. The finding of chronic psychological stress as a predictor of perceived acute stress and recovery is also consistent with Gabbett's (2016) training-injury prevention paradox, which suggests monitoring the ratio of acute:chronic training load is more meaningful than acute training load alone. Regardless of sport type, athletes who have high levels of chronic psychological stress may display magnified acute RESTQ-Sport responses during stressful conditions compared to athletes who have low levels of chronic psychological stress.

Among contact sport athletes, years of experience at competition level unexpectedly emerged as a positive predictor of perceived acute stress. Previous research has indicated that organizational stressors (e.g., media, coach support, trades, perceptions of administration, pressures to perform on demand) and life stressors (i.e., travel, sleep disturbances, time away from family, etc.) prevail at the collegiate and elite levels of competition (Hanton, Fletcher, & Coughlan, 2005; Mellalieu, Neil, Hanton, & Fletcher, 2009; Rice et al., 2016). Thus, athletes who have been participating at a given competitive level for several years may have magnified perceptions of acute stress. Additionally, it should be noted that the data for years of experience at competitive level were treated as ratio level data, yet less experienced athletes provided more detailed responses than the more experienced athletes (e.g., "1 year and 2 months" vs. "about 10 years"). To these ends, this finding should be interpreted with caution, as only 3% of the sample had more than four years of experience at their competition level, and nearly 65% of the sample had fewer than two years of experience at their competition level.

Limitations and Directions for Future Research

While the above findings augment recommendations regarding training load management as outlined in the IOC consensus statements, limitations of the current study prompt continued research in this area. First, the current study design did not account for training modalities used or physical fitness levels of the participants. The model suggested in Figure 6 should be tested using a longitudinal research design or controlled experimental design which involves athletes training at quantifiable loads (Gabbett, 2016). Second, the current study did not include athlete coping strategies as predictor variables. Problem-focused and emotion-focused coping strategies may influence perceptions of stress and recovery (Kim & Duda, 2003; Lazarus & Folkman, 1984), and so these variables should be included in future research.

Finally, the current study design did not account for the theoretical dual-role of exercise intensity tolerance, pain catastrophizing, and perceived susceptibility to sport injury on the dependent variables. As an example of the dual-role, research has suggested that high exercise intensity tolerance may facilitate the completion of intense overloads necessary to induce training adaptations (Tempest & Parfitt, 2016) while simultaneously blunting the protective symptoms associated with overtraining and injury (Ekkekakis et al., 2005). Similarly, given the role of pain in the functioning of the body's immune system, Deroche et al. (2011) suggest that pain catastrophizing may be a protective mechanism of athlete health and safety in the short-term, yet may also be a hindrance to long-term performance enhancement if athletes are unable to exercise at the high intensities prescribed. Researchers have also noted the potential dual-role of perceived susceptibility to sport injury, where the construct functions as a facilitator of injury/disease prevention behaviors for some individuals, and a deterrent of injury/disease prevention behaviors in others (Gerrard, Gibbons, & Bushman, 1996; Katapodi, Lee, Facione, & Dodd, 2004). Future research should examine the dual-role functionality of all constructs as they relate to perceptions of stress and recovery by identifying possible moderators of the dual-role relationships. Such work might be informed further by the tenets of reversal theory (Thatcher, Kerr, Amies, & Day, 2007) or Smith's cognitive-affective model of athletic burnout (Smith, 1986).

Conclusion

The current study was completed in direct response to the IOC consensus statement recommendations for monitoring training load using subjective measures like the RESTQ-Sport. The current study was the first of its kind to examine previously untested psychological antecedents to perceived stress and recovery, further expanding on the overtraining and burnout literature. In addition to data-driven directions for future research on sport-specific and psychological nuances of perceived stress and recovery (Figure 6), the current findings support greater specificity in psychological interventions informed by the RESTQ-Sport in practice. Considering the current findings, practitioners are encouraged to monitor both acute and chronic psychological responses to training load, and use the presented data to inform individualized intervention strategies.

Figures & Tables

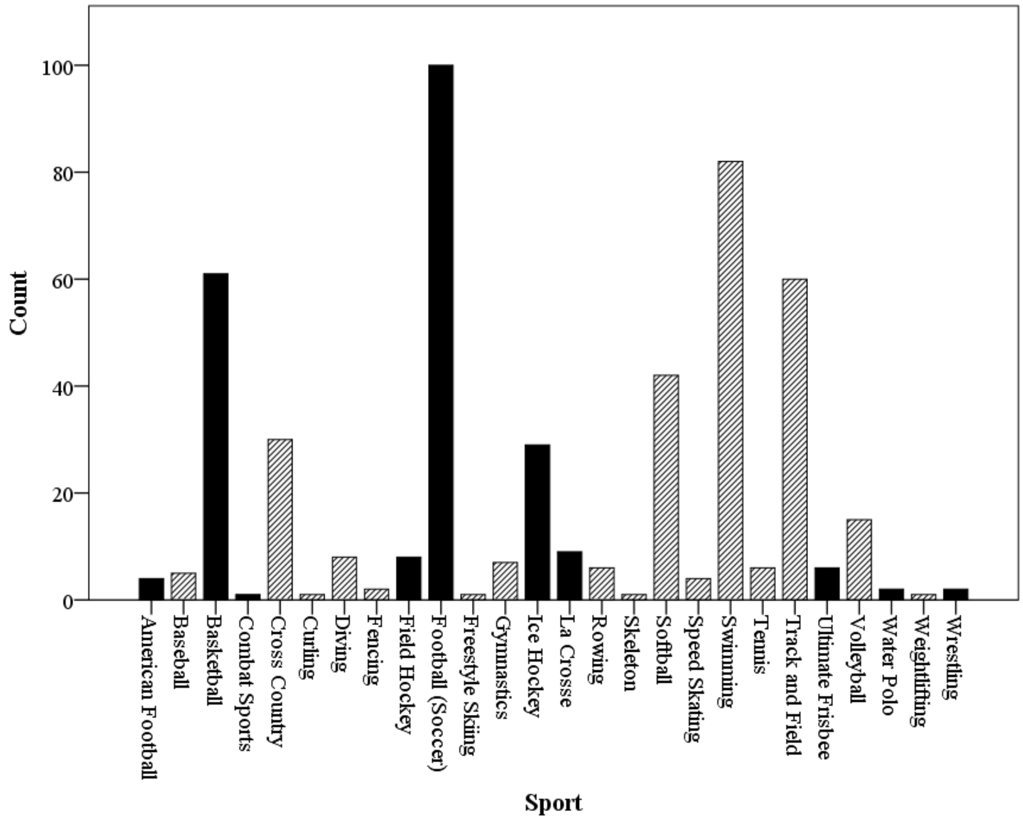

Figure 5. Frequency distribution of participants by sport type (contact sports = black bars, non-contact sports = pattern bars).

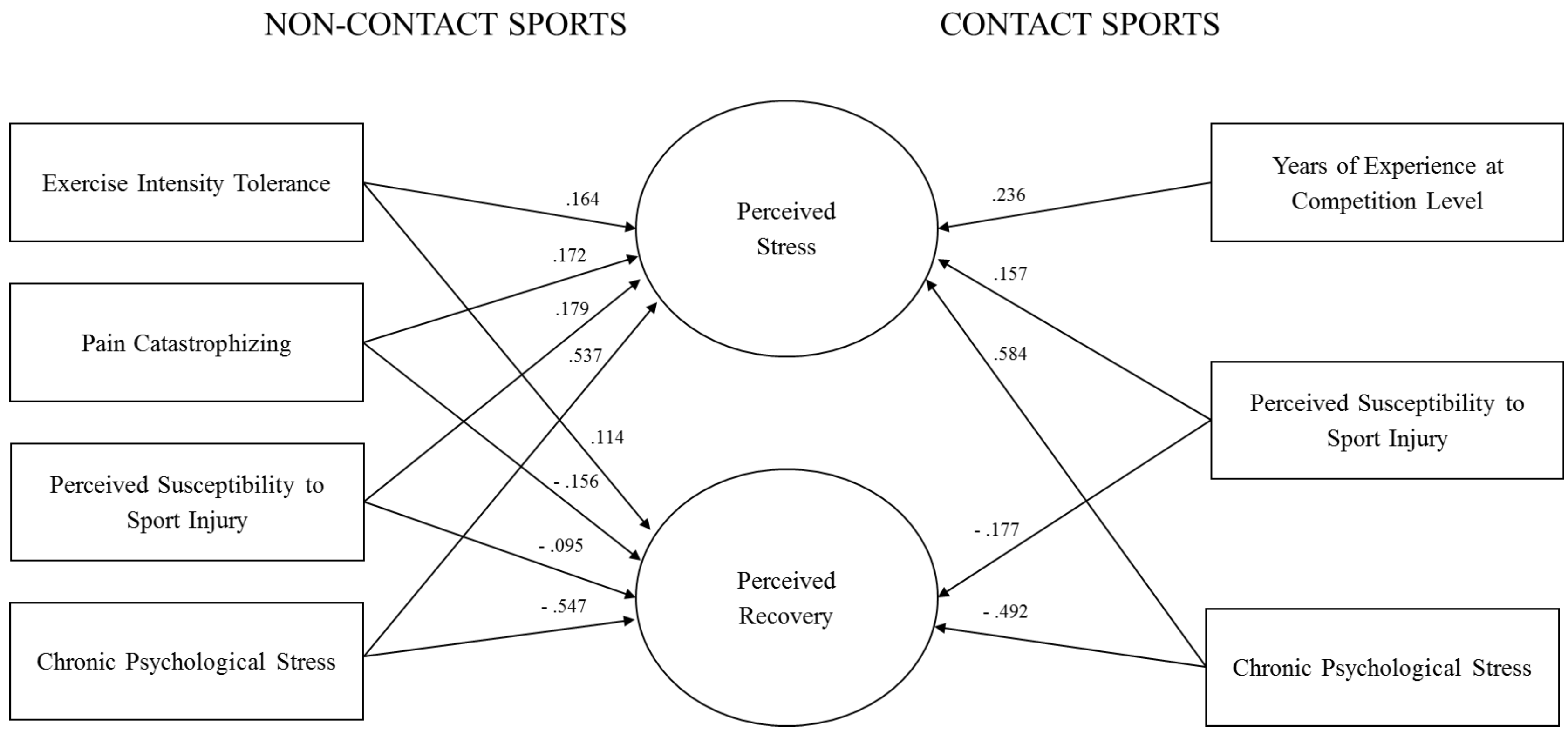

Figure 6. Significant predictors of perceived stress and recovery from Model 3 in non-contact (left side of model) and contact sport athletes (right side of model). Non-significant predictors of Model 3 are not shown.

Table 31

Athlete Demographic Characteristics

Characteristic	Overall (*N* = 494) Percent by Category	Non-Contact Sport (*n* = 272) Percent by Category	Contact Sport (*n* = 222) Percent by Category
Gender			
Male	33.0%	38.2%	26.6%
Female	67.0%	61.8%	73.4%
Race/Ethnicity			
Caucasian/White	89.3%	88.6%	90.1%
Black/African American	3.6%	2.6%	5.0%
Latino/a or Hispanic	3.4%	5.5%	0.9%
Asian	0.8%	0.7%	0.9%
Native American	0.2%	--	0.5%
Other	0.4%	2.6%	2.7%
Nationality			
American (USA)	87.2%	91.9%	81.5%
Canadian	7.1%	4.4%	10.4%
British or English	2.1%	1.1%	4.1%
Australian	0.6%	1.1%	--
Other	2.6%	1.5%	4.1%
Season Status			
Pre-Season or Training Camp	12.6%	16.9%	7.2%
In-Season	67.0%	61.4%	73.9%
Off-Season	18.6%	20.2%	16.7%
Other	1.8%	1.5%	2.3%
Competition Level			
NCAA Division III	33.8%	31.6%	36.5%
NCAA Division II	14.4%	17.3%	10.8%
NCAA Division I	40.7%	43.4%	37.4%
CCAA	3.0%	1.8%	4.5%
BUCS	2.4%	1.5%	3.2%
Professional (NGB)	2.2%	0.4%	5.0%
International/Olympic	1.6%	2.6%	0.5%
Other	1.8%	1.5%	2.3%

Note. NCAA = National Collegiate Athletic Association, CCAA = Canadian Collegiate Athletic Association, BUCS = British Universities & Colleges Sport, NGB = National Governing Body.

Table 32

Descriptive Statistics

Variable	Overall (*N* = 494)	Non-Contact Sport (*n* = 272)	Contact Sport (*n* = 222)
Exercise Intensity Tolerance	29.85 ± 4.79 (29.37 – 30.33)	29.84 ± 5.08 (29.14 – 30.54)	29.85 ± 4.43 (29.19 – 30.51)
Pain Catastrophizing	13.28 ± 10.45 (12.23 – 14.33)	13.49 ± 10.57 (12.04 – 14.94)	13.04 ± 10.35 (11.50 – 14.58)
Perceived Susceptibility to Sport Injury	2.67 ± 0.90 (2.58 – 2.76)	2.67 ± 0.99 (2.53 – 2.80)	2.67 ± 0.80 (2.55 – 2.79)
Chronic Psychological Stress	18.20 ± 7.11 (17.49 – 18.92)	17.94 ± 7.63 (16.89 – 18.98)	18.52 ± 6.45 (17.56 – 19.48)
Perceived Stress	10.95 ± 5.54 (10.40 – 11.51)	10.83 ± 5.66 (10.06 – 11.61)	11.09 ± 5.41 (10.29 – 11.90)
Perceived Recovery	19.60 ± 5.66 (19.03 – 20.17)	19.91 ± 5.54 (19.15 – 20.67)	19.22 ± 5.78 (18.36 – 20.08)

Note. All descriptive statistics reported as *M* ± *SD* (95% lower bound and upper bound confidence intervals).

Table 33

Model Summary in Non-Contact Sport Athletes

Dependent Variable	R^2	Adj. R^2	SEE	F	df	p	ΔR^2
Perceived Stress							
Model 1	.026	.005	5.713	1.262	4, 195	.286	.026
Model 2	.320	.294	4.812	12.618	7, 195	< .001	.294*
Model 3	.540	.521	3.966	27.474	8, 195	< .001	.221*
Perceived Recovery							
Model 1	.021	.000	5.524	1.020	4, 195	.398	.021
Model 2	.236	.208	4.918	8.307	7, 195	< .001	.215
Model 3	.465	.442	4.127	20.318	8, 195	< .001	.229

* Significant ΔF ($p < .001$).

