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Psychobiosocial Experiences in Sport: Development and Initial Validation of a Semantic Differential Scale

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Abstract

Objectives: To develop and validate the Psychobiosocial Experience Semantic Differential scale in sport (PESD-Sport), a new measure to assess discrete emotions and performance-related experiences in sport as conceptualized within the individual zones of optimal functioning (IZOF; Hanin, 2000, 2007, 2010) framework.

Method: In Study 1, we developed a preliminary 53-item version of the scale using a semantic differential format in the construction of the items pertaining to 12 psychobiosocial modalities. We chose this format to attain a clear representation of psychobiosocial states between opposites along perceived performance functionality (i.e., functional, dysfunctional). The preliminary scale was then administered in a sample of 280 athletes. In Study 2, a 30-item scale derived from Study 1 was cross validated in a second independent sample of 302 athletes.

Results: Findings from Study 1 provided preliminary evidence of factorial and construct validity for a 10-modality, 30-item model (3 items for each modality). Findings from Study 2 supported the factor structure of a model containing 30 items loading into 10 modalities (i.e., unpleasant/pleasant emotions, confidence, anxiety, assertiveness, cognitive, bodily-somatic, motor-behavioral, operational, communicative, and social support). Convergent, discriminant, and nomological validity of the PESD-Sport was also demonstrated.

Conclusion: Based on a substantive theoretical framework, this new measure of discrete emotions and performance-related experiences can advance the knowledge on the relationship between psychobiosocial states and performance. The scale could also inform applied interventions aimed at improving psychobiosocial experiences for performance enhancement.

Keywords: emotions, performance, IZOF model, assessment, scale development

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The reciprocal relationship between emotions and sport performance has been attracting the interest of researchers and professionals for many years (Hanin, 2000; Jones et al., 2005; Lane et al., 2012; Martinent et al., 2012; Martinent & Ferrand, 2015; Ruiz et al., 2017; Turner & Jones, 2018). Emotions and related feelings are omnipresent in the athletic arena and profoundly influence mental processes of athletes, including perception, attention, memory, decision making, effort, persistence, as well as behavioral responses and interpersonal relationships (Beatty & Janelle, 2020; Janelle et al., 2020; Ruiz & Robazza, 2021). Over the years, the research and applied interest on emotions has led to the development of both idiographic assessment procedures (Flett, 2014; Robazza et al., 2000; Ruiz & Hanin, 2004b) and nomothetic scales (see Chow & Gilson, 2018). Idiographic measures involve assessment strategies tailored to a particular individual, are often unstandardized and, therefore, the resulting inferences are not always generalizable across persons. On the other hand, nomothetic assessment procedures are similar across individuals, are standardized, provide measures of the same variables on the same dimensions for all respondents, and the derived judgments often depend on comparisons with measures from other persons (Haynes & O'Brien, 2000). The Competitive State Anxiety Inventory (CSAI-2; Martens et al., 1990) and the Sport Anxiety Scale-2 (SAS-2; Smith et al., 1990) have been among the most popular nomothetic measures of state and trait anxiety, while the Sport Emotion Questionnaire (Jones et al., 2005) has been used to assess precompetitive emotions of anger, anxiety, dejection, excitement, and happiness.

In a more holistic approach based on the individual zones of optimal functioning (IZOF) model (Hanin, 2000, 2007, 2010), individualized profiling procedures have been proposed to assess a wide assortment of emotional and other performance-related experiences. These experiences fall under the umbrella of the so-called psychobiosocial states (or experiences) exerting functional or dysfunctional effects on individual performance (Hanin, 2010; Hanin & Ekkekakis, 2014). In addition to idiographic profiling methods, two normative measures have been developed to assess psychobiosocial states (PBS-S; Ruiz et al., 2019b) and psychobiosocial trait-like states (PBS-ST; Robazza et al., 2016) of athletes, while another measure has been proposed for students involved in physical education (PBS-SPE; Bortoli et al., 2018).

The research and applied advantages of assessing psychobiosocial states using either idiographic or nomothetic methods have been demonstrated in many studies conducted both in sport (e.g., Bortoli et al., 2009, 2011, 2012; Middleton et al., 2017; Morano et al., 2020; Nateri et al., 2020; Ruiz & Hanin, 2004a, 2004b; Ruiz et al., 2019a) and physical education contexts (e.g., Bortoli et al, 2014, 2015, 2017; Di Battista et al., 2019). For example, a state-like assessment was implemented within 1 hr prior to competition on elite basketball players and carom billiard players using a nomothetic method (i.e., same lists of functional and dysfunctional states across athletes). In the first study (Robazza et al., 2012), biological markers of precompetitive anxiety and activation (i.e., testosterone, cortisol, α-amylase, and chromogranin A) correlated with players' functional states. In the second study (Di Corrado et al., 2015), functional states were found to mediate the effect of technical and cognitive self-efficacy on billiard players' performance. In a third study with orienteering athletes (Robazza et al., 2018), psychobiosocial states, cognitive functions (i.e., memory, visual attention, and mental flexibility), endocrine responses (i.e., salivary cortisol and chromogranin A), and performance data were collected repeatedly before, during, and after races under competitive pressure. Increased cortisol levels and decreased cognitive functions associated with competitive pressure were reflected in higher intensity of dysfunctional states and lower intensity of functional states. The findings of the three studies suggest that psychobiosocial states measures can be effectively implemented to examine performance-related psychophysiological changes.

A clear benefit of idiographic methods is that they can improve awareness of one's emotional experiences related to performance and provide a useful platform for the development of athlete-centered self-regulation and intervention programs (Ruiz et al., 2016). On the other hand, standardized assessment tools are less time and energy demanding than idiographic procedures. They can be easily administered to large samples of participants, be readily validated, and produce comparative norms (Lee & Taylor, 2018). The two standardized scales of psychobiosocial states mentioned above have been proposed as global measures of functional and dysfunctional states of athletes (Robazza et al., 2016; Ruiz et al., 2019b). The global perspective endorsed in the construction of the two psychobiosocial scales is to some extent akin to the circumplex conceptualization of affect (Russell, 1980, 2003; Russell et al., 1989). Within the circumplex model, affect is assessed across two dimensions of activation (from sleepiness to high arousal) and hedonic tone (from displeasure to high pleasure), and measured on the so-called affect grid. The dimensions included in the psychobiosocial scales are functionality (i.e., the perceived effect on performance) and hedonic tone.

The use of affect grid in several IZOF-based sport related studies (e.g., Edmonds et al., 2008; Johnson et al., 2007a, 2007b, 2009) was justified as it was believed to be “a parsimonious, idiosyncratically generalizable, and ecologically valid construct that could replace the general concept of emotions” (Johnson et al., 2007a, p. 318). Global scales assessing either functionality dimensions (i.e., psychobiosocial state scales) or activation–hedonic tone dimensions (i.e., affect grid) provide simple and effective measures easily applicable in field research (Flett, 2014, 2015). However, these simplifications fail to provide a comprehensive representation of emotions (Lazarus, 1991, 2001). Accordingly, a main limitation of the existing measures of functional and dysfunctional states (Robazza et al., 2016; Ruiz et al., 2019b) is that they are global measures of psychobiosocial experiences rather than discrete measures of experiences across the functional and dysfunctional dimension. As Lazarus (2006) pointed out, “Although dimensional analysis is useful for certain purposes, this reduction of the qualitative aspects of emotions to a very small number of dimensions greatly oversimplifies their psychosocial dynamics.” (p. 11). Thus, to complement the *dimensional* scales currently used, the main purpose of our two-study investigation was to develop a scale to assess a wide range of *discrete* modalities of psychobiosocial experiences.

Psychobiosocial Experiences

Grounded in the IZOF model (Hanin, 2000, 2007), psychobiosocial experiences are conceived as a variety of emotional and non-emotional manifestations of subjective experiences (e.g., cognitive, motivational, volitional, bodily, behavioral, communicative) related to past, present, and future (anticipated) performances. This position is consistent with the Lazarus' (1991) cognitive-motivational-relational theory in which emotions are viewed as organized psychophysiological reactions to ongoing person-environment relationships. Causal cognitive, motivational, and relational variables are part of the process that arouses and sustains emotions.

At the heart of Lazarus' perspective and other appraisal theories of emotions is the individual's evaluation, either conscious or unconscious, of the significance of a situation. The appraisal process involves cognitive, motivational, and relational contents, including personal goals, beliefs about oneself and the world, availability of personal resources, and environmental demands. This process elicits a cascade of responses involving expressions (e.g., face, voice, gesture), bodily (autonomic) reactions (e.g., heart rate, blood flow, endocrine changes), action tendencies (i.e., approach, avoidance), and feelings (i.e., subjective experience; Sanders, 2013). This group of coordinated, integrated, and organized responses constitutes an emotion (Matsumoto & Ekman, 2009). Notably, the multi-modality view is typical of appraisal theories, and is also shared with the other current major perspectives of emotion, namely, basic emotion (primary, fundamental, discrete) and dimensional (e.g., valence or arousal) theories (Coppin & Sander, 2021). This view has proven useful not only to conceptualize, but also to measure emotions (Mauss & Robinson, 2009).

The multi-modality perspective from the mainstream theories on emotions is also endorsed in the IZOF model, in which psychobiosocial experiences are construed as situational (state-like), multimodal, and dynamic manifestations of total human functioning, or as relatively stable manifestations (trait-like). From reflection on the conditions leading to successful and unsuccessful performances, individuals develop awareness, attitudes, and preferences/rejections (meta-experiences) toward their experiences (Hanin & Ekkekakis, 2014).

Similarities exist between the IZOF model conceptualization of psychobiosocial experiences (Ruiz et al., 2016) and other theories used to investigate emotions in achievement contexts. In Pekrun's (2006) control-value theory of achievement emotions, for example, emotions (such as anxiety) are conceptualized as sets of interrelated affective (feeling uncomfortable), cognitive (worry), motivational (withdrawal tendencies), and physiological (peripheral activation) processes (Pekrun et al., 2011). Furthermore, Blascovich's (2008) biopsychosocial model of challenge and threat integrates biological (autonomic and endocrine), psychological (cognitive and affective), and social processes underlying challenge and threat motivational states related to human performance (for reviews, see Hase, 2019; Uphill, 2019).

In the IZOF model (Hanin, 2000, 2007, 2010), psychobiosocial experiences are manifested in the dimensions of form (display), content (type), and intensity (quantity). The form dimension comprises at least eight modalities: emotion, cognitive, motivational, volitional (psychological component), bodily-somatic, motor-behavioral (biological component), operational, and communicative (social component). All modalities are interrelated (for a full discussion, see Ruiz et al., 2016; Ruiz & Robazza, 2020; for a review, see Ruiz et al., 2017).

The emotion modality is a central component of psychobiosocial experiences. Theoretically, it is described considering the interplay between valence (i.e., pleasant or unpleasant experience) and functionality (i.e., functional or dysfunctional effects on performance), leading to pleasant– and unpleasant–functional states, as well as pleasant– and unpleasant–dysfunctional states, which represent the content of emotional experiences. Functionality depends on the meaning individuals attribute to their interaction with the environment, their perceived resources to deal with the situation, and self-regulation skills. For example, pleasant–functional (e.g., feeling charged) or unpleasant–functional (e.g., angry) states can help mobilize resources to face competitive demands, while unpleasant–dysfunctional (e.g., sluggish) or pleasant–dysfunctional (e.g., relaxed) states may indicate low energy or failure to activate resources. A large body of empirical evidence supports the notion that athletes can perceive anxiety (e.g., being anxious or worried) as either debilitative or facilitative, depending on the individual perception of the impact of anxiety symptoms on competitive performance (Jones et al., 1994; Jones & Swain, 1992; Mellalieu et al., 2006; Neil et al., 2012).

