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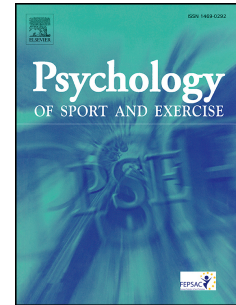
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Measuring Psychological Need States in Sport: Theoretical Considerations and a New  
Measure

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**Measuring Psychological Need States in Sport: Theoretical Considerations and a**

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**New Measure**

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12 Abstract

13 **Objectives**

14 Research guided by Self-determination Theory (Deci & Ryan, 1985; Ryan & Deci, 2017) has  
15 repeatedly demonstrated the importance of focusing on both the bright (satisfaction) and dark  
16 (frustration) sides of the three basic psychological needs. Recently, researchers have also  
17 argued for the utility of assessing a third need state, that of “unfulfillment”. In this paper, we  
18 outline an effort to develop and provide initial validity evidence for scores of a new  
19 multidimensional and sport-specific measure, the Psychological Need States in Sport-Scale  
20 (PNSS-S), to assess the satisfaction, frustration, and unfulfillment of all three needs.

21 **Method**

22 In Study 1, we developed 46 candidate items, and tested evidence for the factorial structure of  
23 the responses to the newly developed items, internal consistency and discriminant validity of  
24 the subscale scores. Following refinement, the replication of the favored model was tested  
25 using an independent sample of athletes in Study 2. Evidence for the nomological network of  
26 the subscales of the new measure was also demonstrated in Study 2.

27 **Results**

28 Factor models incorporating all three need states showed poor fit with the data. However,  
29 following post-hoc modifications, a six-factor model assessing the need states of satisfaction  
30 and frustration, separately for autonomy, competence, and relatedness, was found to have  
31 good fit to the data. After refinement, the 29-item six-factor model was found to demonstrate  
32 good fit, good standardized factor loadings, factor correlations in the expected directions, and  
33 acceptable estimates of internal consistency in Study 2. Tests of nomological networks  
34 showed that the six need states were significantly predicted by contextual autonomy,  
35 competence, and relatedness support/thwarts as expected. Autonomy and competence need  
36 satisfaction were significantly associated with engagement; and competence and relatedness

37 need satisfaction were significantly associated with positive affect. In addition, autonomy and  
38 competence need frustration were significantly associated with exhaustion and all three need  
39 frustration states significantly predicted negative affect.

#### 40 **Conclusions**

41 A tripartite conceptualization of the need states was not empirically supported. Nevertheless,  
42 the PNSS-S makes a unique contribution to the sport literature, as it represents the first sport-  
43 specific measure of six distinct, yet, correlated states of the satisfaction and frustration of  
44 autonomy, competence, and relatedness needs.

45 *Key words:* self-determination theory, need satisfaction, need frustration, need unfulfillment,  
46 scale development, exploratory structural equation modeling

47 Research grounded in Self-determination Theory (SDT; Deci & Ryan, 1985; Ryan &  
48 Deci, 2017) has repeatedly focused on both the bright and dark side experiences of the three  
49 basic psychological needs, and explored their differential associations with motivation and  
50 psychological functioning (Bartholomew, Ntoumanis, & Thøgersen-Ntoumani, 2011;  
51 Vansteenkiste & Ryan, 2013). Recently, researchers have also argued for the utility of  
52 assessing the unfulfillment of psychological needs as a third need state (e.g., Cheon et al.,  
53 2019; Costa, Ntoumanis, & Bartholomew, 2015), which, alongside need satisfaction and  
54 frustration, could aid a more comprehensive understanding of athlete motivation and well-  
55 being/ill-being. Existing investigations in sport, however, are either limited to the use of  
56 separate measures of perceived need satisfaction and need frustration (e.g., Bartholomew,  
57 Ntoumanis, Ryan, & Thøgersen-Ntoumani, 2011; Ng, Lonsdale, & Hodge, 2011), or involve  
58 adaptations of non-sport-specific measures (e.g., Chen et al., 2015) to assess both these two  
59 need states simultaneously. Items of these measures also reflect references to interpersonal  
60 behaviors of significant others, as well as one's personal experiences that occur as a result of  
61 behaviors of significant others. In this two-study paper, we aimed to address the gap in the  
62 literature pertaining to the absence of a single sport-specific measure of the three need states  
63 by developing and providing initial validity evidence for a new multidimensional measure of  
64 athletes' psychological need states of satisfaction, frustration, and unfulfillment.