Table 34

Significance Tests Results for Perceived Stress Regression Coefficients among Non-Contact Sport Athletes

Variable	*B*	*SE B*	β	*T*	*p*	Zero	Partial	Part
Model 1 (Constant)	15.991	5.295		3.020	.003			
Gender	-.269	.894	-.022	-.301	.763	-.025	-.022	-.022
Age	-.371	.287	-.121	-1.292	.198	-.018	-.093	-.092
Years of Experience in Sport	.122	.100	.089	1.216	.226	.102	.088	.087
Years of Experience at Competition Level	.672	.417	.154	1.613	.108	.090	.116	.115
Model 2 (Constant)	2.452	5.103		.481	.631			
Gender	-.795	.768	-.065	-1.036	.302	-.025	-.075	-.062
Age	-.219	.243	-.072	-.902	.368	-.018	-.066	-.054
Years of Experience in Sport	.113	.085	.083	1.327	.186	.102	.096	.080
Years of Experience at Competition Level	.243	.358	.055	.678	.498	.090	.049	.041
Exercise Intensity Tolerance	**.172**	**.069**	**.153**	**2.474**	**.014**	**.174**	**.178**	**.149**
Pain Catastrophizing	**.195**	**.036**	**.360**	**5.402**	**.000**	**.463**	**.367**	**.325**
Perceived Susceptibility to Sport Injury	**1.518**	**.385**	**.265**	**3.944**	**.000**	**.415**	**.276**	**.237**
Model 3 (Constant)	-.988	4.221		-.234	.815			
Gender	-1.172	.634	-.096	-1.848	.066	-.025	-.134	-.092
Age	-.227	.200	-.074	-1.132	.259	-.018	-.082	-.056
Years of Experience in Sport	.031	.071	.022	.433	.666	.102	.032	.021
Years of Experience at Competition Level	.034	.296	.008	.114	.909	.090	.008	.006
Exercise Intensity Tolerance	**.185**	**.057**	**.164**	**3.228**	**.001**	**.174**	**.230**	**.160**
Pain Catastrophizing	**.093**	**.032**	**.172**	**2.953**	**.004**	**.463**	**.211**	**.146**
Perceived Susceptibility to Sport Injury	**1.027**	**.322**	**.179**	**3.194**	**.002**	**.415**	**.227**	**.158**
Chronic Psychological Stress	**.406**	**.043**	**.537**	**9.474**	**.000**	**.653**	**.570**	**.470**

Table 35

Significance Tests Results for Perceived Recovery Regression Coefficients among Non-Contact Sport Athletes

Variable	*B*	*SE B*	β	*T*	*p*	Zero	Partial	Part
Model 1 (Constant)	22.761	5.120		4.446	.000			
Gender	-.820	.864	-.070	-.949	.344	-.075	-.069	-.068
Age	-.043	.278	-.015	-.155	.877	-.066	-.011	-.011
Years of Experience in Sport	-.109	.097	-.083	-1.124	.262	-.103	-.081	-.080
Years of Experience at Competition Level	-.302	.403	-.072	-.748	.455	-.086	-.054	-.054
Model 2 (Constant)	24.638	5.215		4.725	.000			
Gender	.092	.785	.008	.118	.906	-.075	.009	.008
Age	-.128	.249	-.043	-.513	.609	-.066	-.037	-.033
Years of Experience in Sport	-.125	.087	-.095	-1.430	.154	-.103	-.104	-.091
Years of Experience at Competition Level	-.120	.366	-.028	-.327	.744	-.086	-.024	-.021
Exercise Intensity Tolerance	.137	.071	.126	1.929	.055	.114	.139	.123
Pain Catastrophizing	**-.181**	**.037**	**-.347**	**-4.911**	**.000**	**-.432**	**-.337**	**-.313**
Perceived Susceptibility to Sport Injury	**-1.005**	**.393**	**-.182**	**-2.555**	**.011**	**-.316**	**-.183**	**-.163**
Model 3 (Constant)	28.017	4.392		6.379	.000			
Gender	.462	.660	.039	.701	.484	-.075	.051	.037
Age	-.120	.209	-.041	-.576	.565	-.066	-.042	-.031
Years of Experience in Sport	-.044	.074	-.033	-.591	.555	-.103	-.043	-.032
Years of Experience at Competition Level	.086	.308	.020	.278	.781	-.086	.020	.015
Exercise Intensity Tolerance	**.124**	**.060**	**.114**	**2.084**	**.038**	**.114**	**.151**	**.111**
Pain Catastrophizing	**-.081**	**.033**	**-.156**	**-2.472**	**.014**	**-.432**	**-.178**	**-.132**
Perceived Susceptibility to Sport Injury	**-.523**	**.335**	**-.095**	**-1.563**	**.120**	**-.316**	**-.114**	**-.084**
Chronic Psychological Stress	**-.399**	**.045**	**-.547**	**-8.943**	**.000**	**-.646**	**-.547**	**-.478**

Table 36

Model Summary in Contact Sport Athletes

Dependent Variable	R^2	*Adj.* R^2	SEE	F	df	p	ΔR^2
Perceived Stress							
Model 1	.049	.026	5.230	2.108	4, 166	.082	.049
Model 2	.188	.152	4.943	5.258	7, 166	< .001	.139*
Model 3	.487	.461	3.941	18.760	8, 166	< .001	.299*
Perceived Recovery							
Model 1	.012	-.013	5.792	0.474	4, 166	.755	.012
Model 2	.132	.094	5.480	3.450	7, 166	.002	.120*
Model 3	.345	.312	4.776	10.391	8, 166	< .001	.213*

* Significant ΔF ($p < .001$).

Table 37

Significance Tests Results for Perceived Stress Regression Coefficients among Contact Sport Athletes

Variable	*B*	*SE B*	β	*T*	*p*	Zero	Partial	Part
Model 1 (Constant)	13.304	4.322		3.078	.002			
Gender	1.786	.948	.147	1.884	.061	.141	.146	.144
Age	-.158	.231	-.072	-.683	.496	.002	-.054	-.052
Years of Experience in Sport	-.138	.111	-.102	-1.246	.215	-.078	-.097	-.095
Years of Experience at Competition Level	.655	.333	.204	1.965	.051	.103	.153	.151
Model 2 (Constant)	5.742	4.864		1.180	.240			
Gender	.980	.906	.081	1.082	.281	.141	.085	.077
Age	-.134	.216	-.061	-.620	.536	.002	-.049	-.044
Years of Experience in Sport	-.133	.103	-.099	-1.292	.198	-.078	-.102	-.092
Years of Experience at Competition Level	**.678**	**.311**	**.211**	**2.180**	**.031**	**.103**	**.170**	**.156**
Exercise Intensity Tolerance	.056	.088	.047	.639	.524	.000	.051	.046
Pain Catastrophizing	**.121**	**.039**	**.237**	**3.083**	**.002**	**.302**	**.237**	**.220**
Perceived Susceptibility to Sport Injury	**1.621**	**.507**	**.240**	**3.200**	**.002**	**.316**	**.246**	**.229**
Model 3 (Constant)	2.045	3.897		.525	.600			
Gender	.107	.728	.009	.147	.883	.141	.012	.008
Age	-.314	.173	-.144	-1.810	.072	.002	-.143	-.103
Years of Experience in Sport	-.045	.083	-.034	-.547	.585	-.078	-.043	-.031
Years of Experience at Competition Level	**.759**	**.248**	**.236**	**3.057**	**.003**	**.103**	**.236**	**.174**
Exercise Intensity Tolerance	.058	.070	.048	.831	.407	.000	.066	.047
Pain Catastrophizing	.059	.032	.115	1.836	.068	.302	.145	.105
Perceived Susceptibility to Sport Injury	**1.058**	**.408**	**.157**	**2.592**	**.010**	**.316**	**.202**	**.148**
Chronic Psychological Stress	**.480**	**.050**	**.584**	**9.601**	**.000**	**.643**	**.607**	**.547**

Table 38

Significance Tests Results for Perceived Recovery Regression Coefficients among Contact Sport Athletes

Variable	*B*	*SE B*	β	*T*	*p*	Zero	Partial	Part
Model 1 (Constant)	19.508	4.725		4.129	.000			
Gender	-1.257	1.036	-.096	-1.213	.227	-.094	-.095	-.095
Age	.003	.252	.001	.013	.989	.002	.001	.001
Years of Experience in Sport	.061	.121	.042	.503	.615	.037	.040	.039
Years of Experience at Competition Level	-.165	.364	-.048	-.452	.652	-.020	-.036	-.035
Model 2 (Constant)	21.870	5.392		4.056	.000			
Gender	-.794	1.004	-.061	-.791	.430	-.094	-.063	-.058
Age	-.026	.240	-.011	-.110	.913	.002	-.009	-.008
Years of Experience in Sport	.044	.115	.031	.388	.699	.037	.031	.029
Years of Experience at Competition Level	-.174	.345	-.050	-.504	.615	-.020	-.040	-.037
Exercise Intensity Tolerance	.132	.098	.102	1.349	.179	.136	.106	.100
Pain Catastrophizing	-.080	.044	-.146	-1.838	.068	-.237	-.144	-.136
Perceived Susceptibility to Sport Injury	**-1.793**	**.561**	**-.248**	**-3.194**	**.002**	**-.305**	**-.246**	**-.236**
Model 3 (Constant)	25.214	4.723		5.339	.000			
Gender	-.005	.882	.000	-.005	.996	-.094	.000	.000
Age	.136	.210	.058	.648	.518	.002	.052	.042
Years of Experience in Sport	-.035	.100	-.024	-.351	.726	.037	-.028	-.023
Years of Experience at Competition Level	-.247	.301	-.072	-.820	.413	-.020	-.065	-.053
Exercise Intensity Tolerance	.130	.085	.101	1.526	.129	.136	.120	.098
Pain Catastrophizing	-.024	.039	-.043	-.609	.543	-.237	-.048	-.039
Perceived Susceptibility to Sport Injury	**-1.284**	**.494**	**-.177**	**-2.597**	**.010**	**-.305**	**-.202**	**-.167**
Chronic Psychological Stress	**-.434**	**.061**	**-.492**	**-7.165**	**.000**	**-.540**	**-.495**	**-.461**

Chapter V: Dissertation Conclusions

The Recovery Stress Questionnaire for Athletes (RESTQ-Sport) has been utilized in over one hundred research studies (Kallus & Kellmann, 2016), yet several remaining gaps in the literature hinder the effective translation of the measure from research to practice (Saw, Main, & Gastin, 2015a; Taylor, Chapman, Cronin, Newton, & Gill, 2012). First, previous studies on the psychometric properties (e.g., item performance, reliability, validity) of the RESTQ-Sport have generated inconsistent results. Second, although both the Profile of Mood States (POMS) and RESTQ-Sport are recommended for use in monitoring athletes' responses to training load (Saw, Main, & Gastin, 2016), little research has been conducted to understand the measurement overlap between the two measures. Third and finally, RESTQ-Sport researchers have noted, yet not been able to explain, the substantial proportion of variability in athlete subjective responses to training load and competitions (Saw, Kellmann, Main, & Gastin, 2016). To address the gaps in the RESTQ-Sport literature identified above, the purposes of the current dissertation research were to: (a) utilize advanced methods of psychometric evaluation to identify poor performing items as well as to confirm the most valid factor structure (i.e., measurement model parsimony) of the RESTQ-Sport, (b) examine the measurement overlap between the POMS and RESTQ-Sport, and (c) identify psychological variables (i.e., exercise tolerance, perceived susceptibility to sport injury, pain catastrophizing, chronic psychological stress) that contribute to the intraindividual and interindividual variability in perceived stress and recovery.

Summary of Dissertation Results

In accordance with the first purpose of the study, results of the classical test theory (CTT) and item response theory (IRT) analyses indicated the RESTQ-Sport provides more information about athletes who are at high risk of overtraining (i.e., very stressed and under-recovered) than those who are at low risk of overtraining (i.e., not at all stressed, properly recovered). Results of the IRT analysis further revealed a total of 46 poorly performing items. In terms of the factor analysis, no support was identified for the hypothesized hierarchical factor structure of the RESTQ-Sport. By contrast, the most parsimonious measurement model identified included only the 76-items and 19 latent subscales. The results of the exploratory structural equation modeling (ESEM) analysis further revealed substantial cross-loading issues with the general and sport-specific recovery scales, a finding which was masked in the current and likely previous confirmatory factor analysis (CFA) results. Overall, removal of poor performing items (e.g., items with low discrimination parameters, recovery items that significantly cross-load with the stress factor) might improve the performance of the RESTQ-Sport across the continuum of overtraining.

As it concerns the second purpose of the dissertation research, findings revealed that mood states explained more of the variance in perceived stress (63%) than perceived recovery (54%), and that mood states explained more of the variance in stress-recovery state (71%) than either perceived stress or recovery. Regression coefficients and zero-order correlations supported that the mood states of tension, anger, fatigue, depression, and confusion were positively related to perceived stress and negatively related to perceived recovery, and that vigor was negatively related to perceived stress yet positively related to perceived recovery. The current findings also demonstrated that while there is considerable overlap between the POMS and the RESTQ-Sport, 29-46% of the variance in RESTQ-Sport responses is explained by variables other than mood states. This finding supports previous claims that the POMS and RESTQ-Sport are related measures, yet the RESTQ-Sport may capture more information than mood states alone (Kellmann & Kallus, 2001; Saw et al., 2016). Overall, the results of the current dissertation research refute previous claims that the POMS does not correspond to perceptions of recovery (Kellmann & Kallus, 2001), and provide evidence for the effect of collective mood states on athlete RESTQ-Sport data.