Therefore, emotions such as anger and anxiety can be experienced as functional or dysfunctional for performance regardless of their hedonic valence. This is in function of several factors, comprising personality traits (e.g., trait anxiety, self-confidence), skill level, competitive experience, and coping strategies (Mellalieu et al., 2006; Neil et al., 2012; Robazza & Bortoli, 2007; Robazza et al., 2006; Ruiz & Hanin, 2011). Functionality is then at the core of many studies on emotions in sport, including the current investigation aimed at developing a measure of psychobiosocial experiences.

According to the IZOF model tenets (Hanin, 2010), functionality is also used to classify all other modalities of psychobiosocial states. The cognitive modality refers to the ability (e.g., being focused) or inability (e.g., being distracted) to pay attention to relevant stimuli and maintain the focus of attention to effectively meet the demands of the task. The motivational modality regards pre-decisional processes related to choosing (e.g., motivated) or withdrawing from (e.g., demotivated) a specific goal or course of action. The volitional modality is related to post-decisional processes in which intentions translate into the mobilization (e.g., being persistent) or demobilization (e.g., being irresolute) of resources for task execution and completion. According to Beckmann (2019) "volition is conceived of as a set of central executive processes that regulate the person's thoughts, feelings, and actions in a top-down manner…" (p. 311). Volition is deemed especially important in sticking to one's plan and long-term goals.

To the emotion, cognitive, motivational, and volitional modalities that form the psychological component of psychobiosocial states, Ruiz et al. (2021) added two more modalities regarding feelings of confidence (e.g., confident vs. unconfident) and assertiveness (e.g., aggressive vs.

surrendered) in achieving a goal. Self-confidence, often used interchangeably with self-efficacy (Bandura, 1977, 1997), is the belief in one's ability to perform a task successfully and achieve a specific goal. Self-confidence has long been regarded as one of the mental factors influencing sport performance and most consistently distinguishing highly successful from less successful athletes (Vealey, 2001; Vealey & Chase, 2008; Vealey & Vernau, 2013). Self-confident people can also display assertive behaviors (Strycharczyk et al., 2020). Assertive and aggressive behaviors are at the heart of many sporting disciplines, especially of collision and combat sports (e.g., ice hockey, judo, rugby, and wrestling). These behaviors, which are manifested with high energy and intensity to achieve performance goals, are socially and morally acceptable if they occur within the rules of sports, without intention to harm other competitors (Kerr, 2002; Kosiewicz, 2018).

The bodily-somatic modality reflects feelings of activation (e.g., physically-charged) or deactivation (e.g., physically-drained) of the organism, while the motor-behavioral modality involves individual feelings of movement efficiency (e.g., coordinated) or inefficiency (e.g., uncoordinated). Both modalities are conceptualized in the IZOF model (Hanin, 2010) as part of the biological component of psychobiosocial states.

The operational modality encompasses feelings of effectiveness (e.g., consistent) or ineffectiveness (e.g., inconsistent) task execution and action determined by social criteria objectively or subjectively expressed, such as performance scores and rankings. The communicative modality relates to effective (e.g., communicative) or ineffective (e.g., uncommunicative) social interaction with teammates or others involved in the activity. Along with the operational and communicative modalities, Ruiz et al. (2021) added the social support modality (e.g., feeling supported vs. feeling neglected) in the social component of psychobiosocial states. Emotions and emotion-related states, in fact, are social phenomena, and have interpersonal consequences. They are experienced, manifested, and managed within social contexts in the interaction with and in search of support from important others, such as coaches and teammates (Tamminen & Gaudreau, 2014; Tamminen & Neely, 2021).

Study purpose

Drawing on the substantive theoretical framework represented by the IZOF model (Hanin, 2000, 2007), which is one of the most relevant theoretical approaches in sport psychology (for reviews, see Ruiz et al., 2017; Ruiz & Robazza, 2020), the purpose of this study was to develop a new *discrete* multimodality scale specifically intended to assess discrete psychobiosocial experiences. Dimensional scales in the assessment of psychobiosocial states have already been developed (Robazza et al., 2016; Ruiz et al., 2019b). What is still missing is a discrete nomothetic measure of psychobiosocial modalities to integrate dimensional scales and provide a more fine-grained information on the relationship between psychobiosocial experiences and performance. The new measure falls within the measurement domain of subjective experience proposed by Quigley et al. (2014), where self-report is believed to be an appropriate way to assess an individual's experience despite possible issues arising from participants' ability to access and communicate experiences, participants' knowledge of the emotion words and related emotion concepts, and social desirability. This scale is expected to contribute to the IZOF-based knowledge and be used for both research and applied purposes.

Specifically, in a two-study investigation we aimed to develop a scale based on the 12 modalities identified by Ruiz et al. (2021) in their conceptualization of psychobiosocial experiences: (a) unpleasant/pleasant emotion (emotion u/p), confidence, anxiety, motivation, volition, assertiveness, and cognitive (psychological component); (b) bodily-somatic and motor-behavioral (biological component); and (c) operational, communicative, and social support (social component). The emotion modality comprised unpleasant (e.g., sad) and pleasant (e.g., happy) emotions expected to exert dysfunctional and functional effects, respectively. The emotion modality was thus labeled "emotion u/p" to distinguish it from the other emotion-related modalities that may have unpleasant hedonic valence (e.g., anxiety) or not have hedonic valence on their own. For example, being distracted (cognitive modality) can be tied to pleasant or unpleasant feelings although it is not itself an emotionally valenced state.

In Study 1 we developed a preliminary version of the scale, administered the scale in a sample of athletes, and examined its factor structure. From an initial large pool of items, we expected to identify a small number of items best representing each of the different modalities and to reach a satisfactory factor structure. In Study 2 we cross validated the scale obtained in Study 1 in a second independent sample of athletes. To assess construct validity, we examined convergent, discriminant, and nomological validity of the instrument through correlations with other existing emotion and motivation scales often used in sport contexts. Findings were expected to support the factor structure found in Study 1, as well as the convergent, discriminant, and nomological validity of the new psychobiosocial scale. As Eronen and Bringmann (2021) argued, construct validation should be an iterative and ongoing process that helps in strengthening the conceptual basis of a psychological theory. This is also useful in establishing causal inference, as having well-defined constructs and valid measurements makes it easier to infer causal relationships. Construct validation is also crucial for testing a causal theory (Schimmack, 2021), represented by the IZOF model in the current study.

In addition to the purpose of developing a valid tool, our goal was to propose a relatively short measure that could be easily applied in sport. In athletic contexts, it is often essential to minimize the time and psychological burden of data collection, especially when assessments are repeated over time. For this purpose, we chose a semantic differential format in the construction of items following Verhagen et al.'s (2015) procedural guidelines as explained below. A main advantage of semantic differentials is that they are less demanding for participants and researchers than other methods (Rosenberg & Navarro, 2018). We also assumed that a semantic differential presentation of psychobiosocial experiences would allow for a clear and unambiguous distinction between opposite states along the functionality distinction, thus facilitating the athletes' reflection on their own conditions with respect to performance. While designing the study, we also followed best practice recommendations for ongoing construct validation as established by several authors (e.g., Flake et al., 2017).

Method

Study 1

The purpose of Study 1 was to develop a preliminary version of a Psychobiosocial Experience Semantic Differential scale in sport (PESD-Sport) and examine its factor structure. Internal consistency, composite reliability, and average variance extracted were assessed to establish construct reliability. We also assessed convergent validity and discriminant validity, namely, the degree to which the scale modalities measure the same concept and the degree to which the scale modalities are distinct.

Participants

The final sample consisted of 280 competitive athletes (131 women, 149 men), aged 16 to 34 years (M = 21.56, SD = 5.20), recruited from main sport clubs located in central Italy. The athletes had between 1 to 30 years of competitive experience (M = 9.26, SD = 5.67) at regional level (79%), national level (14%), and international level (7%). They competed in a variety of individual sports (n = 88; e.g., track & field, martial arts, swimming, tennis, and fencing) and team sports (n = 192; e.g., volleyball, basketball, soccer, rugby, water polo, and futsal), and trained on average 2.97 times a week (SD = 1.67). No significant differences were found for age and sport experience between men and women or individual and team sports ($p > .05$).

Measure

In the development of the PESD-Sport, we followed the set of procedural guidelines for semantic differentials development recommended by Verhagen et al. (2015). The first step involved the establishment of a sample of valid bipolar scales. To this purpose we used all the items of the individualized multidimensional profiling of psychobiosocial states proposed by Ruiz et al. (2021) for individualized assessments, which is an extended version of the individualized profiling previously developed by Ruiz et al. (2016). With this assessment, the athlete is presented with a stimulus list of 23 items (from 3 to 6 adjectives to form an item), for a total of 93 adjectives to assess 12 functional and dysfunctional state modalities. The psychological component comprises pleasant and unpleasant states (emotion), confidence, anxiety, motivation, volition, assertiveness, and cognition. The biological component consists of bodily and motor-behavioral feelings, while the social component embraces operational feelings, communication, and social support. Using a retrospective method, the athlete is asked to select and rate the intensity of those functional and dysfunctional state descriptors that best represent frequently occurring personal experiences associated with recalled optimal and suboptimal performances. Most of the items were already included in the Italian version of the PBS-ST scale (Robazza et al., 2016).

Based on this large pool of items (i.e., 93 adjectives) and others deriving from earlier research on psychobiosocial experiences in sport (Robazza et al., 2016; Ruiz et al., 2016, 2019b), three researchers with substantial expertise on psychobiosocial states examined the adjectives separately and identified their antonyms to be included as scale anchors in the new semantic differential instrument. Antonyms were established for all adjectives except those relating to anxiety and communicative modalities. As noted earlier, athletes may experience similar anxiety symptoms as functional or dysfunctional, depending on their appraisal of the effect of these symptoms on performance (Mellalieu et al., 2006; Neil et al., 2012). Similarly, the effect of the same communicative behaviors on performance can be experienced differently among athletes. Indeed, some prefer to isolate themselves to concentrate and cope with competitive pressure, while others seek the support of their coach and peers (Rees & Freeman, 2012). This different perception of the effects of communication from one individual to another led to the removal of the items of the communicative modality from both the PBS-ST (Robazza et al., 2016) and PBS-S (Ruiz et al., 2019b) scales due to high variability in the perception of functional and dysfunctional effects. Therefore, on the anxiety and communicative modalities we formulated the opposites as “harmful” and “useful” (e.g., “Anxious in a harmful way–Anxious in a useful way”, “Being communicative is harmful–Being communicative is useful”).

After having examined the adjectives and identified their antonyms separately, the researchers discussed the items until they reached agreement on all adjectives and their antonyms. This aligns with the second step of the procedural guidelines for semantic differentials development (Verhagen et al., 2015), which involves an examination of psychological bipolarity with an expert panel, judging the linguistic alignment of each bipolar scale in relation to the concept under study. In a third step, extensive discussion took place in several meetings to identify from 4 to 6 items (i.e., adjectives and their antonyms) deemed to represent each of the 12 modalities. Again, the researchers examined the items until full consensus was reached. A total of 53 items comprised the provisional version of the PESD-Sport. The items pertaining to each modality were systematically spaced to minimize order bias and anchoring effects making contextual contamination (i.e., the degree to which a measured dimension affects the subsequent evaluation of the other dimensions). According to Rosenberg and Navarro (2018), negative (dysfunctional for performance) adjectives were placed on the left of a Likert-type scale with their positive (functional for performance) antonyms on the right. This arrangement is less mentally taxing and facilitates respondents to make judgments. Ratings were placed on a 9-point, bipolar Likert-type scale ranging from 4 (*very much*) to 0 (*neither… nor*) on the "dysfunctional" side and from 0 to 4 on the "functional" side. Thus, the format of the scale was 4–0–4. Scores on the dysfunctional side were then transformed into negative scores for analysis. Thus, the score of an item could range from –4 to 4, with 0 indicating no effect.