### 65 **Basic Psychological Need Satisfaction, Frustration, and Unfulfillment**

66 Assessments of basic psychological need relevant constructs in the SDT literature  
67 have undergone significant advancements in recent times. Traditionally, the state of need  
68 satisfaction was the focus of the theory. Researchers considered it to be a unipolar construct,  
69 with scores ranging from low to high. High scores on measures of need satisfaction were  
70 associated with adaptive outcomes. For example, in the sport context, high need satisfaction  
71 was shown to be associated with outcomes such as autonomous motivation (e.g., Ntoumanis

72 & Standage, 2009), subjective vitality (e.g., Adie, Duda, & Ntoumanis, 2008), positive affect  
73 (e.g., Mack et al., 2011), enjoyment (e.g., Quested et al., 2013), and positive developmental  
74 experiences (e.g., Taylor & Bruner, 2012). Contrastingly, low scores on measures of need  
75 satisfaction were associated with maladaptive outcomes. For example, in the context of sport,  
76 need satisfaction scores were found to be negatively associated with burnout (Hodge,  
77 Lonsdale, & Ng, 2008), and physical symptoms (Reinboth, Duda, & Ntoumanis, 2004).  
78 However, this pattern of results did not always hold, and some researchers found low need  
79 satisfaction scores to be unrelated to ill-being (e.g., Sheldon & Bettencourt, 2002; Reinboth  
80 & Duda, 2006; Quested & Duda, 2010).

81         The inconsistent results linking low need satisfaction to maladaptive outcomes were  
82 explicated by Bartholomew, Ntoumanis, Ryan, & Thøgersen-Ntoumani (2011), who asserted  
83 that experiencing low levels of need satisfaction was qualitatively different to experiencing  
84 need frustration<sup>1</sup>. The researchers illustrated their point with the example of a male athlete  
85 experiencing loneliness in his sport. Such an experience might be the result of the athlete's  
86 inability to meaningfully connect with his teammates, or because he had been subjected to  
87 purposeful exclusion by his teammates. According to Bartholomew and colleagues (2011),  
88 the former would be a case of low need satisfaction (or what the researchers referred to as  
89 "need dissatisfaction"), and the latter would be a case of need frustration. Psychological need  
90 frustration was thus conceptualized as the negative personal experiential state of feeling that  
91 one's needs are actively undermined by others in a given context (Bartholomew, Ntoumanis,  
92 Ryan, & Thøgersen-Ntoumani, 2011). Through this dual-process model, the researchers  
93 demonstrated need frustration to be a stronger (in an absolute sense) predictor of maladaptive  
94 outcomes relative to need satisfaction (e.g., burnout, disordered eating, depression, negative  
95 affect, and perturbed physical arousal; Bartholomew, Ntoumanis, Ryan, Bosch, & Thøgersen-  
96 Ntoumani, 2011).

97           Although Bartholomew and colleagues (2011) presented a conceptually-based  
98 argument for the distinction between need frustration and need dissatisfaction, they did not  
99 empirically test if the two constructs had unique factorial structure and predictive value; this  
100 consideration was examined by Costa et al. (2015). The researchers developed and assessed  
101 items to capture need dissatisfaction (defined as a “lack of need satisfaction”, p. 12) and  
102 demonstrated, using multi-trait multi-method confirmatory factor analysis (MTMM; CFA),  
103 that these items could be perceived differentially from those of need frustration in the context  
104 of interpersonal relationships. However, in testing for evidence of differential predictive  
105 utility using structural equation modeling (SEM), the authors reported need dissatisfaction to  
106 have poor predictive effects, as it failed to predict the outcome measures of interpersonal  
107 competence (index of optimal functioning) and interpersonal sensitivity (index of diminished  
108 functioning) uniquely.

109           Costa and colleagues’ (2015) attempt to assess the predictive ability of need  
110 dissatisfaction was speculated to be unsuccessful due to the outcomes they employed (Cheon  
111 et al., 2019). For instance, in the past, need frustration has been demonstrated to best predict  
112 “darker” outcomes associated with maladaptive functioning (e.g., burnout and disordered  
113 eating; Bartholomew, Ntoumanis, Ryan, Bosch et al., 2011). Need dissatisfaction, on the  
114 other hand, has been proposed to be a better predictor of more passive forms of maladaptive  
115 functioning, such as disengagement and boredom (Cheon et al., 2019).