Regarding the third purpose of the dissertation research, findings revealed that among non-contact sport athletes, exercise intensity tolerance, pain catastrophizing, and perceived susceptibility to sport injury were significant predictors of perceived stress and recovery. Among contact sport athletes, only perceived susceptibility to sport injury was a significant predictor of perceived stress and recovery. Results also indicated that chronic psychological stress was a significant positive predictor of perceived stress and a negative predictor of perceived recovery in both non-contact and contact sport athletes. More specifically, it was observed that chronic psychological stress explained an additional 22-30% of the variance in perceived stress and an additional 21-23% of the variance in perceived recovery over and above all other examined variables. Taken together, results illuminate the effect of intraindividual (i.e., chronic psychological stress) and interindividual (e.g., sport-type, exercise tolerance, perceived susceptibility to injury, pain catastrophizing) characteristics on RESTQ-Sport outcomes.

Findings of this dissertation research will go a long way toward advancing the scholarly literature sports medicine and sport psychology alike, due in large part to the robust methodology employed. First, the data analysis procedures utilized expand on those used in previous studies. The use of IRT, ESEM, and multiple regression expand on the CTT, CFA, and correlation procedures utilized in previous research, which in turn allowed for a comprehensive critique of RESTQ-Sport measurement and theory. Second, the sample size utilized ($N = 567$) was sufficient to power the advanced statistical procedures employed in the dissertation. Lastly, the research hypotheses tested were directly informed by gaps in the literature that currently impede the effectiveness of sports medicine and sport psychology practice. Such a scientist-practitioner approach to research is touted as critical to the advancement of practice (Giacobbi, Poczwardowski, & Hager, 2005; Wylleman, Harwood, Elbe, Reints, & de Caluwé, 2009).

Limitations & Directions for Future Research

The contributions of the current dissertation research to the extant literature notwithstanding, there are limitations of the work which prompt directions for future research. One limitation of the current dissertation research is the homogeneity in participant characteristics (e.g., collegiate, white/Caucasian, United States/American nationality), which limits the generalizability of findings to diverse populations of athletes. Future research is warranted to study the RESTQ-Sport measurement and theory in more diverse groups of English-speaking athletes, and those who may be most likely to complete the RESTQ-Sport as part of their sport monitoring protocols (e.g., professional and international/Olympic level competitors).

Additionally, a limitation of the current dissertation research is that no environmental or social data were included within the cross-sectional design. Future research should account for the environmental and social context that could theoretically influence athletes' responses to training load, as measured by the RESTQ-Sport. Examples of such contextual variables include, but are not limited to, competition outcomes, season outcomes, training and rehabilitation resources, as well as coach or other staff perceptions of and commitment to the process of recovery.

Another limitation of the current dissertation research is that despite the theorized relationship between stress and recovery latent constructs (Kellmann, 2002, 2010), stress and recovery were treated as orthogonal constructs. To attain a nuanced understanding of RESTQ-

Sport measurement, which in turn would enhance the specificity of practical interventions informed by RESTQ-Sport data, future research must be conducted to more clearly define the mathematical relation between stress states and recovery demands (Kellmann, 2002, 2010). The substantial overlap in stress and recovery measurement identified in the current study further reinforces the need for data-driven examinations of the relationship between stress and recovery.

As a final thought, and from a scientist-practitioner perspective, it is clear that additional research is needed to improve the general understanding of recovery as an integrated process, as well as to determine the effectiveness of recovery interventions for achieving intended outcomes. This need for research is even more apparent in the field of sport psychology, as the psychological aspects of recovery have been the least investigated of all potential variables thought to influence recovery (e.g., physiology, nutrition, physiotherapy). To put this recommendation for future research into additional context, researchers have been studying the psychology of stress since the late 1960s, with efforts to understand the role of stress in sport peaking in the 1980s and 1990s. By contrast, studies examining the psychology of recovery have only recently surfaced in the 2000s, with little to no advancement of recovery theory occurring outside Kellmann’s work (2002, 2010). The lack of scientific evidence to support recovery interventions in practice is problematic, as many of the theories underpinning periodization and training load management (e.g., general adaptation syndrome, stimulus-fatigue-recovery-adaptation theory, fitness-fatigue paradigm) suggest positive training adaptations and subsequent performance gains are contingent upon on the effectiveness of recovery periods (Haff & Haff, 2012). Given the rapidly advancing body of literature on training load quantification and training dose prescription (Bartlett, O’Connor, Pitchford, Torres-Ronda, & Robertson, 2017; Drew & Finch, 2016; Gabbett, 2016; Halson, 2014; Schwellnus et al., 2016;

Soligard et al., 2016; Wallace, Slattery, & Coutts, 2014), it is anticipated that recovery will be a top sport science priority area of research in the coming decades.

Implications for Professional Practice

The results of this dissertation research hold implications for sports medicine and sport psychology practice. The research conducted to clarify the psychometric properties of the RESTQ-Sport indicated potential problems with the reliability and validity of several perceived recovery scales. Given the potential for item redundancy in the 76-item measure, shorter versions of the RESTQ-Sport (i.e., RESTQ-Sport-36-R) may prove more reliable and valid. In addition, the research conducted to understand the overlap between the POMS and RESTQ-Sport indicated that mood states collectively explain a substantial proportion of the variance (54-71%) in perceived stress and recovery. Practitioners should be aware that across the overtraining continuum, mood disturbances are typically observed once an athlete has reached a state of nonfunctional overreaching. For red-flagging procedures (Saw, Kellmann, et al., 2016), both the POMS and RESTQ-Sport would be appropriate choices, whereas for intervention procedures, the RESTQ-Sport may be more suitable than the POMS to inform specific interventions (e.g., social recovery, sleep quality).

Finally, the research conducted to examine the oft-cited intraindividual and interindividual variability in RESTQ-Sport outcomes demonstrated that sport-type, athlete trait characteristics, and chronic psychological stress significantly influence perceptions of stress and recovery. As it relates to adjustments to training load, sport type and athlete characteristics should be accounted for prior to any reductions or increases in training load based on RESTQ-Sport outcomes. Practitioners should also be aware that chronic psychological stress has a substantial impact on RESTQ-Sport outcomes, and could consider monitoring perceptions of stress and recovery using the acute:chronic ratio method proposed by Gabbett (2016). Given the aforementioned paucity of recovery intervention research, practitioners are also encouraged to utilize the RESTQ-Sport within an integrated training load response monitoring protocol. Such comprehensive approaches will allow for careful determination of the athlete's recovery needs, thereby informing interventions that can be employed within existing environmental parameters (e.g., traveling, competition phase, training camps, limited financial resources).

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APPENDICES

APPENDIX A

Demographic Questionnaire

Study Title: A psychometric evaluation and revision of the Recovery Stress Questionnaire for Athletes (RESTQ-Sport)
IRB Protocol # = 17.037

1. Age (continuous)
2. Gender (nominal)
    a. Male
    b. Female
    c. Other
3. Cultural background
    a. Race/ethnicity (nominal)
        i. White/Caucasian
        ii. African American
        iii. Asian
        iv. Black
        v. Pacific Islander
        vi. Native American
        vii. Other
    b. Nationality (nominal)
        i. American
        ii. Australian
        iii. Canadian
        iv. British or English
        v. Other
4. Please indicate your highest level of education attained
    a. Some high school education
    b. High school diploma
    c. Post-high school education
    d. Bachelor's degree
    e. Other
    If you chose Other, please explain what level of education you have attained
5. Sport (nominal)
    a. Archery
    b. Basketball
    c. Freestyle Skiing
    d. Climbing
    e. Cycling
    f. Ultimate Frisbee
    g. Combat sports
    h. Equestrian
    i. Water polo
    j. Swimming
    k. Track and Field
    l. Cross Country

m. Baseball
n. Softball
o. Ice Hockey
p. Field Hockey
q. La Crosse
r. American football
s. Football or soccer
t. Sailing
u. Rowing
v. Marathon or Ultra-marathon running
w. Cricket
x. Gymnastics
y. Trampoline & Tumble Gymnastics
z. Curling
aa. Badminton
bb. Diving
cc. Synchronized swimming
dd. Figure skating
ee. Speed skating
ff. Skeleton
gg. Ski jumping
hh. Biathlon
ii. Wrestling
jj. Fencing
kk. Weightlifting
ll. Table tennis
mm. Tennis
nn. Volleyball
oo. Judo
pp. Handball
qq. floorball

6. Level of sport (nominal)
    a. NCAA Division III
    b. NCAA Division II
    c. NCAA Division I
    d. Professional sport sanctioned by National Governing Body (NGB)
    e. Olympic sport sanctioned by International Olympic Committee (IOC)
7. Years of experience in current sport (continuous)
8. Years of experience at the current level of sport (continuous)
9. Injury history (nominal & continuous) – Explicitly listed as optional
    a. Mild (i.e., prevented sport participation for less than 7 days)
    b. Moderate (i.e., prevented sport participation for 7-21 days)
    c. Severe (i.e., prevented sport participation for more than 21 days)

   d. Career-ending (i.e., injury was a direct cause of retirement from/discontinuation of sport)

10. Medical history (nominal & continuous) – Explicitly listed as optional
    a. Diagnosed mental disorder (optional to identify/report)
    b. Diagnosed bacterial/viral infection (optional to identify/report)
    c. Diagnosed inflammatory disease (optional to identify/report
    d. Diagnosed auto-immune disease (optional to identify/report
    e. Diagnosed endocrine disorders (optional to identify/report)
    f. Other conditions that influence sport participation (optional to identify/report
11. Medications (nominal and freetext) – Explicitly listed as optional
    a. Birth control
    b. Blood pressure
    c. Anti-anxiety
    d. Anti-depressant
    e. Other
12. Current participation in training or competition (nominal)
    a. Pre-season
    b. In-season
    c. Off-season

APPENDIX B

Participant Consent Form

University of Wisconsin – Milwaukee

Consent to Participate in Online Survey Research

Study Title: A psychometric evaluation and revision of the Recovery Stress Questionnaire for Athletes (RESTQ-Sport)

Person Responsible for Research: Student PI: Stacy Gnacinski, Faculty-PI: Barbara Meyer

Study Description: The purpose of this research study is to examine the reliability and validity of the RESTQ-Sport, and if necessary, improve the psychometric properties of the measure. Approximately 2000 subjects will participate in this study. If you agree to participate, you will be asked to complete an online survey that will take approximately 30-60 minutes to complete. The survey questions will ask you to indicate your perceptions of stress, recovery, mood, exercise tolerance, training distress, pain, and perceived susceptibility to injury.

Risks / Benefits: Risks to participants are considered minimal. Collection of data and survey responses using the internet involves the same risks that a person would encounter in everyday use of the internet, such as breach of confidentiality. While the researchers have taken every reasonable step to protect your confidentiality, there is always the possibility of interception or hacking of the data by third parties that is not under the control of the research team.

There will be no costs for participating. There are no known benefits of participating, other than advancing research on athlete performance and health.

Limits to Confidentiality: Identifying information such as your name and the Internet Protocol (IP) address of this computer will be collected for research purposes (i.e., ensuring that each athlete has completed the survey once only). Data will be retained on the Qualtrics website server for 30 days and will be deleted after this time. However, data may exist on backups or server logs beyond the timeframe of this research project. Data transferred from the survey site will be saved in an encrypted format for 10 years. Only the PI, co-PI and affiliated graduate students will have access to the data collected by this study. However, the Institutional Review Board at UW-Milwaukee or appropriate federal agencies like the Office for Human Research Protections may review this study's records. The research team will remove your identifying information upon downloading survey responses, and all saved files will not include any identifiers. De-identified data will be stored in a locked file on a password-protected computer in Pavilion 375, and any identifiers will be saved in a separate document accessible only by the PI and co-PI. All study results will be reported without identifying information so that no one viewing the results will ever be able to match you with your responses.

Voluntary Participation: Your participation in this study is voluntary. You may choose to not answer any of the questions or withdraw from this study at any time without penalty. Your decision will not change any present or future relationship with the University of Wisconsin Milwaukee.

Who do I contact for questions about the study: For more information about the study or study procedures, contact Stacy Gnacinski at gnacins4@uwm.edu or (262) 352-2238.

Who do I contact for questions about my rights or complaints towards my treatment as a research subject? Contact the UWM IRB at 414-229-3173 or irbinfo@uwm.edu

Research Subject's Consent to Participate in Research:

By entering this survey, you are indicating that you have read the consent form, you are age 18 or older and that you voluntarily agree to participate in this research study.

Thank you!

APPENDIX C

IRB #17.037 Approval Form

UNIVERSITY of WISCONSIN
UWMILWAUKEE
Department of University Safety & Assurances

Melody Harries
IRB Administrator
Institutional Review Board
Engelmann 270
P. O. Box 413
Milwaukee, WI 53201-0413
(414) 229-3182 *phone*
(414) 229-6729 *fax*

http://www.irb.uwm.edu
harries@uwm.edu

New Study - Notice of IRB Exempt Status

Date: August 16, 2016

To: Barbara Meyer, PhD
Dept: Kinesiology

CC: Stacy Gnacinski

IRB#: 17.037
Title: A psychometric evaluation and revision of the Recovery Stress Questionnaire for Athletes (RESTQ-Sport)

After review of your research protocol by the University of Wisconsin – Milwaukee Institutional Review Board, your protocol has been granted Exempt Status under Category 2 as governed by 45 CFR 46.101(b).

This protocol has been approved as exempt for three years and IRB approval will expire on August 15, 2019. If you plan to continue any research related activities (e.g., enrollment of subjects, study interventions, data analysis, etc.) past the date of IRB expiration, please respond to the IRB's status request that will be sent by email approximately two weeks before the expiration date. If the study is closed or completed before the IRB expiration date, you may notify the IRB by sending an email to irbinfo@uwm.edu with the study number and the status, so we can keep our study records accurate.

Any proposed changes to the protocol must be reviewed by the IRB before implementation, unless the change is specifically necessary to eliminate apparent immediate hazards to the subjects. The principal investigator is responsible for adhering to the policies and guidelines set forth by the UWM IRB, maintaining proper documentation of study records and promptly reporting to the IRB any adverse events which require reporting. The principal investigator is also responsible for ensuring that all study staff receive appropriate training in the ethical guidelines of conducting human subjects research.