In the fourth step we administered the provisional version of the PESD-Sport to the sample of athletes to test the dimensionality of the instrument and select the best indicators to be used in the final step with an independent sample (Study 2).

Procedure

Both studies here reported were conducted following ethical approval from the local university ethics committee and in accordance with the declaration of Helsinki. We then contacted sport managers and coaches and explained the general purpose of the investigation to obtain authorization to approach the athletes. Athletes were eligible if they trained with a coach at least twice a week, competed regularly during the sport season, and were over 16 years of age. Prior to scale administration, participants were informed that participation in the study was voluntary, they could end the session at any time without consequences, and individual responses would remain confidential. They were also informed about the general purpose of the study and presented with instructions indicating that there were no right or wrong answers. Written informed consent was obtained from participants or parents in the case of participants under 18 years of age. Athletes completed the PESD-Sport individually in a quiet room before regular practice sessions following instructions of an investigator who administered the scale to groups of up to five participants. Athletes were asked to complete the PESD-Sport items referring to how they usually feel just before an important competition. Then, they had to choose one either functional or dysfunctional descriptor from each row that best reflected their experiences and rate its intensity on the 4–0–4 scale.

Data Analysis

To examine the factor structure of the PESD-Sport and identify a small number of adjectives best representing the psychobiosocial modalities, we performed exploratory structural equation modeling (ESEM; Marsh et al., 2009; Morin & Maïano, 2011). The factor structures tested were theoretically justifiable and targeted the state modalities. Exploratory and confirmatory factor analysis are integrated in ESEM models in which all factor loadings and cross loadings are freely estimated (Asparouhov & Muthén, 2009). ESEM models were estimated using Target rotation that, similarly to the confirmatory factor analysis (CFA) approach, relies on the a priori specification of the key construct indicators with all cross-loadings being freely estimated but with a target value close to zero. The robust maximum likelihood estimator (MLR) for non-normal data was used for ESEM. We then conducted CFA that is more restrictive than ESEM because cross-loadings are constraint to zero. CFA models were estimated using the maximum likelihood parameter estimates (MLM) with standard errors and a mean-adjusted chi-square test statistic that are robust to non-normality (Byrne, 2012).

The different psychobiosocial modalities were expected to be correlated and thus to possibly imply higher-order or hierarchical factors. We therefore tested first-order, higher-order, and nested-factor models (Brunner et al., 2012; Canivez, 2016). Specifically, in the final version of the PESD-Sport we tested seven competing measurement models that could represent the scale structure: (1) a single first-order factor model with correlated factors (i.e., the psychobiosocial modalities) with paths leading to the observed variables (i.e., the items); (2) a higher-order factor model with paths specified from a second-order factor, representing global psychobiosocial experiences, to the first-order factors (i.e., the psychobiosocial modalities) with paths leading to the observed indicators. The influence of the second-order factor on observed indicators is fully mediated by the first-order factors; (3) a higher-order factor model with paths specified from the three second-order factors representing psychological (i.e., emotion u/p, confidence, anxiety, motivation, volition, assertiveness, and cognitive modalities), biological (i.e., bodily-somatic and motor-behavioral modalities), and social components (i.e., operational, communicative, and social support modalities) leading to the first-order factors. The influence of the three second-order factors on observed indicators is fully mediated by the first-order factors; (4) the same higher-order factor model with three second-order factors in which the operational modality (e.g., "effective in my performance") of the social component is included in the biological component because of its inherent similarity with both the bodily-somatic modality (e.g., "physically energetic") and motor-behavioral modality (e.g., "dynamic in my movements"); (5) a nested-factor model (also called bifactor measurement model) in which both a general factor (i.e., global psychobiosocial experiences) and the first-order factors (i.e., psychobiosocial modalities) had direct paths to the observed indicators. In this case the direct influence of the general factor on the observed variables is not mediated by the first-order factors; (6) a nested-factor model with three factors, representing psychological, biological, and social states, and the first-order factors (i.e., psychobiosocial modalities) having direct paths to the observed indicators. Also in this case the direct influence of the three factors on the observed variables is not mediated by the first-order factors; and (7) the same nested-factor model with three factors in which the operational feelings modality of the social component is included in the biological component.

Model fit was evaluated using chi-square (χ^2) goodness-of-fit index, normed chi-square (χ^2/df), comparative fit index (CFI), Tucker Lewis fit index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR). Values for χ^2/df < 5, CFI and TLI > .90, and RMSEA and SRMR equal of or smaller than .08, were considered representing acceptable fit (Browne & Cudeck, 1993; Schumacker & Lomax, 2016). Excellent fit was inferred when CFI and TLI values were close to .95, and RMSEA and SRMR were smaller than .06 (Hu & Bentler, 1999). To determine if items were reasonable indicators of the latent factors, we considered standardized values to be above .50 and statistically significant (Hair et al., 2019). To compare the fit of alternative models, we used the Akaike's Information Criterion (AIC) values and the parsimony comparative fit index (PCFI). Improvements in model fits are reflected in higher values of CFI, TLI, and PCFI, and lower values of χ^2, χ^2/df, RMSEA, SRMR, and AIC. All data analyses were conducted in M*plus* version 8.5 (Muthén & Muthén, 2017).

The internal consistency of the subscale scores was determined through reliability alpha values, composite reliability values, and reliability omega values (Watkins, 2017). Estimates greater than .70 were deemed adequate. We also determined the average variance extracted of the latent variables, which is a measure of convergence among a set of items representing a latent construct. Values close to or larger than .50 of average variance extracted suggest adequate convergence of items (Hair et al., 2019). Discriminant validity was established by comparing the average variance extracted estimates for each factor with the squared interconstruct correlations associated with that factor. Discriminant validity is inferred when variance extracted estimates are greater than the corresponding interconstruct squared correlation estimates (Hair et al., 2019).

Results

Data were initially screened for missing values, univariate normality, and multivariate outliers. Seven cases were removed from further analyses because of missing values or identified as outliers (Mahalanobis' distance, $p < .001$). Minimum and maximum values for skewness of the 53 items ranged from −2.024 to −.299 and for kurtosis from −.835 to 4.841. Therefore, the robust maximum likelihood method was deemed appropriate for factor analysis.

Factor analysis results are reported in Table 1. Both ESEM and CFA models on 12 modalities, 53 items configuration demonstrated poor model-data fit. An examination of the parameter estimates and modification indices indicated several items with poor standardized factor loadings (< .30), cross-loadings on unintended factors (> .30) that were larger than the target factor loadings, and multiple (two or more) moderate-sized or large modification indices (over 15) to be taken into consideration for deletion. As a result, 23 of the 53 items were systematically deleted in several iterations. This systematic item removal and reanalysis yielded a final scale composed of 30 items loading into 10 modalities represented by 3 items each. According to Hair et al. (2019), measurement scales should have a minimum of three items per factor. The 10 modalities comprised: emotion u/p, confidence, anxiety, assertiveness, and cognitive (psychological modality); bodily-somatic and motor-behavioral (bodily modality); and operational, communicative, and social support (social modality). Motivation and volition items were excluded because of their cross-loadings and large modification indices indicating substantial overlapping with assertiveness items. This suggests communality (i.e., proportion of common variance) of the items due to the semantic meaning of assertiveness (e.g., feeling submissive−fierce), motivational (e.g., demotivated−motivated), and volitional (e.g., irresolute−resolute) modalities as related to performance. CFA on the resultant 10-modality, 30-item model showed the best fit, whereas higher-order and nested-factor models did not reach acceptable fit (see Table 1). The PESD-Sport is reported in Supplementary File 1.

All standardized factor loadings were above .600 (λ = .634–.860) and item residual variances ranged from δ = .260 to .598 (see Table 2). Latent factor correlation values ranged from .201 to .895 (see Table 3). Seven correlations were low (*r* between .20 and .39; Zhu, 2012), 16 correlations were moderate (*r* between .40 and .59), 20 correlations were moderately high (*r* between .60 and .79), and 2 were high (*r* > .80). Correlation coefficients and reliability indices are reported in Table 3.

Discussion

Taken together, findings of Study 1 provided preliminary evidence of construct validity of the PESD-Sport. Good CFA fit indices for the 10-modality, 30-item model supported the factor structure of the scale according to the conceptual representation of psychobiosocial experiences. Internal consistency values (α, ω, and CR) were all above .70, thus scale reliability was demonstrated. Moreover, standardized loading estimates and AVE values were higher than .50 on all modalities indicating adequate convergent validity of the scale modalities. Taking as a reference the minimum AVE value of .501 observed for the communicative modality, AVE estimates were greater than the squared correlations between two modalities for 38 correlations out of 45. This result together with cross-loadings on unintended factors smaller than the target factor loadings supported the discriminant validity of the scale modalities.

Study 2

The aim of Study 2 was to cross validate the 10-modality, 30-item solution of the scale obtained in Study 1 in a second independent sample. We also investigated convergent and discriminant validity through correlations with two emotion related measures, and examined nomological validity via comparison with two motivation scales. The emotion and motivation measures have been often used in sport settings.

Participants

We involved participants with demographic characteristics similar to those of Sample 1. The final sample comprised 302 competitive athletes (124 women, 178 men), aged 16 to 34 years (M = 22.18, SD = 6.10) from sport clubs in central Italy. The athletes had between 1 to 31 years of competitive experience (M = 9.40, SD = 5.93) at regional level (77%), national level (15%), and international level (8%). They competed in a range of individual sports (n = 117) and team sports (n = 185) similar to the athletes of Sample 1, and trained on average 2.95 times a week (SD = 1.52). Differences for age and sport experience between men and women or individual and team sports were not significant ($p > .05$).

Measures

Assessment was conducted using the 10-modality, 30-item solution of the PESD-Sport derived from Study 1 (see Supplementary File 1), the Sport Emotion Questionnaire (SEQ; Jones et al., 2005), the Sport Performance Psychological Inventory (IPPS-48; Robazza et al., 2009), the Perceived Motivational Climate in Sport Questionnaire-2 (PMCSQ-2; derived from Newton et al., 2000), and the Basic Psychological Needs in Sport Scale (BPNSS; Gillet et al., 2008). The SEQ and IPPS-48 were administered to test convergent and discriminant validity of the PESD-Sport, while the PMCSQ-2 and BPNSS were used to test nomological validity.

The Sport Emotion Questionnaire (SEQ). The SEQ (Jones et al., 2005) is a 22-item, sport-specific measure of precompetitive intensity of anger (e.g., annoyed, irritated), anxiety (e.g., nervous, apprehensive), dejection (e.g., unhappy, disappointed), excitement (e.g., enthusiastic, energetic), and happiness (e.g., joyful, cheerful). Ratings are provided along a 5-point Likert-type scale ranging from 0 (*not at all*) to 4 (*extremely*). CFA values indicated that the 5-factor structure was acceptable (CFI = .93, RMSEA = .07; see also Arnold, 2015). In a study with Italian athletes, the factor structure (CFI = .930, TLI = .919, RMSEA = .047) and reliability (α range = .741−.863, CR range = .742−.864) were confirmed (Robazza et al., 2016). In our study, the question "how you feel right now, at this moment, in relation to the upcoming competition" (Jones et al., 2005) was aligned with the PESD-Sport directions, and thus modified asking the athletes to refer to how they usually feel before an important competition.

The Sport Performance Psychological Inventory (IPPS-48). The IPPS-48 (Robazza et al., 2009) measures a range of mental skills and psychological strategies used by athletes in competition and during practice. Developed in Italian language (Inventario Psicologico della Prestazione Sportiva), it is composed of 48 items pertaining to 8 factors included into cognitive and emotion higher-order factors. In the current study we administered the items comprised within the emotion higher-order factor, which are included in self-confidence (e.g., "I am confident in my competitive abilities"), emotional arousal control (e.g., "I am able to relax and control tension when needed"), worry (e.g., "I feel panicked before competition"), and concentration disruption (e.g., "My attention wanders while competing") subscales. Athletes are asked to report how frequently they have experienced the situations and the feelings described rating them on a 6-point Likert-type scale ranging from 1 (*never*) to 6 (*always*). The factor structure (CFI = .950, TLI = .944, RMSEA = .046) and reliability (α range = .756−.916, CR range = .773−.916) were supported in an Italian sample (Robazza et al., 2016).

The Perceived Motivational Climate in Sport Questionnaire (PMCSQ-2). The Italian version of the PMCSQ-2 (Bortoli & Robazza, 2004) was derived from Newton et al. (2000). The questionnaire is made up of 12 items included in a 6-item mastery climate scale (e.g., "On this team, the coach makes sure participants improve on skills they're not good at") and a 6-item performance climate scale (e.g., "On this team, participants are encouraged to outplay the other participants"). Participants were asked to complete the questionnaire with reference to their sporting experience. Item responses are ranked on a 5-point scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). In a study with an Italian sample Cronbach α value was .76 on mastery scale scores and .70 on performance scale scores (Bortoli & Robazza, 2004). The scale was then used in studies with Italian samples of athletes (Vitali et al., 2015) also assessing psychobiosocial states (Bortoli et al., 2011, 2012).

Basic Psychological Needs in Sport Scale (BPNSS). The BPNSS (Gillet et al., 2008) was developed in French language and is composed of 15 items loading into 3 subscales to assess perceived competence (e.g., "I often don't feel very competent"), autonomy (e.g., "I feel free to make my own choices"), and relatedness (e.g., "I feel comfortable with others"). Athletes were asked to fill in the questionnaire thinking about their sporting experience. Responses are indicated on a 7-point scale ranging from 1 (*not at all true*) to 7 (*very true*). Gillet et al. (2008) provided evidence for the factorial structure (CFI = .95, RMSEA = .06) and internal consistency with α values ranging from .72 to .77. Using the backward translation procedures, the scale was translated from French into Italian independently by two researchers fluent in French language. The scale was then translated back into French by a native speaker. The translated text was checked and discussed until consensus was reached on the original meaning.

Procedure

All measures were administered following the same procedure described in Study 1 (i.e., institutional approval and administration of questionnaires). Athletes were asked to rate the items according to the instructions provided for each measure. Specifically, participants were required to report how they usually feel before an important competition on the PESD-Sport and the SEQ, the frequency they have experienced the situations and the feelings associated with practice and competition on the IPPS-48, and their perception of the sporting experience on the PMCSQ-2 and BPNSS.

Data Analysis

ESEM and CFA were conducted to examine the factorial validity of the PESD-Sport derived from Study 1. Descriptive statistics, correlation coefficients, and reliability values of the study variables were also computed. We then assessed configural, measurement, and structural invariance of the scale across the two study samples using multigroup CFAs with increasing parameter constraints one at a time (Byrne, 2012; Wang & Wang, 2020). A configural model was established as baseline against which several increasingly rigorous models were evaluated (Farmer & Farmer, 2014). To test measurement invariance and structural invariance between groups, different restrictions are imposed in hierarchical steps on the parameters of interest. Testing measurement invariance involved configural (i.e., same number of factors and factor loading pattern across groups), weak measurement (i.e., equality of the factor loadings), strong measurement (i.e., equality of the factor loadings and intercepts), and strict measurement (i.e., equality of the factor loadings, intercepts, and error variance) invariance. Testing structural invariance involved factor variance (i.e., equality of variance of factor scores) and factor covariance (i.e., equality of covariance of factor scores) invariance. At each testing step of model comparisons (i.e., the configural model vs. a specified model), we derived the likelihood ratio test for model comparison based on the Satorra-

Bentler scaled chi-square difference (ΔS-B χ^2) between models. If the model statistic χ^2 does not change significantly after imposing the restrictions, the assumption of parameters invariance is retained. We also examined the difference in CFI, RMSEA, and SRMR between models. Differences in CFI < .010, RMSEA < .015, and SRMR < .030 are considered criteria of invariance (Chen, 2007; Cheung & Rensvold, 2002).

Invariance across gender and sport type (individual vs. team) was examined using multiple indicator, multiple cause (MIMIC) models, also known as CFA with covariates (Brown, 2015). In a MIMIC model, multiple indicators reflect the underlying latent factors, and the multiple causes (i.e., observed predictors) influence latent factors. The covariates in our model were gender and sport type dummy coded to represent group membership (i.e., woman = 0, man = 1; and individual sport = 0, team sport = 1). A gender by sport interaction term was also derived. We performed MIMIC modeling rather than multi-group CFA due to the relatively unbalanced sample size between covariates (i.e., smaller number of women and athletes of individual sports in the sample compared to men and team sports athletes). MIMIC modeling allows a robust and parsimonious testing of measurement invariance (indicator intercepts) and population heterogeneity (factor means) between groups.

Finally, convergent, discriminant, and nomological validity of the PESD-Sport was investigated after having established the factorial validity of the SEQ, IPPS-48, PMCSQ-2, and BPNSS. In particular, convergent and discriminant validity of the PESD-Sport was determined in comparison with the SEQ and IPPS-48, while nomological validity was ascertained with respect to the PMCSQ-2 and BPNSS.

Results

Data were screened for missing values, univariate normality, and multivariate outliers. Nine cases were removed from additional analyses because of missing values or they were identified as outliers (Mahalanobis' distance, $p < .001$). Minimum and maximum values for skewness of the 30 items ranged from −2.047 to −.396 and for kurtosis from −.472 to 5.790. Again, the robust maximum likelihood method was deemed appropriate for factor analysis.

ESEM and CFA fit indices supported the 10-modality, 30-item solution of the PESD-Sport obtained in Study 1 (Table 1). Similarly to Study 1, higher-order and nested-factor models did not yield acceptable fit. All standardized factor loadings were above .600 (λ = .658–.909) and item residual variances ranged from δ = .173 to .567 (Table 2). Compared to the other modalities, lower intensity ratings were observed for all items in the anxiety modality and one item of the communicative modality (i.e., Expansive in a harmful way–Expansive in a helpful way) in both Study 1 and Study 2. Yet, mean values of items were all positive ranging from .87 to 2.88 in Sample 1, and from 1.19 to 2.86 in Sample 2 (Table 2). Latent factor correlation values ranged from .478 to .912 (Table 3). Eleven correlations were moderate (r between .40 and .59), 25 correlations were moderately high (r between .60 and .79), and 9 were high (r > .80). Correlation coefficients and reliability indices are contained in Table 3.

The multi-group comparisons to assess the invariance of the scale across the two study samples showed that the CFA configural model fit the data adequately (Table 4), thus indicating the same factor structure (i.e., same number of factors and same patterns of free and fixed factor loadings) of the PESD-Sport across the two study groups. Full measurement and structural invariance of the scale was also observed as indicated by the ΔS-B χ^2, CFI, RMSEA, and SRMR patterns in the comparison between the configural and the other models. Indeed, the ΔCFI and ΔRMSEA values were smaller than .010 and .015 thresholds respectively, four out of five ΔSMR values were smaller than the .030 threshold, and three out of five ΔS-B χ^2 tests were non-significant.

MIMIC analysis results showed acceptable fit of the model. The estimated parameters indicated significant effects (p < .05) of gender on emotion u/p, confidence, anxiety, bodily-somatic, assertiveness, and communicative modalities, while gender × sport interaction was not significant. Mean modality scores of male participants were higher than those of female participants. Inspection of modification indices showed no substantial differences in item responses. Thus, the inclusion of gender and sport as covariates did not alter the factor structure or determined differences in item functioning.

Before examining convergent, discriminant, and nomological validity of PESD-Sport, we determined the factorial validity and reliability of the measures. The SEQ, IPPS-48, PMCSQ-2, and BPNSS needed several adjustments before reaching acceptable fit and reliability (Table 5). Specifically, the hypothesized 5-factor structure of the SEQ was not supported, χ^2/df = 2.016, CFI = .902, TLI = .887, RMSE = .058 (.050–.066), SMR = .072, due to eight items with poor standardized factor loadings (< .30) or cross-loadings on unintended factors (> .30). Item removal resulted in a 3-factor solution comprised of happiness (e.g., happy) and excitement (e.g., enthusiastic) factors combined, anger (e.g., angry) and dejection (e.g., sad) combined, and anxiety (e.g., nervous). The initial 4-factor structure of the IPPS-48, χ^2/df = 1.811, CFI = .920, TLI = .910, RMSE = .052 (.044–.059), SMR = .071, was improved after specification of two correlated errors on the Self-confidence scale and four correlated errors on the Worry scale. The initial factor structure of the PMCSQ-2 was poor, χ^2/df = 3.230, CFI = .879, TLI = .850, RMSE = .086 (.072–.100), SMR = .053. Acceptable fit was obtained after specification of four correlated errors on the mastery climate scale and two correlated errors on the Performance scale. Finally, the 3-factor structure of the BPNSS did not fit the data, χ^2/df = 4.967, CFI = .730, TLI = .674, RMSE = .115 (.104–.125), SMR = .100. The removal of five items with poor standardized factor loadings or cross-loadings on unintended factors yielded an acceptable fit.

Latent factor correlations between the PESD-Sport and the criterion-related measures showed a pattern of relationships in the expected direction (Table 6). Most of the psychobiosocial modalities related positively with the Happiness & Excitement scale of the SEQ, the Self-confidence and Emotional arousal control scales of the IPPS-48, the Mastery climate scale of the PMCSQ-2, and Competence and Relatedness scales of the BPNSS. Many modalities also related negatively with the Anger & Dejection and Anxiety scales of the SEQ, the Worry and

Concentration disruption scales of the IPPS-48, and the Performance scale of the PMCSQ-2. According to Zhu's (2012) indications, 4 correlations were moderately high, 28 were moderate, and 56 were low, while 32 coefficients were not significant. Convergent validity (i.e., degree to which two measures of similar concepts are related) was therefore demonstrated in the relationship between the PESD-Sport with the SEQ and IPPS-48 scales. Correlation coefficients ranging from low to moderate also suggest discriminant validity, indicating that the PESD-Sport taps unique constructs.

Nomological validity (i.e., extent to which a scale relates to existing theory-based concepts) was examined through structural equation modeling (SEM). The PMCSQ-2 and BPNSS dimensions were entered as antecedents of the PESD-Sport modalities. The measurement model showed acceptable fit to the data, $\chi^2/df = 1.536$, CFI = .919, TLI = .916, RMSE = .042 (.038–.046), SMR = .053. Mastery climate was significant ($p < .01$) predictor of confidence ($\lambda = .305$), assertiveness ($\lambda = .329$), cognitive ($\lambda = .431$), bodily-somatic ($\lambda = .288$), motor-behavioral ($\lambda = .264$), and operational ($\lambda = .373$) modalities. Performance climate was significant predictor of confidence ($\lambda = .280$), assertiveness ($\lambda = .269$), and cognitive ($\lambda = .288$) modalities. Competence was significant predictor of emotion u/p ($\lambda = .230$), confidence ($\lambda = .393$), anxiety ($\lambda = .239$), assertiveness ($\lambda = .291$), cognitive ($\lambda = .288$), bodily-somatic ($\lambda = .207$), motor-behavioral ($\lambda = .241$), operational ($\lambda = .317$), communicative ($\lambda = .152$), and social support ($\lambda = .162$) modalities. Finally, relatedness was significant predictor of emotion u/p ($\lambda = .288$), confidence ($\lambda = .188$), assertiveness ($\lambda = .166$), communicative ($\lambda = .1255$), and social support ($\lambda = .304$) modalities.