As Principal Investigator, it is also your responsibility to adhere to UWM and UW System Policies, and any applicable state and federal laws governing activities which are independent of IRB review/approval (e.g., FERPA, Radiation Safety, UWM Data Security, UW System policy on Prizes, Awards and Gifts, state gambling laws, etc.). When conducting research at institutions outside of UWM, be sure to obtain permission and/or approval as required by their policies.

Contact the IRB office if you have any further questions. Thank you for your cooperation, and best wishes for a successful project.

Respectfully,

Melody Harries

Melody Harries
IRB Administrator

APPENDIX D

Fair Use Copyright Checklist

Fair Use Checklist
Copyright Advisory Office
Columbia University Libraries
Kenneth D. Crews, Director
http://copyright.columbia.edu

Name: Stacy L. Gnacinski

Institution: University of Wisconsin-Milwaukee

Project: Dissertation: "A psychometric evaluation of the Recovery Stress Questionnaire for Athletes (RESTQ-Sport)"

Date: 8/16/16

Prepared by: Stacy L. Gnacinski & Barbara B. Meyer

Purpose

Favoring Fair Use

- [ ] Teaching (including multiple copies for classroom use)
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- [x] Scholarship
- [ ] Nonprofit educational institution
- [ ] Criticism
- [x] Comment
- [ ] News reporting
- [ ] Transformative or productive use (changes the work for new utility)
- [ ] Restricted access (to students or other appropriate group)
- [ ] Parody

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- [ ] Profiting from the use
- [ ] Entertainment
- [ ] Bad-faith behavior
- [ ] Denying credit to original author

Nature

Favoring Fair Use	Opposing Fair Use
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[x] Important to favored educational objectives	[ ] Fiction

Amount

Favoring Fair Use	Opposing Fair Use
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[ ] Portion used is not central or significant to entire work	[ ] Portion used is central to or "heart of the work"
[x] Amount is appropriate for favored educational purpose	

Effect

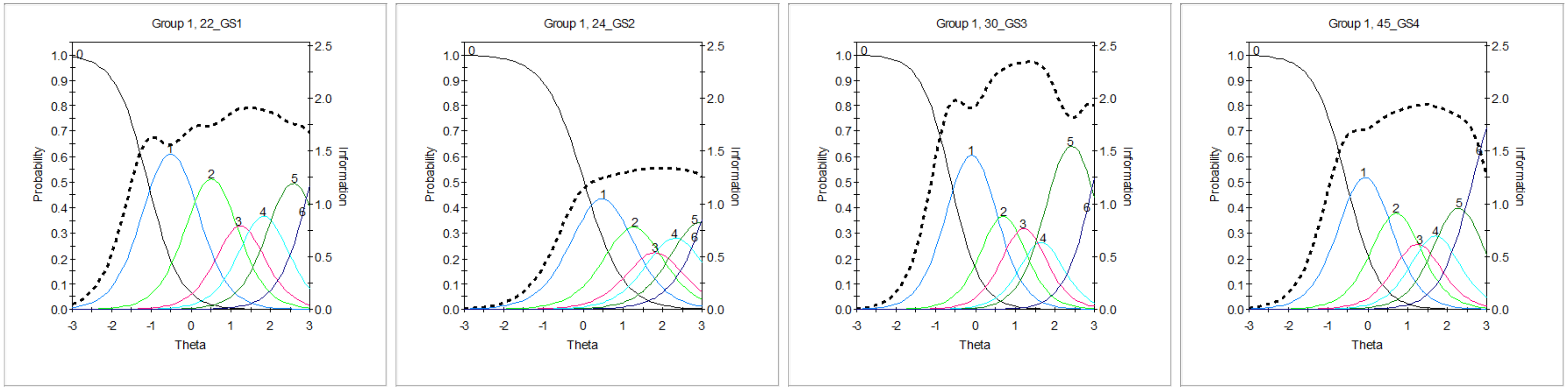
Favoring Fair Use	Opposing Fair Use
[x] User owns lawfully purchased or acquired copy of original work	[ ] Could replace sale of copyrighted work
[ ] One or few copies made	[ ] Significantly impairs market or potential market for copyrighted work or derivative
[x] No significant effect on the market or potential market for copyrighted work	[ ] Reasonably available licensing mechanism for use of the copyrighted work
[x] No similar product marketed by the copyright holder	[ ] Affordable permission available for using work
[ ] Lack of licensing mechanism	[ ] Numerous copies made
	[ ] You made it accessible on the Web or in other public forum
	[ ] Repeated or long-term use