Discussion

The multi-group comparison used to assess invariance across Study 1 and Study 2 samples supported the factor structure, full measurement invariance, and structural invariance of the PESD-Sport. The inclusion of gender and sport as covariates did not modify the factor structure or determined differences in item functioning, although mean modality scores of men were higher than those of women.

Collectively, the findings of Study 2 supported the construct validity and reliability of the PESD-Sport, with good fit indices and internal consistency values (α, ω, and CR) all above .70. Standardized loading estimates, higher than .60 and AVE values higher than .50 on all modalities, demonstrated adequate convergent validity of the scale modalities. Taking as a reference the minimum AVE value of .530 of the communicative modality, AVE estimates were larger than the squared correlations between two modalities for 29 correlations out of 45. This result together with cross-loadings on unintended factors smaller than the target factor loadings upheld the discriminant validity of the PESD-Sport modalities.

Convergent validity was further demonstrated as latent factor correlations between the PESD-Sport modalities and the criterion-related measures (i.e., SEQ and IPPS-48) revealed a pattern of relationships in the expected direction. Most of the correlations ranged from low to moderate, thus indicating discriminant validity of the PESD-Sport scales in comparison with the SEQ and IPPS-48. This finding suggests that the PESD-Sport gauges unique constructs. Nomological validity was also inferred as the scores of the mastery climate subscale of the PMCSQ-2, and competence and relatedness subscales of the BPNSS were significant predictors of most of the psychobiosocial modalities.

General Discussion

Psychobiosocial states have been extensively investigated in sport and physical education settings using idiographic and nomothetic procedures (see Ruiz et al., 2017). The three existing normative scales developed to assess psychobiosocial states in sport (Robazza et al., 2016; Ruiz et al., 2019b) and physical education (Bortoli et al., 2018) are global measures aimed at assessing functional and dysfunctional dimensions of psychobiosocial states. What was still missing was a normative measure of discrete states across the functionality dimensions. Therefore, our goal was to complement currently available *dimensional* measures with a scale that specifically assesses the *discrete* modalities of psychobiosocial experiences. The scale is framed within a multi-modality view advocated in mainstream psychology by appraisal, basic emotion, and dimensional theories, which are the current dominant families of emotion theories aimed at assessing, understanding, and explaining emotions (for a discussion, see Coppin & Sander, 2021). In the sport context, the multi-modality perspective is also emphasized in the IZOF model (Hanin, 2007).

We also aimed to develop a relatively brief instrument in order to reduce the response burden in terms of amount of time and effort placed on participants, especially when the assessment of psychobiosocial experiences is combined with other measures in studies that address multiple hypotheses within a sample. A short measure is therefore expected to improve participants' levels of response accuracy, commitment, and adherence to research. A minimum of three items in a factor has been suggested to provide coverage of the theoretical domain of a construct and also adequate identification for the construct in a CFA (Hair et al., 2019). Notably, other tools containing a small number of items in each factor have been proposed in the evaluation of psychological constructs linked to emotions. For example, the subscales of the 6-factor, 18-item Athletic Mental Energy Scale (AMES; Lu et al., 2018) and the 5-factor, 10-item Brief Emotional Intelligence Scale (BEIS-10; Davies et al., 2010) consist of three and two items, respectively. In addition to the small number of items, the semantic differential format of the PESD-Sport is meant to reduce the assessment time (Rosenberg & Navarro, 2018), as well as to facilitate responding through a clear distinction between opposite states along the functionality dimensions.

Factor Structure of the PESD-Sport

From an initial large pool of adjectives, including (but not limited to) those proposed by Ruiz et al. (2021) for individualized assessments of 12 functional and dysfunctional modalities of a psychobiosocial experience, 53 items were selected and adapted for a provisional version of a PESD-Sport. Using both ESEM and CFA, we identified a final version of the instrument consisting of 30 items loading into 10 factors (i.e., modalities). We then tested seven first-order, higher-order, and nested-factor models to identify the best structure of the scale. The decision to test first-order and higher order models was based on the IZOF model (Hanin, 2007, 2010), a substantive theoretical framework that inspired the instrument development. According to Myers et al. (2014), the theoretical approach that a priori guides the development of an instrument can support, or at least not preclude, the possibility that the responses to the items can be directly influenced by one or more general latent constructs as well as by specific latent factors. In both study samples, the correlated first-order model yielded the best fit to the data. Specifically, both a second-order factor representing global psychobiosocial experiences and three second-order factors representing global psychological, biological, and social components did not fit the data better than a first-order structure. This finding is partially in agreement with the IZOF conceptualization of psychobiosocial states. Indeed, CFA did not corroborate the inclusion of psychobiosocial experiences in higher-order psychological, biological, and social latent factors as conceived in the IZOF model. However, support was found for the multimodal display of emotion and non-emotion related content as conceptualized in the IZOF. From an applied perspective, the scores of the three items forming each of the 10 modalities of the PESD-Sport can be plotted in aggregated or complete multimodal profiles to enable direct representation of psychobiosocial experiences at the individual or group level (see Supplementary File 1). Possible areas of intervention could thus be identified and inform multimodal intervention and self-regulation procedures to optimize individual states associated with performance.

Support was also provided for the inclusion in the PESD-Sport of three new modalities consisting of feelings of confidence, assertiveness, and social support (Ruiz et al., 2021). Since the publication of the CSAI-2 (Martens et al., 1990), confidence has been extensively assessed in combination with cognitive anxiety and somatic symptoms of anxiety. Research findings summarized in two meta-analyses showed a consistent relationship between self-confidence and competitive performance (Craft et al., 2003; Woodman & Hardy, 2003). Self-confidence is viewed as a key protective factor that helps buffer against dysfunctional symptoms of competitive anxiety (Ong & Chua, 2021). Preperformance confidence, together with reappraisal on the role of emotions, was also found to moderate the relationship between in-game emotions (i.e., dejection and happiness) and cognitive interference (i.e., performance worries, task-irrelevant thoughts, and thoughts of escape; Stanger et al., 2018).

Self-confidence has also been suggested to influence how athletes experience the effects of anger toward performance (Robazza & Bortoli, 2007). Anger and moral disengagement can lead to aggressive and antisocial behavior intended to harm or offend another person, and result in impaired performance (Ring et al., 2019). In his cognitive-motivational-relational theory of emotion, Lazarus (2000) considered anger as a high-arousal negatively-toned emotion stemming from damage, loss, and threats. However, Lazarus himself admitted that in some circumstances the mobilized energy resulting from “constructive anger” can improve performance or social behavior. Self-confident athletes can perceive anger symptoms as helpful and channel the energy from anger into appropriate behavior. Therefore, functional anger is used to generate energy, sustain effort, allocate attention to task-relevant information, and direct physical and mental resources for skill execution (Robazza et al., 2006, Ruiz & Hanin, 2004a, 2011; Woodman et al., 2009; for a review, see Campo et al., 2012). According to this view, the functional assertiveness descriptors included in the PESD-Sport (i.e., fighting spirit, gritty, combative) can be viewed as related to functional feelings of anger and aggressiveness aimed at energizing behavior toward the achievement of performance goals. Interestingly, motivation and volition items were excluded from the final version of the PESD-Sport based on the findings in Study 1 indicating substantial overlapping with assertiveness items. Most likely, feelings such as demotivated−motivated and irresolute−resolute, pertaining to the motivation and volition modalities, were perceived equivalent to the assertiveness items due to their semantic similarity.

The inclusion of social support as a new modality of psychobiosocial experiences was motivated by the strong evidence that emotions are social phenomena that are experienced, manifested, and regulated in the interaction with important others, such as coaches and teammates (Tamminen & Gaudreau, 2014; Tamminen & Neely, 2021). Social support is an important variable to measure because of its beneficial influence on many areas including self-confidence (Freeman & Rees, 2010), psychological responses to sport injury (Mitchell et al., 2014), coping with competitive and organizational stressors (Arnold et al., 2018; Rees & Hardy, 2004), burnout and self-determined motivation (DeFreese & Smith, 2013), well-being (DeFreese & Smith, 2014), and performance (Freeman & Rees, 2009). There are various dimensions of social support deriving from interactions with others. These involve emotional (i.e., comfort and security), esteem (i.e., competence and self-esteem), informational (i.e., advice or guidance), and tangible (i.e., instrumental advice) support (Cutrona & Russell, 1990; Freeman & Rees, 2009). Athletes who feel supported can believe they have the social resources to deal with stress. They are less likely to experience events as stressful and may use seeking support as a strategy for coping with stress (Bianco & Eklund, 2001).

Mean scores of all the items (Table 2) were positive and most of them around moderate intensity on the functional side, except for the anxiety items and one item of the communicative modality with a lower intensity value. This result indicates that, at a group level, the athletes experienced their preperformance psychobiosocial states as functional for their usual competitive performance. This is not surprising given that the study sample consisted of experienced athletes who regularly underwent training and competitions and who took part in many competitive events.

Despite the large individual differences reported in the literature in the perception of the effects of anxiety symptoms, including personality traits (such as trait anxiety and self-confidence), skill level, competitive experience, and coping strategies (Mellalieu et al., 2006; Neil et al., 2012; Ruiz & Hanin, 2011), the positive mean scores of anxiety items suggest that for most of the athletes in this study a low level of anxiety was perceived as exerting functional effects on performance.

Regarding the communicative modality, in a previous study aimed to develop a global measure of psychobiosocial states (Robazza et al., 2016), "communicative, outgoing, sociable, connected" adjectives, proposed to represent functional communication, loaded poorly in the expected factor. On the other hand, "uncommunicative, withdrawn, alone, disconnected" adjectives, intended to represent dysfunctional communication, were perceived as functional at the group level. This result may reflect the very idiosyncratic characteristics of the communication process, as it was also found in a later study (Ruiz et al., 2019). Indeed, before competing some athletes tend to isolate themselves or withdraw from other people to better concentrate, avoid distractions, think about their upcoming tasks, and manage competitive stress. Conversely, other athletes prefer to keep communication open with other people, in particular with the coach and teammates, to review competition strategies, confirm individual tasks, and keep stress under control. This may explain the low mean score of an item of the communicative modality (i.e., Being expansive is harmful–Being expansive is useful) found in this study.

Measurement Invariance and Construct Validity

The same factor structure, full measurement invariance, and structural invariance of the PESD-Sport was observed in the two study samples. The inclusion of gender and sport as covariates did not change the factor structure nor did it lead to differences in item functioning, although mean scores of men in some modalities (i.e., emotion u/p, confidence, anxiety, assertiveness, and bodily-somatic) were higher than those of women suggesting that male athletes tend to perceive a higher level of functionality. This likely reflects gender differences in the experiences of success that shape emotions and the sense of competence, as well as differences in the socialization process due to gender-stereotyped beliefs and behaviors mediated by socialization agents, such as parents, siblings, and coaches (Gill, 2020; Morano et al., 2020; Fisher et al., 2017). Being less emotional and more confident, aggressive, and competitive are characteristics most often stereotypically associated with masculinity.

Findings relating to convergent, discriminant, and nomological validity provided evidence of construct validity of the PESD-Sport. In both studies, high standardized loading estimates and AVE values on all modalities supported convergent validity of the scale. In Study 2, convergent validity was also demonstrated in the latent factor correlations between the PESD-Sport and the criterion-related measures (i.e., SEQ and IPPS-48), showing a pattern of relationships in the expected direction. Specifically, most of the psychobiosocial modalities correlated positively with the pleasant/functional scales of the SEQ and IPPS-48, and negatively with the unpleasant/dysfunctional scales of the same instruments.

Discriminant validity of the different modalities was found in both studies with AVE estimates greater than the squared correlation between two modalities for most correlations, and cross-loadings on unintended factors smaller than the target factor loadings. The discriminant validity of the PESD-Sport in comparison with measures of related constructs was also supported by the low to moderate correlation coefficients between the psychobiosocial modalities and scales of the SEQ and IPPS-48. Similar results were found in a previous study using the PBS-ST scale in which correlations between scores on functional and dysfunctional subscales with the SEQ and IPPS-48 scales were low (Robazza et al., 2016).

Finally, nomological validity was found in the relationship between the PESD-Sport with mastery climate of the PMCSQ-2, and competence and relatedness scales of the BPNSS. Subscale scores of these measures predicted most of the psychobiosocial modalities. This is in line with previous research findings showing scores of mastery and performance climate to be associated with functional and dysfunctional psychobiosocial states in young athletes (Bortoli et al., 2012) and physical education students (Bortoli et al., 2014, 2015, 2018; Di Battista et al., 2019). Moreover, scores of basic psychological needs of competence, autonomy, and relatedness were related to psychobiosocial states in young athletes (Morano et al., 2020).

Limitations and Future Research Directions

A study limitation is the number of constructs used to assess convergent, discriminant, and nomological validity to establish the construct validity of the PESD-Sport. In addition to the constructs examined in the present study, the validity of the scale should be further examined in relation to measures of other relevant constructs, such as emotional intelligence (Laborde et al., 2016; Nateri et al., 2020), passion (Schellenberg et al., 2021), mental energy (Lu et al., 2018), psychophysical recovery (Loch et al., 2021), and mood states as assessed by the Profile of Mood States (POMS; McNair et al., 1992) which has been widely used in sport (see Beedie et al., 2000) also in an abbreviated form (i.e., the 24-item Brunel Mood Scale; Terry et al., 1999, 2003). The scale can also be used to test predictions deriving from the IZOF model (Hanin, 2000, 2007), which is the theoretical view at the basis of its development, as well as the multi-states (MuSt) theory (Ruiz et al., 2021). The MuSt theory has been proposed as a holistic perspective that draws upon and develops ideas from the IZOF model to account for the variety of athletes' performance experiences in training and competition and have an impact on performance. For both theoretical and applied aims, it would be worth examining the predictive validity of the single and interactive effects of the psychobiosocial modalities on performance process and outcome. To this purpose, rather than using retrospective recalls, the scale directions could be modified to attain a situational, state-like version of the scale (i.e., "how you feel right now").

Another limitation is that the scale was developed in Italian and administered to a sample of experienced athletes. The validity of the scale should be examined across athletes of different cultures, ages, competitive levels, and sporting experience to determine the extent to which its validity can be generalized across samples.

Finally, we examined the validity of the PESD-Sport using self-report measures only. An objective evaluation of behavioral, biological, neural (Bertollo et al., 2020; Robazza et al., 2012), and performance (Di Corrado et al., 2015) markers is a necessary further step to assess in more detail the validity of the new measure and advance our knowledge of the relationship between psychobiosocial experiences, underlying psychophysiological reactions, and athletic performance process and outcomes.

Another area of future research is the study of the relationship between global measures of psychobiosocial experiences, previously conceptualized in a dimensional perspective (Bortoli et al., 2018; Robazza et al., 2016; Ruiz et al., 2019b), and the PESD-Sport as a measure of discrete experiences. While dimensional scales allow for a clear distinction of states along the functionality dimensions and the study of their global interaction, a discrete measure provides more precise information on the single and interactive modalities that form a psychobiosocial experience.

Conclusion

The study of emotions in sport is an area of growing research interest. Idiographic and nomothetic methods of assessment and their combination can provide an important contribution toward a better understanding of emotions and performance-related experiences in the athletic domain. The scale developed in this study is the first nomothetic measure specifically aimed to assess discrete psychobiosocial experiences. Study findings provided support to the factor structure and reliability of the PESD-Sport. Construct validity of the instrument was also demonstrated in terms of convergent, discriminant, and nomological validity in comparison with related measures used in the sporting context. Based on a substantive theoretical framework (i.e., the IZOF model), the scale can complement existing dimensional scales and advance the knowledge on the relationship between psychobiosocial experiences and performance. Future research should ascertain the extent to which the PESD-Sport can inform emotion self-regulation interventions targeting a range of emotion-related states of athletes to help them achieve and maintain optimal states for performance.

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Table 1

Fit Indices for the Factor Models of the PESD-Sport from Study 1 (N = 280) and Study 2 (N = 302)

Model	χ^2 (*df*)	χ^2/*df*	CFI	TLI	RMSEA (90% CI)	SRMR	AIC	PCFI
Study 1								
12 mod, 53 items, ESEM	1632.665 (808)	2.021	.877	.791	.060 (.056–.065)	.023	48606.423	.734
12 mod, 53 items, CFA – first-order	2556.081 (1259)	2.030	.806	.787	.061 (.057–.064)	.083	49541.602	.144
10 mod, 30 items, ESEM	307.413 (180)	1.708	.957	.896	.050 (.041–.060)	.018	27373.452	1.675
10 mod, 30 items, CFA – first-order	509.302 (360)	1.415	.949	.939	.038 (.030–.046)	.046	27460.676	.356
10 mod, 30 items, CFA – higher-order	687.711 (395)	1.741	.901	.890	.051 (.045–.058)	.068	27651.963	.228
10 mod, 30 items, CFA – 3 higher-order	730.523 (395)	1.849	.887	.875	.055 (.049–.061)	.095	27666.298	.225
10 mod, 30 items, CFA – 3 higher-order[1]	664.307 (395)	1.682	.909	.900	.049 (.043–.056)	.070	27572.008	.230
10 mod, 30 items, CFA – nested-factor	669.377 (375)	1.785	.901	.885	.053 (.046–.059)	.063	27612.727	.288
10 mod, 30 items, CFA – 3 nested-factor	672.785 (382)	1.761	.902	.888	.052 (.046–.059)	.072	27604.126	.267
10 mod, 30 items, CFA – 3 nested-factor[1]	644.661 (382)	1.688	.911	.899	.050 (.043–.056)	.063	27557.076	.269
Study 2								
10 mod, 30 items, ESEM	340.924 (180)	1.894	.963	.910	.054 (.056–.063)	.016	28247.895	1.685
10 mod, 30 items, CFA – first-order	622.101 (360)	1.741	.939	.926	.049 (.043–.056)	.038	28434.849	.352
10 mod, 30 items, CFA – higher-order	827.934 (395)	2.096	.899	.889	.060 (.054–.066)	.059	28671.404	.228
10 mod, 30 items, CFA – 3 higher-order	925.080 (395)	2.342	.877	.865	.067 (.061–.072)	.149	28753.309	.222
10 mod, 30 items, CFA – 3 higher-order[1]	857.201 (395)	2.170	.893	.882	.062 (.057–.068)	.117	28656.329	.226
10 mod, 30 items, CFA – nested-factor	822.866 (375)	2.194	.896	.880	.063 (.057–.069)	.056	28642.610	.287
10 mod, 30 items, CFA – 3 nested-factor	861.820 (382)	2.256	.889	.873	.064 (.059–.070)	.063	28667.732	.263
10 mod, 30 items, CFA – 3 nested-factor[1]	829.546 (382)	2.172	.896	.882	.062 (.056–.068)	.059	28627.330	.265

Note. Mod = modalities, ESEM = Exploratory Structural Equation Modeling, CFA = Confirmatory Factor Analysis, χ^2(df) = chi-square (degrees of freedom), CFI = comparative fit index, TLI = Tucker Lewis fit index, RMSEA = root mean square error of approximation, SRMR = standardized root mean square residual, AIC = Akaike's Information Criterion, PCFI = Parsimony comparative fit index. [1]The operational modality of the social component is included in the biological component.

Table 2

Descriptive Statistics and Factor Loadings of PESD-Sport for the Sample of Study 1 and the Sample of Study 2

Modality Item	Sample 1 ($N = 280$)						Sample 2 ($N = 302$)					
	M	*SD*	SK	K	*λ*	*δ*	*M*	*SD*	SK	K	*λ*	*δ*
Emotion u/p												
1	2.880	1.410	-1.886	4.109	.665	.558	2.860	1.469	-1.593	2.572	.809	.346
11	2.520	1.330	-0.966	0.420	.779	.393	2.450	1.552	-1.375	2.000	.818	.331
21	2.530	1.505	-1.266	1.473	.802	.357	2.490	1.574	-1.265	1.682	.841	.293
Confidence												
2	2.110	1.541	-1.176	1.214	.634	.598	2.150	1.665	-1.217	0.851	.668	.553
12	2.010	1.810	-1.399	1.618	.808	.346	1.980	1.852	-1.140	0.690	.761	.420
22	1.900	1.774	-1.105	0.822	.782	.388	2.100	1.765	-1.040	0.397	.851	.275
Anxiety												
3	1.210	1.815	-0.703	-0.115	.743	.448	1.350	1.766	-0.783	0.185	.771	.406
13	1.480	1.944	-0.740	-0.250	.821	.326	1.390	1.819	-0.615	-0.359	.833	.306
23	0.870	1.961	-0.436	-0.453	.805	.351	1.190	1.833	-0.674	0.053	.754	.431
Assertiveness												
4	2.630	1.396	-1.506	2.681	.716	.488	2.700	1.498	-1.367	1.916	.721	.480
14	2.520	1.461	-1.462	2.439	.711	.495	2.510	1.648	-1.597	2.764	.787	.380
24	2.510	1.407	-1.194	1.706	.757	.427	2.520	1.524	-1.182	1.311	.752	.434
Cognitive												
5	2.280	1.674	-1.411	1.653	.725	.474	2.330	1.598	-1.339	2.127	.658	.567
15	2.620	1.476	-1.905	4.561	.826	.318	2.850	1.362	-2.047	5.790	.829	.313
25	2.340	1.521	-1.617	3.233	.832	.308	2.640	1.369	-1.660	3.585	.871	.242
Bodily-somatic												
6	2.130	1.655	-1.495	2.323	.719	.484	2.130	1.559	-1.297	1.933	.803	.355
16	2.410	1.519	-1.269	1.757	.735	.460	2.440	1.710	-1.504	2.195	.833	.306
26	2.420	1.503	-1.452	2.051	.854	.271	2.450	1.596	-1.474	2.228	.877	.230

Table 2 Continues

Table 2 Continued

Motor-behavioral												
7	2.210	1.641	-1.564	2.600	.749	.440	2.360	1.547	-1.319	1.920	.787	.380
17	2.340	1.321	-1.487	4.148	.688	.527	2.450	1.357	-1.211	1.579	.860	.261
27	2.120	1.581	-1.380	2.098	.838	.298	2.310	1.487	-1.523	2.989	.741	.450
Operational												
8	2.090	1.449	-1.431	2.213	.753	.433	2.240	1.455	-1.202	1.942	.833	.307
18	2.100	1.552	-1.702	3.851	.846	.284	2.350	1.422	-1.363	2.707	.866	.251
28	1.960	1.516	-1.337	2.250	.675	.544	2.000	1.660	-1.191	1.124	.792	.372
Communicative												
9	2.08	1.740	-0.891	0.183	.717	.485	2.25	1.776	-1.209	0.999	.719	.483
19	1.42	1.794	-0.696	0.025	.741	.451	1.63	1.671	-0.590	-0.128	.682	.534
29	2.24	1.763	-1.306	1.689	.664	.559	2.38	1.742	-1.365	1.887	.780	.392
Social support												
10	2.270	1.455	-1.205	1.351	.860	.260	2.200	1.650	-1.240	1.299	.870	.242
20	2.330	1.573	-1.447	2.407	.822	.325	2.340	1.630	-1.326	1.756	.909	.173
30	2.520	1.427	-1.196	1.049	.738	.456	2.610	1.514	-1.642	3.181	.821	.326

Note. *M* = mean, *SD* = standard deviation, SK = skewness, K = kurtosis, λ = standardized factor loading, δ = standardized residual variance.