Most recent revision: 051408

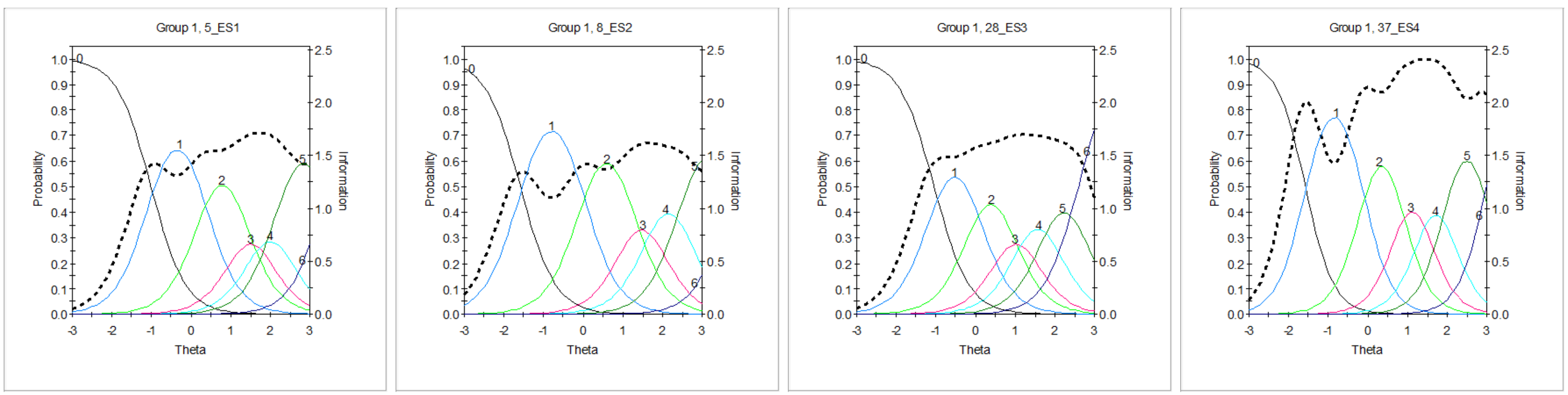
APPENDIX E

Category Response Curves

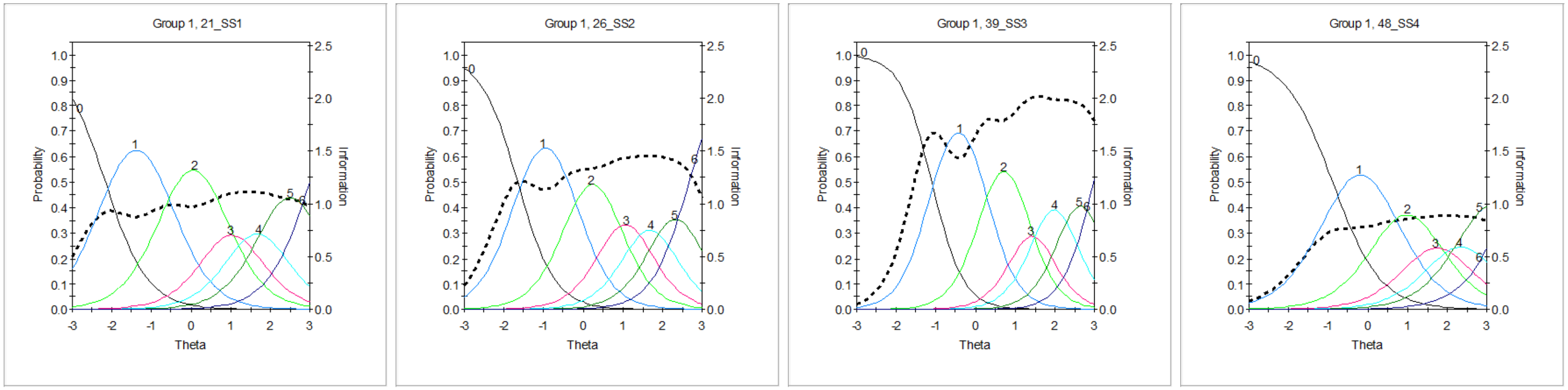
General Stress Items



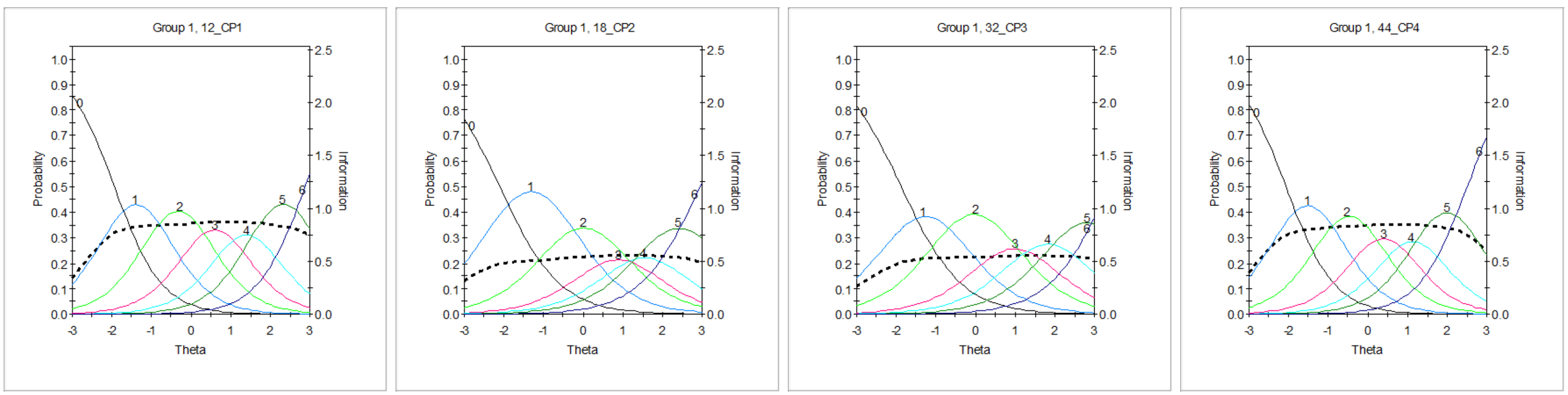
Emotional Stress Items



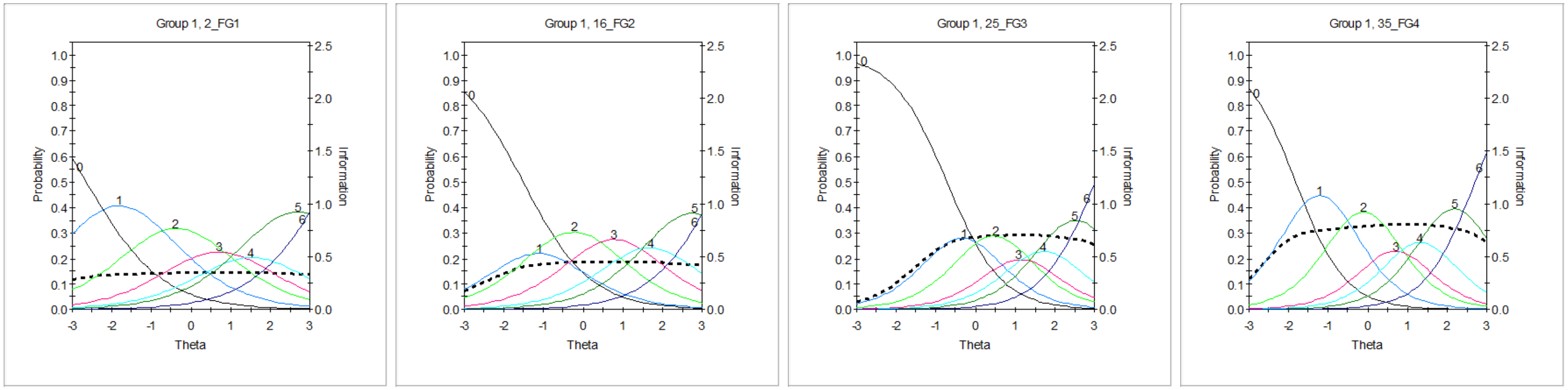
Social Stress Items



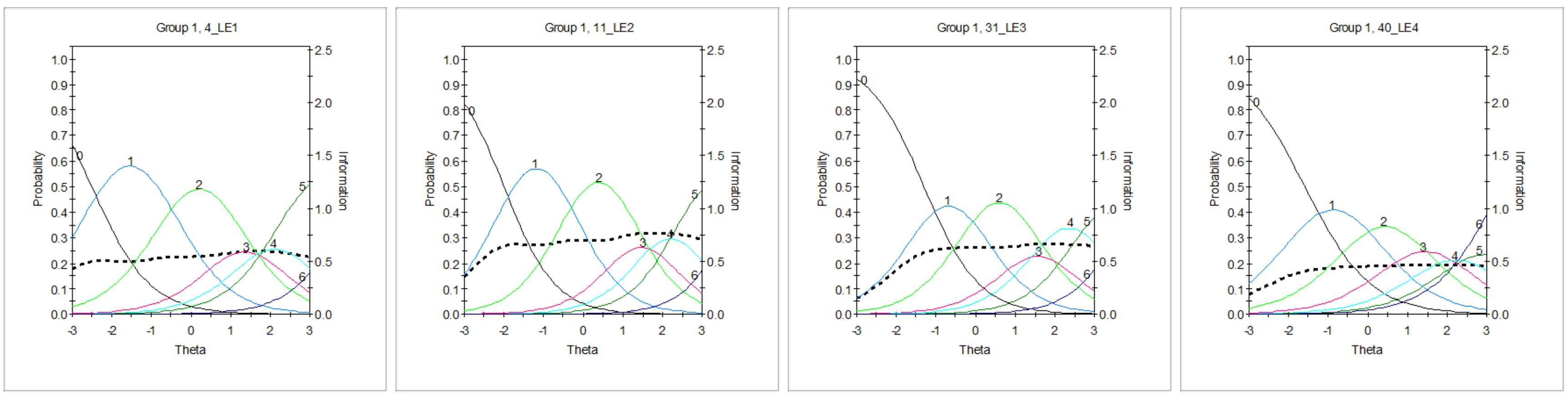
Conflicts/Pressure Items



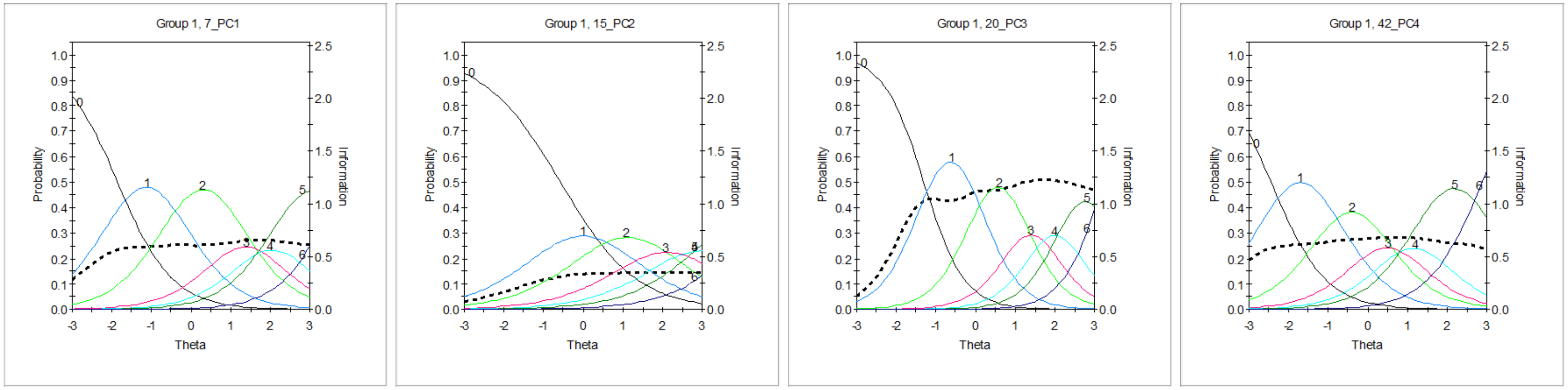
Fatigue Items



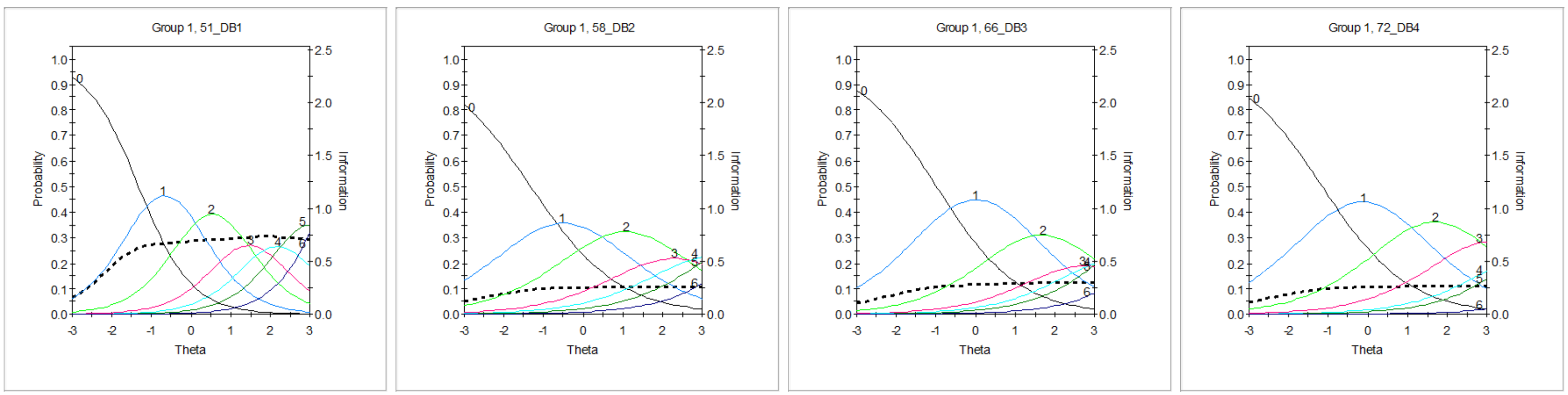
Lack of Energy Items



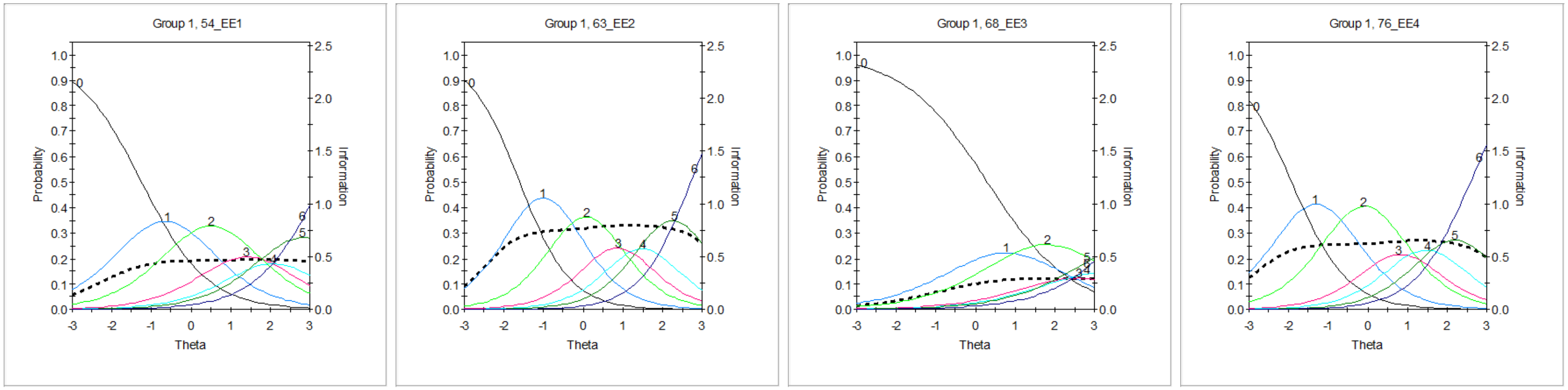
Physical Complaints Items



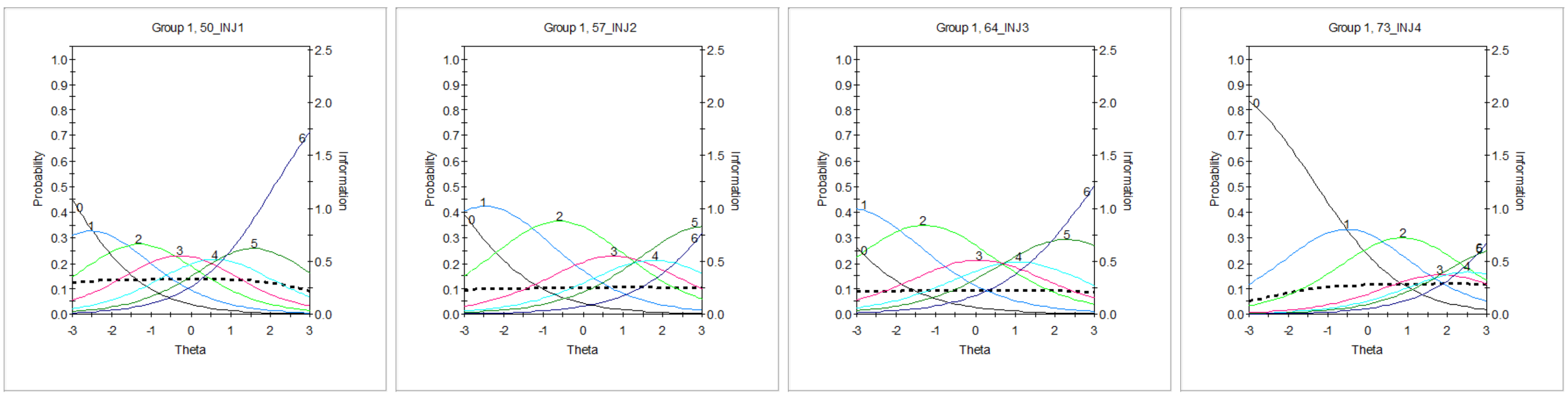
Disturbed Breaks



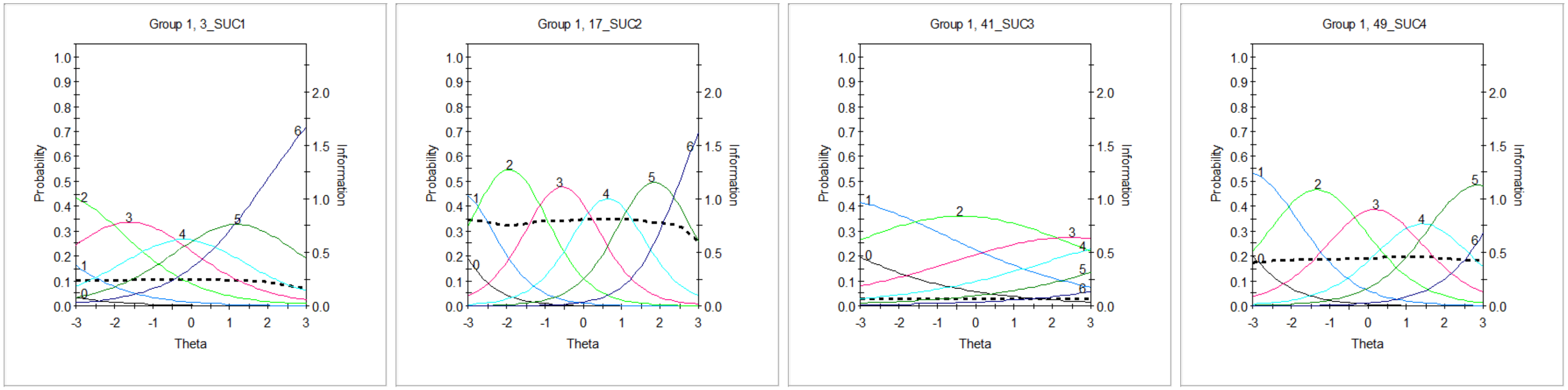
Emotional Exhaustion Items



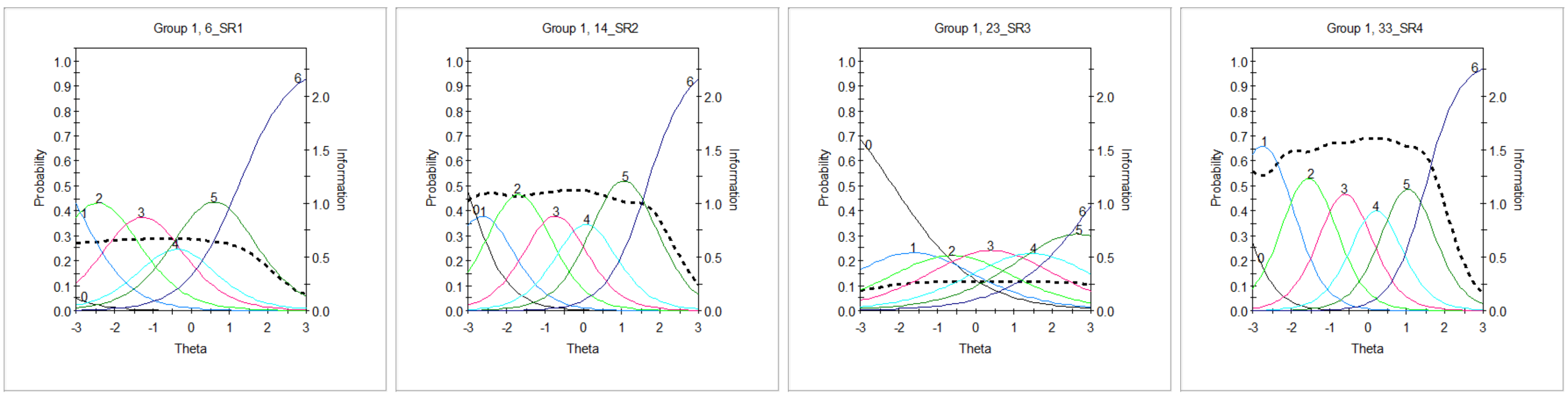
Injury Items



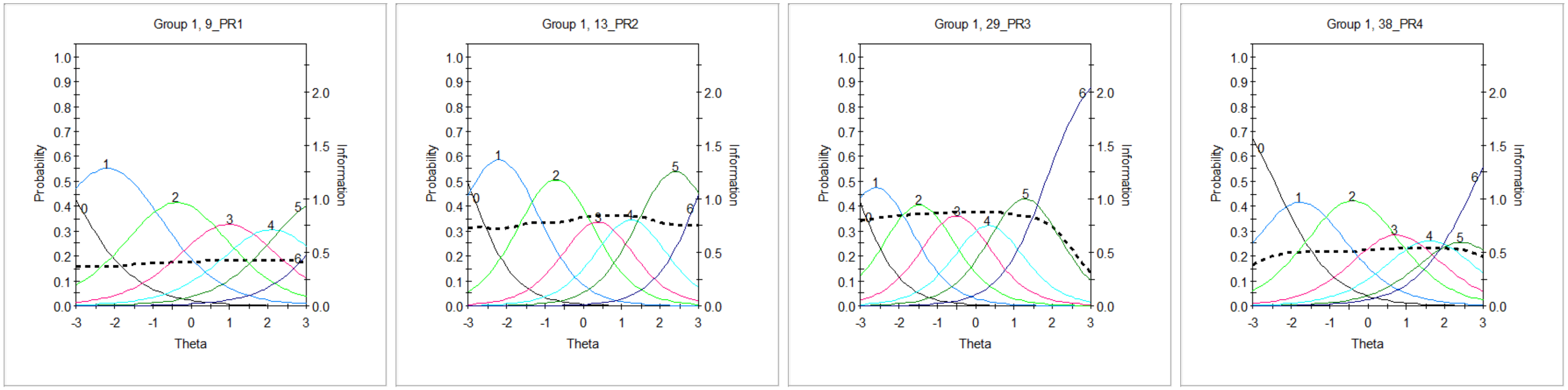
Success Items



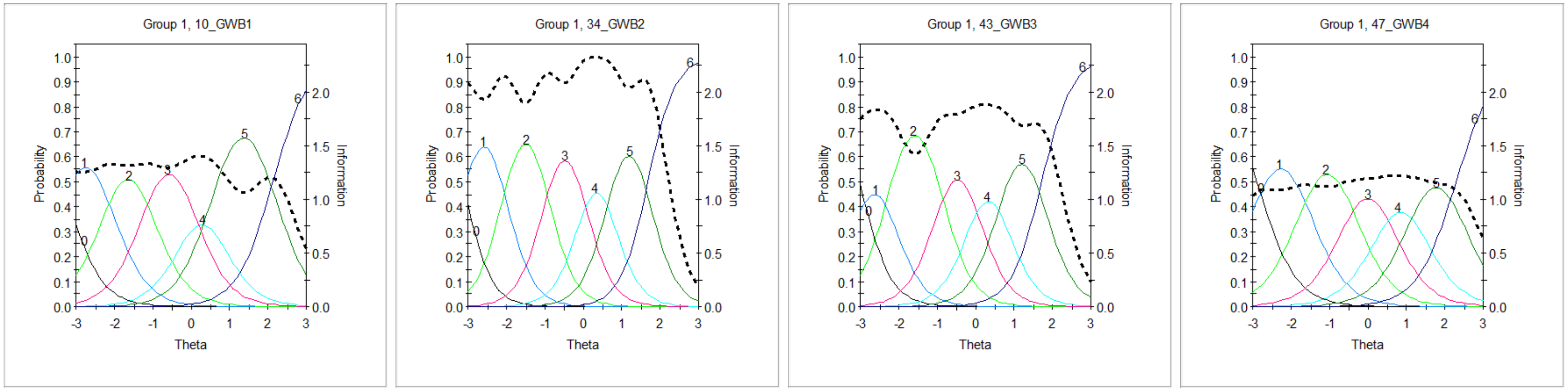
Social Recovery Items



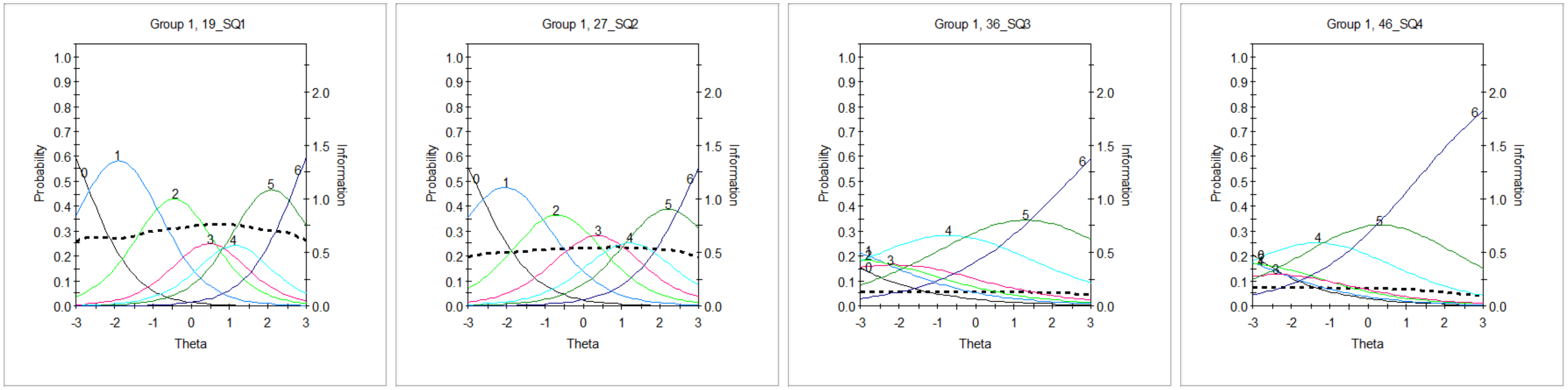
Physical Recovery Items



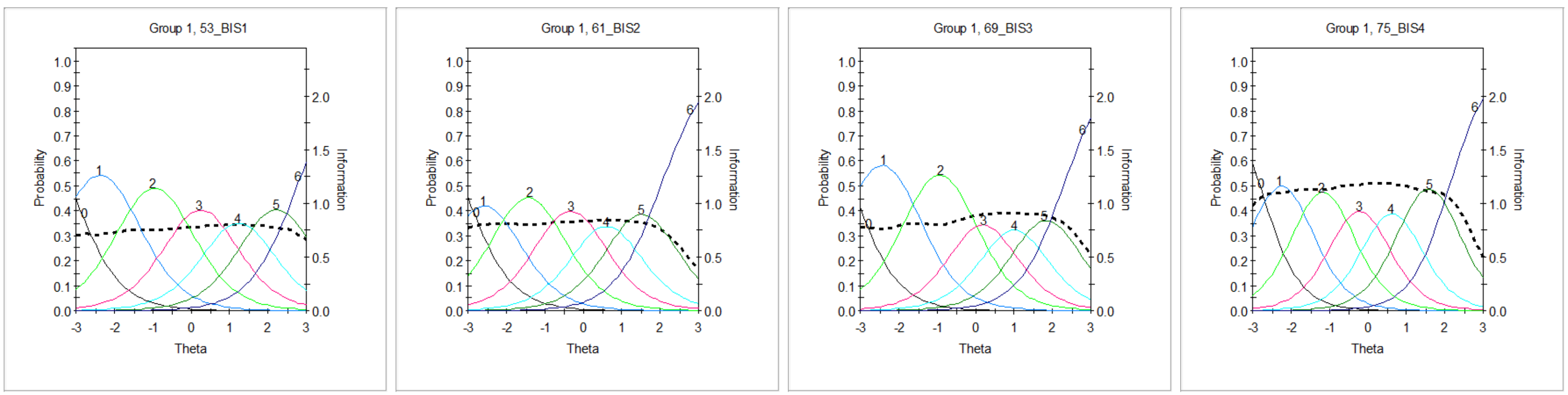
General Well-Being Items



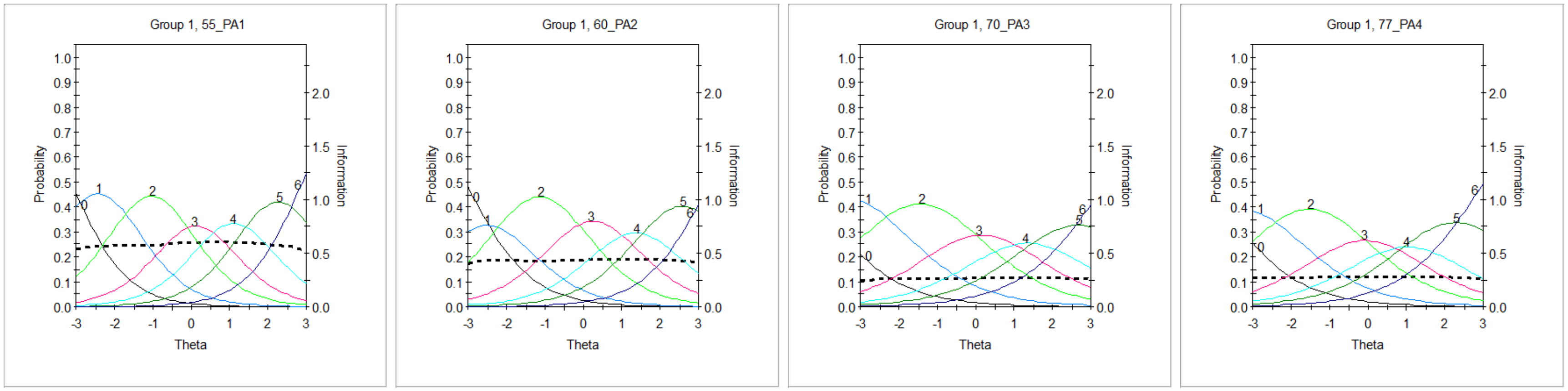
Sleep Quality Items



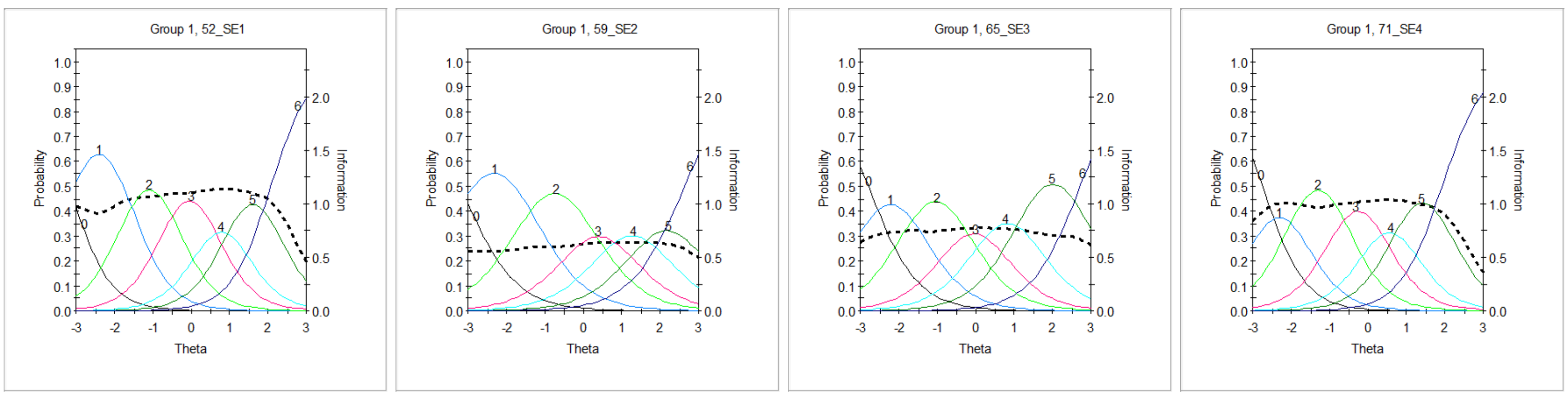
Being In Shape Items



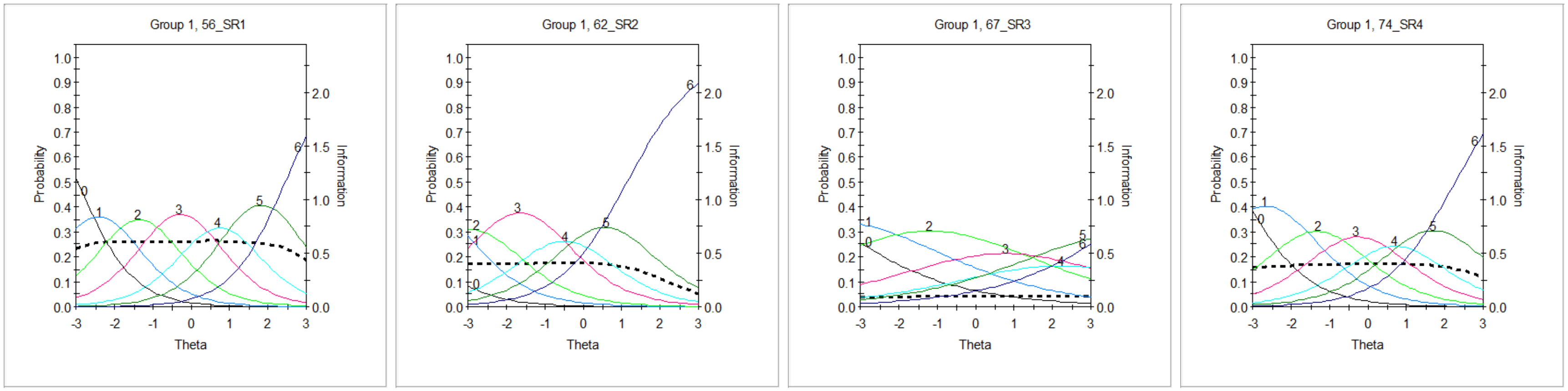
Personal Accomplishment Items



Self-Efficacy Items



Self-Regulation Items



Curriculum Vitae

Stacy L. Gnacinski, MS

General Information

University of Wisconsin-Milwaukee
College of Health Sciences
Department of Kinesiology – Integrative Health Care & Performance Unit
3409 N. Downer Ave.
Milwaukee, WI 53201-0413

Formal Education

University of Wisconsin-Milwaukee (2017)
Doctorate of Philosophy, Health Sciences
Major Specialization: Sport Psychology
Doctoral Minor: Statistics
Advisor: Barbara B. Meyer, PhD
Dissertation: *A psychometric evaluation of the Recovery Stress Questionnaire for Athletes (RESTQ-Sport).*

University of Wisconsin-Milwaukee (2013)
Masters of Science, Kinesiology
Specializations: Sport Psychology and Exercise Physiology
Advisor: Barbara B. Meyer, PhD
Thesis: *Occupational athletes: An integrated approach to understanding firefighting performance*.

University of Wisconsin-La Crosse (2009)
Bachelor of Science, Biology
Minors & Certificates: Chemistry, French

Professional Experience

- Executive Board Student Representative, Association for Applied Sport Psychology (2015-2017)
- Graduate Student Sport Psychology Consultant (2013-present)
- Lecturer, Department of Kinesiology, University of Wisconsin-Milwaukee (2014-present)
- Lecturer, Department of Health and Human Movement Sciences, Carroll University (2014)
- Behavioral Coach, Wellspring Camps-Wisconsin, USA (2014)

Professional Certifications

- Certified Strength and Conditioning Specialist (CSCS) – National Strength and Conditioning Association (NSCA), March 22, 2017.
- Certified Consultant – Association for Applied Sport Psychology (CC-AASP), application to be submitted September 1, 2018.
- Corrective Exercise Specialist (CES) – National Academy of Sports Medicine (NASM), Certification #1488563, August 31, 2014.
- Functional Movement Screen (FMS) Level I Certification – Functional Movement Systems (FMS), May 24, 2012.