Table 3

Pearson Product Moment Correlations Between Latent Factors and Reliability Indices

Modality											Sample 1 (N = 280)				Sample 2 (N = 302)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	α	ω	CR	AVE	α	ω	CR	AVE
(1) Emotion u/p	—	.847††	.636†	.762†	.644†	.704†	.642†	.733†	.787†	.826††	.789	.774	.794	.564	.863	.836	.863	.677
(2) Confidence	.792†	—	.768†	.801††	.652†	.730†	.694†	.831††	.684†	.680†	.777	.770	.788	.555	.790	.785	.806	.583
(3) Anxiety	.402§	.695†	—	.653†	.528§	.582§	.593§	.728†	.514§	.478§	.833	.808	.833	.625	.829	.805	.829	.619
(4) Assertiveness	.710†	.789†	.620†	—	.715†	.811††	.642†	.700†	.574§	.515§	.773	.756	.772	.530	.798	.777	.798	.568
(5) Cognitive	.502§	.594§	.500§	.658†	—	.714†	.815††	.763†	.524§	.607†	.834	.812	.838	.633	.822	.808	.832	.626
(6) Bodily-somatic	.606†	.602†	.379*	.644†	.513§	—	.840††	.825††	.505§	.574§	.807	.792	.814	.596	.875	.849	.876	.703
(7) Motor-behavioral	.560§	.689†	.414§	.646†	.589§	.697†	—	.912††	.535§	.605†	.790	.782	.804	.579	.840	.814	.839	.636
(8) Operational	.624†	.753†	.524§	.745†	.615†	.633†	.895††	—	.606†	.639†	.802	.783	.804	.579	.864	.843	.870	.690
(9) Communicative	.543§	.477§	.416§	.428§	.352*	.201*	.394*	.394*	—	.695†	.750	.740	.751	.501	.771	.756	.771	.530
(10) Social support	.822††	.656†	.280*	.540§	.528§	.368*	.460§	.614†	.662†	—	.843	.823	.849	.653	.898	.875	.901	.752

Note. Sample 1 correlations are below the diagonal and Sample 2 correlations are above; α = Cronbach's alpha values, ω = omega values, CR = composite reliability, AVE = average variance extracted. Correlation *low, §moderate, †moderately high, ††high.

Table 4

Fit Indices for Multi-group Confirmatory Factor Analyses of the PESD-Sport

Independent variable	Model	$\chi^2(df)$	χ^2/df	CFI	ΔCFI	TLI	RMSEA (90% CI)	ΔRMSEA	SRMR	ΔSMR	ΔS-B χ^2 (Δ*df*)	*p* value
Study group	Configural	1129.565 (720)	1.569	.943		.931	.044 (.039–.049)		.042			
	Weak measurement	1156.898 (740)	1.563	.942	.001	.932	.044 (.039–.049)	.000	.049	.007	27.602 (20)	.119
	Strong measurement	1183.778 (760)	1.558	.941	.002	.933	.044 (.039–.049)	.000	.050	.008	53.075 (40)	.081
	Strict measurement	1237.821 (790)	1.567	.938	.005	.932	.044 (.039–.049)	.000	.050	.008	108.281 (70)	.002
	Factor variance	1193.774 (770)	1.550	.941	.002	.934	.043 (.039–.048)	.001	.067	.025	63.069 (50)	.102
	Factor covariance	1242.331 (805)	1.543	.939	.004	.935	.043 (.038–.048)	.001	.080	.038	111.840 (85)	.027
Gender × Sport	MIMIC	745.912 (420)	1.776	.930		.913	.051 (.045–.057)		.038			

Note. $\chi^2(df)$ = chi-square (degree of freedom), χ^2/df = chi-square/degree of freedom, CFI = comparative fit index, ΔCFI = CFI difference, TLI = Tucker Lewis fit index, RMSEA = root mean square error of approximation, ΔRMSEA = RMSEA difference, SRMR = standardized root mean square residual, ΔSMR = SRMR difference, ΔS-B χ^2 (Δ*df*) = Satorra-Bentler scaled chi-square difference test (degree of freedom difference). MIMIC analysis was conducted on Study 2 sample.

Table 5
Confirmatory Factor Analysis Fit Indices and Reliability Values from Study 2

Instrument	Factor	$\chi^2(df)$	χ^2/df	CFI	TLI	RMSEA (90% CI)	SRMR	α	ω	CR	AVE
SEQ		112.261 (74)	1.517	.967	.960	.041 (.025–.056)	.057				
	Excitement & Happiness (5 items)							.897	.815	.898	.637
	Anger & Dejection (5 items)							.789	.708	.802	.449
	Anxiety (4 items)							.850	.790	.852	.591
IPPS-48[1]		398.364 (243)	1.639	.941	.932	.046 (.038–.054)	.069				
	Self-confidence (6 items)							.877	.758	.885	.535
	Emotional arousal control (6 items)							.808	.692	.873	.424
	Worry (6 items)							.890	.775	.773	.565
	Concentration disruption (6 items)							.763	.655	.813	.371
PMCSQ-2[2]		102.700 (50)	2.054	.954	.939	.059 (.043–.075)	.047				
	Mastery climate (6 items)							.830	.707	.828	.450
	Performance climate (6 items)							.784	.671	.789	.401
BPNSS		64.357 (32)	2.011	.962	.947	.058 (.037–.078)	.056				
	Competence (3 items)							.655	.691	.680	.431
	Autonomy (3 items)							.707	.730	.735	.497
	Relatedness (4 items)							.850	.789	.852	.590

Note. SEQ = Sport Emotion Questionnaire, IPPS-48 = Sport Performance Psychological Inventory, PMCSQ-2 = Perceived Motivational Climate in Sport Questionnaire-2, BPNSS = Basic Psychological Needs in Sport Scale, $\chi^2(df)$ = chi-square (degrees of freedom), CFI = comparative fit index, TLI = Tucker Lewis fit index, RMSEA = root mean square error of approximation, SRMR = standardized root mean square residual, α = Cronbach's alpha values, ω = omega values, CR = composite reliability, AVE = average variance extracted. [1]Two correlated errors on the Self-confidence scale and four correlated errors on the Worry scale. [2]Four correlated errors on the Mastery climate scale and two correlated errors on the Performance climate scale.

Table 6

Latent Variable Correlations Between the PESD-Sport Modalities and Measures from Study 2

Modality	SEQ			IPPS-48				PMCSQ-22		Basic needs		
	Exc-Hap	Ang-Dej	Anx	Self-conf	Em ar	Wor	Conc disr	Mast	Perf	Comp	Aut	Rel
Emotion u/p	.618†	-.424§	-.197	.557§	.358*	-.210*	-.254*	.409§	-.383*	.363*	.115	.451§
Confidence	.526§	-.289*	-.434§	.782†	.594§	-.515§	-.236*	.326*	-.199	.436§	.107	.317*
Anxiety	.402§	-.153	-.246*	.473§	.400§	-.401§	-.163	.228*	-.176	.273*	.132	.135
Assertiveness	.515§	-.206*	-.158	.680†	.477§	-.269*	-.289*	.294*	-.160	.344*	.020	.270*
Cognitive	.366*	-.250*	-.165	.530§	.365*	-.145	-.426§	.336*	-.167	.323*	.123	.193
Bodily-somatic	.421§	-.133	-.150	.584§	.389*	-.197	-.244*	.304*	-.227*	.279*	.012	.200*
Motor-behavioral	.354*	-.215*	-.122	.582§	.381*	-.208*	-.376*	.310*	-.234*	.305*	.075	.218*
Operational	.470§	-.221*	-.223*	.640†	.426§	-.328*	-.269*	.360*	-.240*	.375*	.083	.219*
Communicative	.410§	-.236*	-.197*	.413§	.318*	-.135	-.121	.349*	.236*	.152	-.018	.255*
Social support	.411§	-.317*	-.144	.429§	.243*	-.155	-.181	.432§	-.389*	.306*	.173	.467§

Note. Exc-Hap = Happiness & Excitement, Ang-Dej = Anger & Dejection, Anx = Anxiety, Self-conf = Self-confidence, Em ar = Emotional arousal control, Wor = Worry, Conc disr = Concentration disruption, Mast = Mastery climate, Perf = Performance climate, Comp = Competence, Aut = Autonomy, Rel = Relatedness. Correlation *low, §moderate, †moderately high.

Supplementary material

Performance-related Psychobiosocial Experiences (PESD-Sport)

Below you can find adjectives (descriptors) or sentences that athletes usually use to describe how they feel about their performance. For each row there are two opposing descriptors that can be dysfunctional for performance or functional for performance. Read them carefully and for each row choose one descriptor, ***one only*** (e.g., the descriptor on the left or the one on the right), which best reflects how you usually feel before an important competition. Then mark the intensity of the descriptor on the scale ranging from 1 (***a little***) to 4 (***very much***). If none of the descriptors in a row reflect how you feel in competition, check the middle box 0 (***neither… nor***). There are no right or wrong answers. Please, make sure to complete all rows.

Example:
"I feel quite satisfied with myself". In this case you check box 2 on the right side.

Unsatisfied	4	3	2	1	0	1	~~2~~ (X)	3	4	Satisfied

On the other hand, if for you it is true: "I feel much dissatisfied with myself", then you have to check box 3 on the left side.