Fellowships

1. Distinguished Dissertation Fellowship. (2016-2017). Graduate school fellowship awarded at the University of Wisconsin-Milwaukee. Awarded: $16,500 + $1000 travel grant.
2. Advanced Opportunity Program Fellowship. (2013-2014, 2014-2015, 2015-2016). Graduate school fellowship awarded at the University of Wisconsin-Milwaukee. Awarded: $15,000 + $1000 travel grant.

Merit-Based Academic Scholarships

1. Giorgio Sanna Memorial Scholarship. (2012, 2015). Department of Kinesiology Graduate Achievement Award, University of Wisconsin-Milwaukee. Awarded: $1000 per award.
2. Chancellor's Graduate Student Award. (Fall 2014). College of Health Sciences, University of Wisconsin-Milwaukee. Awarded: $1,250.
3. Chancellor's Graduate Student Award. (Summer 2014). College of Health Sciences, University of Wisconsin-Milwaukee. Awarded: $1,080.
4. College of Health Sciences Alumni Chapter Scholarship. (2013). University of Wisconsin-Milwaukee. Awarded: $1,000.

Honors and Awards

1. Association for Applied Sport Psychology (AASP), Distinguished Student Practice Award. (2015). Award value: $500 and conference registration.
2. Advanced Opportunity Program Fellowship Summer Award. (2015). Graduate school fellowship awarded at the University of Wisconsin-Milwaukee. Award value: $2,596.
3. University of Wisconsin-Milwaukee, College of Health Sciences, Graduate student research competition, 1st place award. (2013). *Examining the effect of a recruit training program on the heart rate recovery of firefighter recruits.* December 7. Award value: $350.

Research Grants

1. **Gnacinski, S.L.**, & Meyer, B.B. (2016). *A psychometric evaluation and revision of the Recovery Stress Questionnaire (RESTQ) for athletes.* University of Wisconsin-Milwaukee, College of Health Sciences, Student Research Grant Award. Awarded: $1985.
2. Meyer, B.B., & **Gnacinski, S.L.** (2015). *Heart rate variability biofeedback: A mental health intervention for student-athletes.* NCAA Innovations in Research and Practice Grant Program. Amount requested: $9994. Not funded.
3. **Gnacinski, S.L.**, & Meyer, B.B. (2014). *Examining the effect of a heart rate variability biofeedback intervention on symptoms of stress, depression, and burnout among student-athletes.* Association for Applied Sport Psychology (AASP) Research Grant. Awarded: $1145.
4. **Gnacinski, S. L.**, Meyer, B.B., Ebersole, K.T., & Zalewski, K.R. (2013). *Occupational athletes: An integrated approach to understanding firefighter performance.* University of Wisconsin-Milwaukee, College of Health Sciences, Student Research Grant Award. Awarded: $500.

Professional Development Publications

1. Hess, C., Chamberlin, J., & **Gnacinski, S**. (2017). Evidence-based Recommendations for Effective Mentorship in Applied Sport Psychology. *AASP Newsletter,* Spring 2017.
2. Student Representatives' Report. *AASP Newsletter*, Fall 2015, Spring 2016, Fall 2016.
3. Simpson, D., **Gnacinski, S.**, Post, P. (2016). The Students Have Spoken. *AASP Newsletter,* Spring 2016.
4. **Gnacinski, S.** (2015). 2015 Distinguished Student Practice Award Winner. *AASP Newsletter,* Summer 2015.
5. **Gnacinski, S.L.,** Meyer, B.B., & Ebersole, K.T. (2012). Backdraft: The use of applied sport psychology to characterize firefighter performance. *Performance Excellence Movement Newsletter,* 2-4.

Book Chapters

1. Meyer, B.B., **Gnacinski, S.L.**, & Fletcher, T.B. (in press). Talent Identification. In J. Taylor (Ed.), *Handbook for assessment in sport psychology consulting.* Human Kinetics.

Peer-Reviewed Publications

1. Meyer, B.B., Markgraf, K., & **Gnacinski, S.L.** (in press). Examining the merit of grit in women's soccer: Questions of theory, measurement, and application. *Journal of Applied Sport Psychology.*
2. **Gnacinski, S.L.,** Arvinen-Barrow, M., Brewer, B.W., & Meyer, B.B. (in press). Factorial validity and measurement invariance of the Perceived Susceptibility to Sport Injury scale. *Scandinavian Journal of Medicine and Science in Sport.*
3. Cornell, D.J., Gnacinski, S.L., Zamzow, A., Mims, J., & Ebersole, K.T. (2017). Measures of health, fitness, and functional movement among firefighter recruits. Int*ernational Journal of Occupational Safety and Ergonomics*, *23*, 198–204.
4. **Gnacinski, S.L.**, Cornell, D.J., Meyer, B.B., Arvinen-Barrow, M., & Earl-Boehm, J. (2016). Functional Movement Screen™ factorial validity and measurement invariance across sex in among collegiate athletes. *Journal of Strength and Conditioning Research, 30*, 3388-3395.
5. Cornell, D.J., **Gnacinski, S.L.**, Zamzow, A., Mims, J., & Ebersole, K.T. (2016). Influence of body mass index on movement efficiency among firefighter recruits. *Work, 54,* 679-687.
6. **Gnacinski, S.L.**, Meyer, B.B., Hess, C.W., Cornell, D.J., Mims, J., & Ebersole, K.T. (2016). The psychology of firefighting: An examination of psychological skills use among firefighters. *Journal of Performance Psychology, 9*, 1 -24.
7. **Gnacinski, S.L.,** Ebersole, K.T., Cornell, D.J., Mims, J., Zamzow, A., & Meyer, B.B. (2016). Firefighters' cardiovascular health and fitness: An observation of adaptations that occur during firefighter training academies. *Work, 54*, 43-50.
8. Massey, W.V., **Gnacinski, S.L.**, & Meyer, B.B. (2015). Psychological skills training in NCAA Division I athletics: Are athletes ready for change? *Journal of Clinical Sport Psychology, 9,* 317-334.
9. **Gnacinski, S.L.**, Meyer, B.B., Cornell, D.J., Mims, J., Zalewski, K.R., & Ebersole, K.T. (2015). Tactical athletes: An integrated approach to understanding and enhancing firefighter health and performance. *International Journal of Exercise Science, 8,* 341-357.
10. Cornell, D.J., **Gnacinski, S.L.,** Langford, M.H., Mims, J., & Ebersole, K.T. (2015). Backwards overhead medicine ball throw and counter movement jump performance among firefighter candidates. *Journal of Trainology, 4*, 11-14.
11. Anderson, N.W., Buchan, B.W., Riebe, K.M., Parsons, L.N., **Gnacinski, S.**, and Ledeboer, N.A. (2011). The effects of solid media type on routine identification of bacterial isolates using matrix-assisted laser desorption/ionization time-of-flight (MALDI-TOF) mass spectrometry. *Journal of Clinical Microbiology, 50,* 1008-1013.

Peer-Reviewed Publications In Revision

1. **Gnacinski, S.L.**, Massey, W.V., Hess, C.W., Nai, M., Arvinen-Barrow, M., & Meyer, B.B. (in revision). Examining stage of change differences in NCAA student-athletes' readiness for psychological skills training. Target*: The Sport Psychologist*.
2. Cornell, D.J.[ǂ], **Gnacinski, S.L.**[ǂ], Meyer, B.B., & Ebersole, K.T. (in revision). Changes in health and fitness in firefighter recruits: An observational cohort study. Target: *Medicine & Science in Sport & Exercise.* [ǂ] denotes shared first authorship.

Presentations at Academic and Professional Meetings

1. **Gnacinski, S.L.**, Ebersole, K.T., Cornell, D.J., & Meyer, B.B. (2017, June). *An integrated perspective on firefighter recruit academies: Examining the sustainability of fitness gains.* Poster presented at the annual meeting for the American College of Sports Medicine, Denver, CO, USA.
2. Ebersole, K.T., Cornell, D.J., & **Gnacinski, S.L.** (2017, June). *Impact of a firefighter recruit training academy on movement quality and balance ability.* Poster presented at the annual meeting for the American College of Sports Medicine, Denver, CO, USA.

3. Nai, M.M., Meyer, B.B., **Gnacinski, S.L.,** Arvinen-Barrow, M. (2017, May). *Association between two factors of grit and conscientiousness in student-athletes*. Poster presented at the annual meeting for the Midwestern Psychological Association, Chicago, IL, USA.
4. Emmer, G., **Gnacinski, S.**, Earl-Boehm, J., & Arvinen-Barrow, M. (2016, October). *An investigation into the role of personality in collegiate athletes' readiness to engage in psychological skills training.* Poster presented at the annual meeting of the Association for Applied Sport Psychology, Phoenix, AZ, USA.
5. Nai, M., Meyer, B., **Gnacinski, S.**, & Arvinen-Barrow, M. (2016, October). *An examination of the association between grit and the Big Five personality traits in NCAA student-athletes.* Poster presented at the annual meeting of the Association for Applied Sport Psychology, Phoenix, AZ, USA.
6. **Gnacinski, S.**, Simpson, D., Post, P., & Christensen, D. (2016, October). *Looking to the next generation of professionals: Student members' needs, interests, and perceived value of AASP membership.* Poster presented at the annual meeting of the Association for Applied Sport Psychology, Phoenix, AZ, USA.
7. **Gnacinski, S.**, Massey, W., Fisher-Hess, C., & Meyer, B. (2016, October). *The transtheoretical model of behavior change: Evidence-based translation of theory to practice with NCAA student-athletes.* Lecture presented at the annual meeting of the Association for Applied Sport Psychology, Phoenix, AZ, USA.
8. Ildefonso, K., **Gnacinski, S.L.**, Earl-Boehm, J.E., & Arvinen-Barrow, M. (2016, June). *Physical predictors of perceived susceptibility to sport injury among collegiate athletes: An exploratory investigation.* Poster presented at the annual meeting for the National Athletic Trainer Association Annual Meeting and Clinical Symposium, Baltimore, MD, USA
9. **Gnacinski, S.**, Meyer, B., Diener, K., & Litzau, K. (2015, October). *An examination of mental health intervention effects among NCAA student-athletes.* Poster presented at the annual meeting of the Association for Applied Sport Psychology, Indianapolis, IN, USA.
10. Markgraf, K., Meyer, B., & **Gnacinski, S.** (2015, October). *Grit in sport: A comparison across performance tiers.* Poster presented at the annual meeting of the Association for Applied Sport Psychology, Indianapolis, IN, USA.
11. Hess, C., Meyer, B., & **Gnacinski, S.** (2015, October). *Social validation of a mental health intervention among collegiate student-athletes: A case comparison.* Poster presented at the annual meeting of the Association for Applied Sport Psychology, Indianapolis, IN, USA.
12. O'Connor, M., Cornell, D., **Gnacinski, S.**, Hess, C., Kelley, K. Poel, D., Zander, R., Arvinen-Barrow M., Truebenbach, C., Earl-Boehm, J. (2015, June). *Relationship between hip strength and dynamic balance performance.* Poster presented at the annual meeting for the National Athletic Trainer Association Annual Meeting and Clinical Symposium, St. Louis, MO, USA.
13. Kelley, K. Poel, D., Cornell, D., **Gnacinski, S.,** Hess, C., O'Connor, M., Zander, R., Arvinen-Barrow M., Truebenbach, C., Earl-Boehm, J. (2015, June). *Identifying sport and gender differences in the lower extremity functional test (LEFT).* Poster presented at the annual meeting for the National Athletic Trainer Association Annual Meeting and Clinical Symposium, St. Louis, MO, USA.
14. **Gnacinski, S.L.,** Meyer, B.B., Hess, C.W., Litzau, K. (2015, May). *Examining the effect of heart rate variability biofeedback on collegiate student-athletes' mental health: A single-case design.* Poster presented at the annual meeting for the Midwestern Psychological Association, Chicago, IL, USA.
15. Hess, C.W., Meyer, B.B., **Gnacinski, S.L.** (2015, May). *Grit and achievement orientation: An examination of the relationship between, and the predictive value of, task and ego achievement orientations on grit levels among elite athletes*. Poster presented at the annual meeting for the Midwestern Psychological Association, Chicago, IL, USA.
16. **Gnacinski, S.L.**, Ebersole, K.T., Cornell, D.J., Mims, J., Meyer, B.B. (2015, May). *The psychology of firefighting: An examination of psychological skills use among firefighters.* Poster presented at the annual meeting for the American College of Sports Medicine, San Diego, CA, USA.
17. Cornell, D.J., **Gnacinski, S.L.,** Zamzow, A., Mims, J., & Ebersole, K.T. (2014, November). *Influence of firefighter recruit training programs on measures of health and fitness*. Midwest Regional Chapter Meeting of the American College of Sports Medicine, Merrillville, IN.
18. **Gnacinski, S.L.**, Meyer, B.B., Cornell, D.J., Zamzow, A., & Ebersole, K.T. (2014, October). *Examining the effect of a training program on the perceptions of stress and recovery among firefighter recruits*. Lecture presented at the annual meeting of the Association for Applied Sport Psychology, New Orleans, LA, USA.