Unsatisfied	4	~~3~~ (X)	2	1	0	1	2	3	4	Satisfied

		Very much	Much	Moderate	A little	neither… nor	A little	Moderate	Much	Very much	
1	Unhappy	4	3	2	1	0	1	2	3	4	Happy
2	Unconfident	4	3	2	1	0	1	2	3	4	Confident
3	Worried in a harmful way	4	3	2	1	0	1	2	3	4	Worried in a helpful way
4	Submissive	4	3	2	1	0	1	2	3	4	Fighting spirit
5	Distracted	4	3	2	1	0	1	2	3	4	Alert
6	Physically weak	4	3	2	1	0	1	2	3	4	Physically vigorous
7	Uncoordinated in my movements	4	3	2	1	0	1	2	3	4	Coordinated in my movements
8	Ineffective in my performance	4	3	2	1	0	1	2	3	4	Effective in my performance
9	Being communicative is harmful	4	3	2	1	0	1	2	3	4	Being communicative is useful
10	I feel ignored	4	3	2	1	0	1	2	3	4	I feel considered
11	Sad	4	3	2	1	0	1	2	3	4	Joyful
12	Insecure	4	3	2	1	0	1	2	3	4	Secure
13	Mentally tense in a harmful way	4	3	2	1	0	1	2	3	4	Mentally tense in a helpful way
14	Fragile	4	3	2	1	0	1	2	3	4	Gritty
15	Unfocused	4	3	2	1	0	1	2	3	4	Focused
16	Physically fatigued	4	3	2	1	0	1	2	3	4	Full of energy
17	Lethargic in my movements	4	3	2	1	0	1	2	3	4	Dynamic in my movements
18	Unskillful in my performance	4	3	2	1	0	1	2	3	4	Skillful in my performance
19	Being expansive is harmful	4	3	2	1	0	1	2	3	4	Being expansive is useful
20	I feel neglected	4	3	2	1	0	1	2	3	4	I feel supported
21	Dejected	4	3	2	1	0	1	2	3	4	Cheerful
22	Uncertain	4	3	2	1	0	1	2	3	4	Certain
23	Nervous in a harmful way	4	3	2	1	0	1	2	3	4	Nervous in a helpful way
24	Surrendered	4	3	2	1	0	1	2	3	4	Combative
25	Inattentive	4	3	2	1	0	1	2	3	4	Attentive
26	Physically drowsy	4	3	2	1	0	1	2	3	4	Physically charged
27	Clumsy in my movements	4	3	2	1	0	1	2	3	4	Smooth in my movements
28	Inconsistent in my performance	4	3	2	1	0	1	2	3	4	Consistent in my performance
29	Being sociable is harmful	4	3	2	1	0	1	2	3	4	Being sociable is useful
30	I feel rejected	4	3	2	1	0	1	2	3	4	I feel accepted

Scoring

Emotion u/p = (1 + 11 + 21)/3
Confidence = (2 + 12 + 22)/3
Anxiety = (3 + 13 + 23)/3
Assertiveness = (4 + 14 + 24)/3
Cognitive = (5 + 15 + 25)/3
Bodily-somatic = (6 + 16 + 26)/3
Motor-behavioral = (7 + 17 + 27)/3
Operational = (8 + 18 + 28)/3
Communicative = (9 + 19 + 29)/3
Social support = (10 + 20 + 30)/3

Note: The English version derives from the Italian version (see last page) and has not been validated

Supplementary material

Figure 1

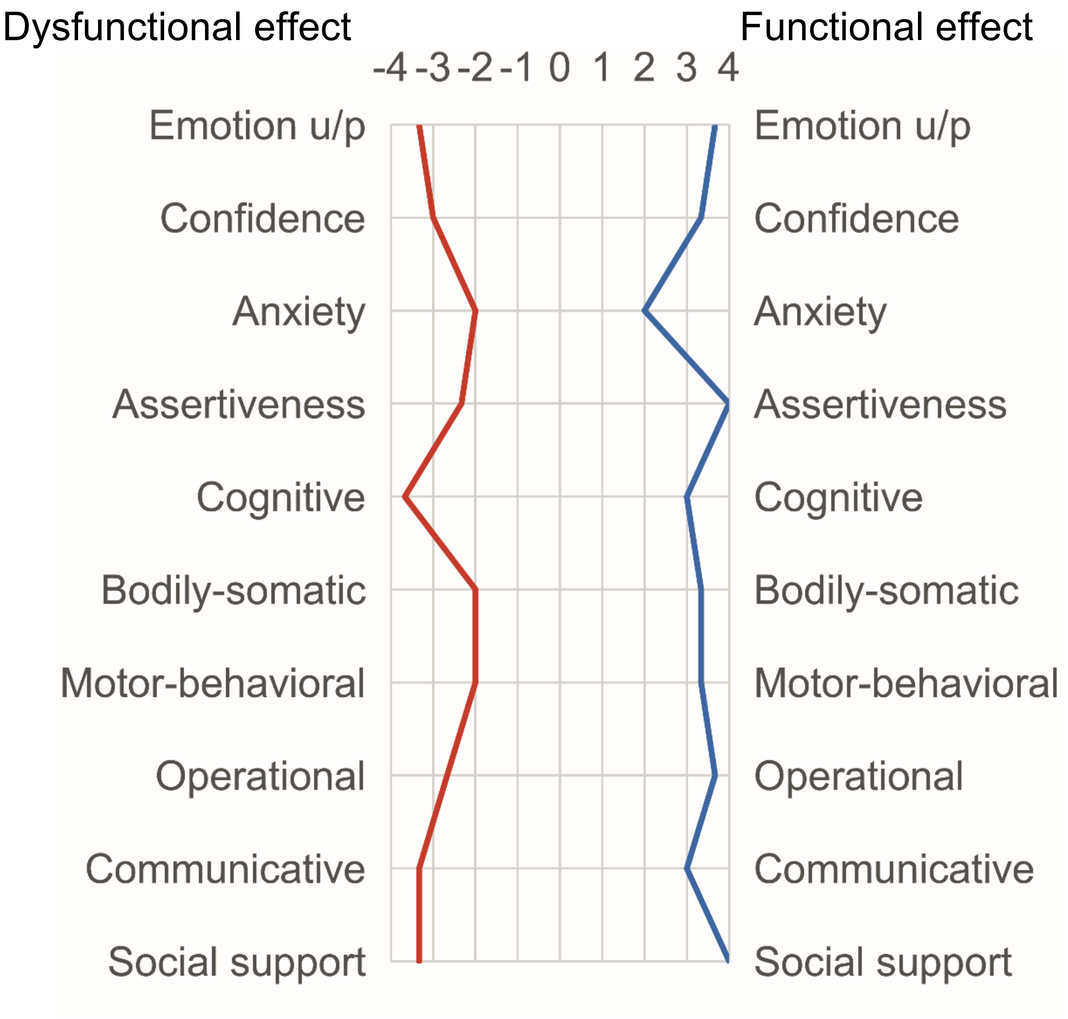
Complete Psychobiosocial States Profile of two Athletes drawn from Study 2

	Dysfunctional effect	Very much	Much	Moderate	A little	neither… nor	A little	Moderate	Much	Very much	Functional effect
1	Unhappy		X							X	Happy
11	Sad		X						X		Joyful
21	Dejected	X								X	Cheerful
2	Unconfident		X						X		Confident
12	Insecure		X							X	Secure
22	Uncertain		X						X		Certain
3	Worried in a harmful way		X					X			Worried in a helpful way
13	Mentally tense in a harmful way				X			X			Mentally tense in a helpful way
23	Nervous in a harmful way			X				X			Nervous in a helpful way
4	Submissive				X				X		Fighting spirit
14	Fragile		X						X		Gritty
24	Surrendered		X						X		Combative
5	Distracted		X						X		Alert
15	Unfocused	X							X		Focused
25	Inattentive	X							X		Attentive
6	Physically weak			X				X			Physically vigorous
16	Physically fatigued			X						X	Full of energy
26	Physically drowsy			X						X	Physically charged
7	Uncoordinated in my movements				X					X	Coordinated in my movements
17	Lethargic in my movements		X						X		Dynamic in my movements
27	Clumsy in my movements			X					X		Smooth in my movements
8	Ineffective in my performance		X						X		Effective in my performance
18	Unskillful in my performance				X					X	Skillful in my performance
28	Inconsistent in my performance	X								X	Consistent in my performance
9	Being communicative is harmful		X						X		Being communicative is useful
19	Being expansive is harmful		X					X			Being expansive is useful
29	Being sociable is harmful	X								X	Being sociable is useful
10	I feel ignored			X						X	I feel considered
20	I feel neglected	X								X	I feel supported
30	I feel rejected	X								X	I feel accepted

Note. A Dysfunctional Profile of an Athlete is Displayed on the Left Side (in red) and a Functional Profile of Another Athlete is Displayed on the Right Side (in blue).

Figure 2

Aggregated Psychobiosocial States Profile of the two Athletes from Study 2 (Figure 1)



Supplementary material

Esperienze Psicobiosociali Associati alla Prestazione (PESD-Sport)

Di seguito sono riportati aggettivi o frasi che gli atleti di solito usano per descrivere come si sentono in relazione alla loro prestazione. Per ogni riga vi sono due descrittori opposti che possono essere dannosi per la prestazione oppure facilitanti la prestazione. Leggili attentamente e per ciascuna riga scegli uno dei due, ***uno solo*** (quello nella parte sinistra oppure quello nella parte destra), che riflette ***come ti senti di solito prima di una gara importante***; indicane poi l'***intensità*** con una X sulla scala che va da 1 (***poco***) a 4 (***moltissimo***). Se in una riga nessuno dei due descrittori è presente nella tua esperienza di gara, segna la casella centrale 0 (***né…né***). Non ci sono risposte giuste o sbagliate. Per favore, accertati di rispondere a tutte le descrizioni.

Esempio:
"Mi sento abbastanza soddisfatto di me stesso". In tal caso devi contrassegnare la casella 2 nella parte destra.

Insoddisfatto	4	3	2	1	0	1	X (2)	3	4	Soddisfatto

Se invece per te è vero: "Mi sento molto insoddisfatto di me stesso", in tal caso devi contrassegnare la casella 3 nella parte sinistra.

Insoddisfatto	4	X (3)	2	1	0	1	2	3	4	Soddisfatto

		Moltissimo	Molto	Abbastanza	Poco	Né…né	Poco	Abbastanza	Molto	Moltissimo	
1	Infelice	4	3	2	1	0	1	2	3	4	Felice
2	Sfiduciato	4	3	2	1	0	1	2	3	4	Fiducioso
3	Preoccupato in modo dannoso	4	3	2	1	0	1	2	3	4	Preoccupato in modo utile
4	Remissivo	4	3	2	1	0	1	2	3	4	Combattivo
5	Distratto	4	3	2	1	0	1	2	3	4	Vigile
6	Fisicamente debole	4	3	2	1	0	1	2	3	4	Fisicamente vigoroso
7	Scoordinato nei movimenti	4	3	2	1	0	1	2	3	4	Coordinato nei movimenti
8	Inefficace nella mia prestazione	4	3	2	1	0	1	2	3	4	Efficace nella mia prestazione
9	Essere comunicativo mi danneggia	4	3	2	1	0	1	2	3	4	Essere comunicativo mi è utile
10	Mi sento ignorato	4	3	2	1	0	1	2	3	4	Mi sento considerato
11	Triste	4	3	2	1	0	1	2	3	4	Gioioso
12	Insicuro	4	3	2	1	0	1	2	3	4	Sicuro
13	Mentalmente teso in modo dannoso	4	3	2	1	0	1	2	3	4	Mentalmente teso in modo utile
14	Fragile	4	3	2	1	0	1	2	3	4	Grintoso
15	Deconcentrato	4	3	2	1	0	1	2	3	4	Concentrato
16	Fisicamente affaticato	4	3	2	1	0	1	2	3	4	Pieno di energia
17	Inerte nei movimenti	4	3	2	1	0	1	2	3	4	Dinamico nei movimenti
18	Scadente nella mia prestazione	4	3	2	1	0	1	2	3	4	Abile nella mia prestazione
19	Essere espansivo mi danneggia	4	3	2	1	0	1	2	3	4	Essere espansivo mi è utile
20	Mi sento trascurato	4	3	2	1	0	1	2	3	4	Mi sento supportato
21	Avvilito	4	3	2	1	0	1	2	3	4	Allegro
22	Incerto	4	3	2	1	0	1	2	3	4	Certo
23	Nervoso in modo dannoso	4	3	2	1	0	1	2	3	4	Nervoso in modo utile
24	Arrendevole	4	3	2	1	0	1	2	3	4	Agguerrito
25	Disattento	4	3	2	1	0	1	2	3	4	Attento
26	Fisicamente scarico	4	3	2	1	0	1	2	3	4	Fisicamente carico
27	Goffo nei movimenti	4	3	2	1	0	1	2	3	4	Fluido nei movimenti
28	Instabile nella mia prestazione	4	3	2	1	0	1	2	3	4	Stabile nella mia prestazione
29	Essere socievole mi danneggia	4	3	2	1	0	1	2	3	4	Essere socievole mi è utile
30	Mi sento rifiutato	4	3	2	1	0	1	2	3	4	Mi sento accettato