19. Ebersole, K.T., **Gnacinski, S.L.**, Cornell, D.J., Gayhart, S.B., Sanger, P.J., & Mims, J. (2014, May). *The influence of firefighter training academies on measures of fitness and performance.* Poster presented at the annual meeting for the American College of Sports Medicine, Orlando, FL, USA.
20. Cornell, D.J., Ebersole, K.T., **Gnacinski, S.L.,** Gayhart, S.B., Sanger, P.J., & Mims, J. (2014, May). *Predicting "failing" Functional Movement Screen™ Scores utilizing the Y-Balance Test among active firefighters and candidates*. Poster presented at the annual meeting for the American College of Sports Medicine, Orlando, FL, USA.
21. Thorp, L.A., Ebersole, K.T., Gayhart, S.B., Cornell, D.J., **Gnacinski, S.L.,** Morgan, A.J., Conlon, J.K., Sanger, P.J., & Mims, J., (2014, April). *Using the Functional Movement Screen™ to assess performance in the occupational athlete.* Poster presented at the annual meeting of the National Undergraduate Research Conference, Lexington, KY.
22. Van Dorin, A., Ebersole, K.T., Cornell, D.J., **Gnacinski, S.L.,** Gayhart, S.B., Sanger, P.J., & Mims, J. (2014, April). *Y-Test determination of injury preventiveness within Milwaukee firefighter recruits.* Poster presented at the annual meeting of the National Undergraduate Research Conference, Lexington, KY.
23. **Gnacinski, S.L.**, Ebersole, K.T., Cornell, D.J., & Meyer, B.B. (2013, October). *Occupational athletes: Moving toward an integrated approach to enhancing firefighting performance.* Poster presented at the annual meeting of the Association of Applied Sport Psychology, New Orleans, LA, USA.
24. Meyer, B.B., Massey, W.V., **Gnacinski, S.L.** (2012, October). *Operationalizing the symbiotic relationship between talent identification and talent development in elite sport*. Workshop submitted to the annual meeting of the Association of Applied Sport Psychology, Atlanta, GA, USA.
25. Buchan, B.W., Mackey, T.A., Reymann, G.A., **Gnacinski, S**., Rashel, J.A., and Ledeboer, N.A. (2012, June). Comparison of the integrated MALDI-Trace system to manual specimen accessioning in preparation of specimens for MALDI-TOF analysis. Poster presented at the 112th ASM General Meeting, San Francisco, CA, USA.
26. Riebe K.M., Buchan, B.W., **Gnacinski, S**., and Ledeboer, N.A. (2012, June). Clinical evaluation of the Vitek 2 SS03 panel for antimicrobial susceptibility testing of Streptococcal species. Poster presented at the 112th ASM General Meeting, San Francisco, CA, USA.

<u>Local Presentations</u>

1. **Gnacinski, S.** (2017, April). *Psychological measures for monitoring athlete responses to training load: Implications for overtraining prevention.* Oral presentation delivered at the National Strength and Conditioning Association Wisconsin State Clinic, Waukesha, WI, USA.
2. Blanchard, H., Meyer, B.B., & **Gnacinski, S.L.** (2016, April). *Rest and recovery in the competitive phase of training in collegiate female volleyball athletes.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Undergraduate Research Symposium, Milwaukee, WI, USA.
3. Ford, J., **Gnacinski, S.,** Earl-Boehm, J., & Arvinen-Barrow, M. (2015, December). *Grit and mental toughness: Are the terms interchangeable in a sport context?* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
4. Ildefonso, K., **Gnacinski, S.**, Earl-Boehm, J., & Arvinen-Barrow, M. (2015, December). *Physical predictors of perceived susceptibility to sport injury among collegiate athletes: An exploratory investigation.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
5. Mendelson, B., Meyer, B.B., & **Gnacinski, S.L.** (2015, December). *Longitudinal monitoring of stress, recovery, and perceived performance in a National Hockey League Player: A single-case design.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
6. Emmer, G., **Gnacinski, S.,** Earl-Boehm, J., & Arvinen-Barrow, M. (2015, December). *An investigation into role of personality in collegiate athletes' readiness to engage in psychological skills training.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.

7. Poel, D., **Gnacinski, S.**, Arvinen-Barrow, M., & Earl-Boehm, J. (2015, December). *What are the relationships (if any) between physical predictors of musculoskeletal injury?* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
8. Meyer, B.B., & **Gnacinski, S.L.** (2015, March 26-27). *Motivational Interviewing and Psychological Skills Training.* Workshop submitted to the Milwaukee Fire Department Peer Fitness Trainers, Milwaukee, WI, USA.
9. Ford, E.E., Ebersole, K.T., Cornell, D.J., Zander, R.A., & **Gnacinski, S.L.** (2015, May). *Relationship between balance and measures of fitness and strength in firefighters.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Spring Research Symposium, Milwaukee, WI, USA.
10. Tischauser, T., Meyer, B.B., **Gnacinski, S.L.,** Hess, C.W., & Mendelson, B. (2015, May). *Examining relationships between grit and Big-Five personality traits among athlete populations.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Spring Research Symposium, Milwaukee, WI, USA.
11. Cornell, D.J., **Gnacinski, S.L.**, Mims, J., & Ebersole, K.T. (2015, May). *Longitudinal influence of a firefighter recruit training program on measures of muscular strength.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Spring Research Symposium, Milwaukee, WI, USA.
12. Meyer, B.B., & **Gnacinski, S.L.** (2015, February 26-27). *Behavior Change and Motivational Interviewing.* Workshop submitted to the Milwaukee Fire Department Peer Fitness Trainers, Milwaukee, WI, USA.
13. Cornell, D.J., Ebersole, K.T., **Gnacinski, S.L.,** Mims, J. (2014, December). *Longitudinal influence of a firefighter recruit training program on measures of obesity.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
14. O'Connor, M., Cornell, D., **Gnacinski, S.**, Hess, C., Kelley, K., Poel, D., Zander, R., Arvinen-Barrow, M., Truebenbach, C., Earl-Boehm, J. (2014, December). *Relationship among hip strength and dynamic balance performance.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
15. Poel, D., Cornell, D., **Gnacinski, S.**, Hess, C., Kelley, K., O'Connor, M., Zander, R., Arvinen-Barrow, M., Truebenbach, C., Earl-Boehm, J. (2014, December). *Identifying sport and gender differences in the lower extremity functional test (LEFT).* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
16. Kelley, K., Cornell, D., **Gnacinski, S.**, Hess, C., O'Connor, M., Poel, D., Zander, R., Earl-Boehm, J., Truebenbach, C., & Arvinen-Barrow, M. (2014, December). *Differences in collegiate athletes' use of psychological strategies in practice and competition: The Panther-PEP study.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
17. Gorgas, J.M. Meyer, B.B., **Gnacinski, S.L.**, Hess, C.W., Mims, J., Zamzow, A., Ebersole, K.T. (2014, December). *An examination of changes in grit over the course of a firefighter recruit training program.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
18. **Gnacinski, S.L.,** & Meyer, B.B. (2014, December). *Psychometric properties of the 8-item and 12-item Grit Scale: A confirmatory factor analysis in the physical domain*. Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
19. Meyer, B.B., & **Gnacinski, S.L.** (2014, April 11-12). *Mental Health and Performance.* Workshop submitted to the Milwaukee Fire Department Peer Fitness Trainers, Milwaukee, WI, USA.
20. **Gnacinski, S.L.,** Meyer, B.B., Ebersole, K.T., & Zalewski, K.R. (2014, May). *Examining the effect of a heart rate biofeedback intervention on the stress and recovery of a National Hockey League player.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
21. DeGrave, K.K., Meyer, B.B., **Gnacinski, S.L.,** Mims, J., & Ebersole, K.T. (2014, May). *Readiness to engage in psychological skills training: A preliminary investigation of firefighters' stage of change.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.

22. Fisher, C.W., Meyer, B.B., **Gnacinski, S.L.,** Mims, J., & Ebersole, K.T. (2014, May). *Technology use and preferences among at-risk populations.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
23. Langford, M.H., Ebersole, K.T., Cornell, D.J., **Gnacinski, S.L.,** Gayhart, S.B., Sanger, P.J., & Mims, J. (2014, May) *Estimating power production during a tire flip task in firefighter recruits.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
24. **Gnacinski, S.L.,** Ebersole, K.T., Cornell, D.J., Gayhart, S.B., Sanger, P.J., Mims, J., & Meyer, B.B. (2013, December). *Examining the effect of a recruit training program on the heart rate recovery of firefighter recruits.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
25. Cornell, D.J., Ebersole, K.T., **Gnacinski, S.L.,** Gayhart, S.B., Sanger, P.J., & Mims, J. (2013, December). *Reach asymmetry on the Y-Balance Test does not predict a "failing" Functional Movement Screen™ score among active firefighters and candidates*. Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
26. Flees, R.J., Ebersole, K.T., Cornell, D.J., **Gnacinski, S.L.,** Gayhart, S.B., Sanger, P.J., & Mims, J. (2013, December). *Relationship between muscular strength and muscular endurance tests*. Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
27. Gayhart, S.B., Ebersole, K.T., Cornell, D.J., **Gnacinski, S.L.,** Sanger, P.J., & Mims, J. (2013, December). *Relationship between Y-Balance Test scores and BOMB throw, 1RM squat, and sit-and-reach performance.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
28. Grindeland, S.J., Ebersole, K.T., Cornell, D.J., **Gnacinski, S.L**., Gayhart, S.B., Sanger, P.J., & Mims, J. (2013, December). *Factors that influence heart rate maximum in cadet firefighters.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
29. Sanger, P.J., Ebersole, K.T., Cornell, D.J., **Gnacinski, S.L.,** Gayhart, S.B., & Mims, J. (2013, December). *Measures of power and strength related to firefighter performance.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
30. Thorp, L.A., Ebersole, K.T., Gayhart, S.B., Cornell, D.J., **Gnacinski, S.L.,** Morgan, A.J., Conlon, J.K., Sanger, P.J., & Mims, J. (2013, December). *Using the Functional Movement Screen™ to assess performance in the occupational athlete.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.
31. Sanger, P.J., Ebersole, K.T., Cornell, D.J., **Gnacinski, S.L.,** Morgan, A.J., Conlon, J.K., & Gayhart, S.B. (2013, April). *Functional movement and measures of power and strength in firefighters.* Poster presented at the University of Wisconsin-Milwaukee, Undergraduate Research Symposium, Milwaukee, WI, USA.
32. Cornell, D.J., Ebersole, K.T., Meyer, B.B., **Gnacinski, S.L.**, Conlon, J.K., & Morgan, A.J. (2012, December). *Relationship between Functional Movement Screen™ scores and race time among novice and experienced marathon runners.* Poster presented at the University of Wisconsin-Milwaukee, College of Health Sciences Fall Research Symposium, Milwaukee, WI, USA.

Undergraduate Courses Taught

1. KIN 270 – Statistics in the Health Professions, University of Wisconsin-Milwaukee, Spring 2014, Spring 2015, Spring 2016, Fall 2016, Spring 2017
2. KIN 400 – Ethics and Values in the Health and Fitness Professions, Fall 2015, Spring 2016, Summer 2016
3. KIN 330 – Exercise Physiology Laboratory Sections, University of Wisconsin-Milwaukee, Fall 2011, Summer 2012, & Fall 2012
4. KIN 430 – Exercise Testing, Fitness, & Prescription Laboratory Sections, University of Wisconsin-Milwaukee, Spring 2012, & Spring 2013
5. KIN 336 – Principles of Strength & Conditioning Laboratory Sections, University of Wisconsin-Milwaukee, Spring 2012, & Spring 2013

Graduate Courses Taught

1. KIN 550 – (Reader/Grader) Psychological Aspects of Human Movement, University of Wisconsin-Milwaukee, Fall 2016
2. KIN 709 – (Reader/Grader) Research Practicum, University of Wisconsin-Milwaukee, Fall 2016
3. EXP 521 – Exercise & Sport Psychology, Carroll University, Fall 2014
4. KIN 550 (Co-Instructor) – Psychological Aspects of Human Movement, University of Wisconsin-Milwaukee, Fall 2014

Service

1. University Service
    - Served as a student representative of the UW-Milwaukee College of Health Sciences Interprofessional Education Committee (2014–2016)
    - Served as a judge for the UW System Spring Symposium for Undergraduate Research (2014, 2015)
    - Supervise undergraduate students seeking research experience in the Laboratory for Sport Psychology & Performance Excellence (2014)
    - Graduate student sport psychology consultant for:
        - Performance & Injury Center (PIC) to help marathon runners participating in the PAWS vs. CLAWS Lakefront Marathon Challenge (2012-present)

2. Professional Memberships
    - Association for Applied Sport Psychology (AASP), 2012—present
    - National Academy of Sports Medicine (NASM), 2014—present
    - National Strength and Conditioning Association (NSCA), 2014—present
    - American College of Sports Medicine (ACSM), 2014—present
        i. Midwest Chapter of the American College of Sports Medicine (MWACSM), 2017-present
    - Midwestern Psychological Association (MPA), 2014—2016

3. Professional Organization Service – Association for Applied Sport Psychology (AASP)
    - AASP Executive Board Student Representative (Term = 2015-2017)
    - Item Writer for AASP Certification Exam (2016)
        i. Online training from measurement psychologists (Dr. Gerald Rosen & Dr. Bob Lipkins completed on April 21, 2016.
            - Training objective: writing high-quality multiple choice questions suitable for use on a national certification examination.
    - Member of the AASP Graduate Program Committee (2015-2016)
    - Annual Conference Abstract Reviewer (2016)
    - Served as an AASP Student Delegate (2012-2015)
        - Specific contributions to the following initiatives: Performance Excellence Movement, Mentorship Match Program, Student Conference Volunteers

4. Invited Manuscript Reviewer
    - *Ergonomics*
    - *Psychology of Sport & Exercise*
    - *Journal of Strength and Conditioning Research*
    - *Journal of Sport and Health Sciences*

5. Community Service
    - Delivering sport psychology consultation to:
        - Junior college baseball athlete (April 2017 – present)
        - Local area cross country/track and field athlete (January 2017 – present)
        - Local area cross country athlete (October 2016 – November 2016)
        - Local area soccer athlete (October 2016 – January 2017)
        - Local area volleyball athlete (October 2016 – present)
        - Local area trampoline and tumble gymnastics athlete (January 2016 – present)
        - Local area gymnastics athlete (October 2015 – May 2016)
        - Local area high school swimming athlete (September 2014 – August 2016)
        - Local area high school golf athlete (August 2014 – August 2015)
        - Local area high school track & field athlete (December 2013 – June 2014)
        - Freshmen student-athletes at Riverside University High School (Spring 2014)
        - Local collegiate women's soccer team (Spring 2013)
    - Attend & actively participate in meetings for Milwaukee-area Latino/a Youth Mental Health Project at Disability Rights Wisconsin (2014)
    - Score keeper for the National Wheelchair Basketball Tournament hosted at Whitnall High School (February 1, 2014)
    - Volunteer coach for a 7-week high school strength & conditioning camp (Summer 2012)
    - Volunteer coach for a middle school volleyball team (Spring 2010)