116           In the case of the need for autonomy, the utility of the third need state of  
117 dissatisfaction, along with that of satisfaction and frustration was recently tested by Cheon et  
118 al. (2019) in a classroom intervention study. The researchers proposed that maladaptive  
119 student behaviors can take two forms. Students can either demonstrate reactive and defiant  
120 functioning in the form of disruptive behavior and oppositional defiance, or they can exhibit  
121 passive and diminished functioning, which could take the form of a lack of motivation,



122 boredom or disengagement. Defiant functioning was hypothesized to be a consequence of  
123 need frustration. In contrast, student passivity or diminished functioning was expected to  
124 occur as a result of need dissatisfaction. The researchers were able to demonstrate that  
125 students' experiences of autonomy dissatisfaction were distinct from autonomy satisfaction  
126 and autonomy frustration by employing exploratory structural equation modeling (ESEM).  
127 Furthermore, autonomy dissatisfaction was found to predict unique variance in classroom  
128 disengagement (an outcome of diminished functioning) along with low autonomy  
129 satisfaction, and low autonomy frustration. Cheon and colleagues (2019) clarified that  
130 autonomy dissatisfaction and low autonomy satisfaction were not to be equated as they were  
131 found to load on to separate factors with few cross-loadings. Additionally, they highlighted  
132 that autonomy dissatisfaction and autonomy frustration may each bear on disengagement in  
133 two different ways; the former more likely to result in passive disengagement, and the latter  
134 more likely to result in active disengagement. Thus, by demonstrating the three autonomy-  
135 relevant experiential states to be operationally distinct, and the considerable unique predictive  
136 utility of autonomy dissatisfaction in student classroom disengagement, Cheon et al. (2019)  
137 underscored the utility of examining not just one (need satisfaction) or two (need satisfaction  
138 and frustration), but three (need satisfaction, frustration, and dissatisfaction) need states.

139         The term need dissatisfaction has been used predominantly in the SDT literature (e.g.,  
140 Bartholomew, Ntoumanis, Ryan, & Thøgersen-Ntoumani, 2011; Cheon et al., 2019; Costa et  
141 al., 2015) to refer to the lack of need fulfillment. Some researchers have, however, used the  
142 term dissatisfaction to refer to the experience of need frustration (e.g., Neubauer & Voss,  
143 2016, 2018; Sheldon & Hilpert, 2012). For example, Neubauer and Voss (2018) stated that  
144 the dimensions of need satisfaction and dissatisfaction are psychometrically distinct  
145 constructs, and not just mere opposites of one another. According to the Merriam-Webster  
146 Dictionary, however, dissatisfaction implies the opposite of satisfaction. In an effort to avoid

147 confusion, in this paper, we will henceforth use the term “need unfulfillment” to refer to the  
148 negative experiential state of a lack of need fulfillment, and “need frustration” to refer to the  
149 negative experiential state of perceiving one’s needs to be actively being undermined in a  
150 given setting.

151         The case for the third state of need unfulfillment is further emphasized by an  
152 examination of the socio-contextual antecedents of the need states. The perceived  
153 interpersonal style of social agents within one’s environment could influence one’s  
154 experience of basic psychological need satisfaction, frustration, and unfulfillment (Cheon et  
155 al., 2019). It is well established that perceived need support from others results in need  
156 satisfaction, whereas perceived need thwarting results in need frustration (Vansteenkiste &  
157 Ryan, 2013). The experience of unfulfillment is speculated to result from interpersonal  
158 behaviors that are perceived to reflect need indifference on part of the social agent (Cheon et  
159 al., 2019). Need indifferent have been posited to be neglectful of others’ basic psychological  
160 needs; on experiencing such interpersonal behaviors, one’s needs are not actively thwarted,  
161 but instead, are overlooked (Cheon et al., 2019).

162         Illustrative examples of the experience of need unfulfillment in sport could include  
163 athletes feeling uncertain about their perspectives being valued, or experiencing ambiguity  
164 with regards to why they do certain tasks in training sessions (autonomy unfulfillment);  
165 feeling under-challenged and feeling that they are not improving and achieving as much as  
166 they would like to (competence unfulfillment); or feeling as though they do not having much  
167 in common with others in their team, being disinterested in their teammates, and feeling they  
168 do not quite “fit in” (relatedness unfulfillment).

### 169 **Existing Self-report Assessments of Need States in Sport and Other Life Domains**

170         The original focus on only the construct of need satisfaction resulted in the  
171 development of numerous self-report measures to assess this need state in a variety of

172 contexts such as education (e.g., Activity-Feeling States Scale; AFS, Reeve & Sickenius,  
173 1994), work (e.g., Basic Needs Satisfaction at Work Scale; BNSW-S, Deci et al., 2001;  
174 Work-related Basic Need Satisfaction Scale; W-BNS, Van den Broek et al., 2010), and  
175 exercise (Basic Psychological Needs in Exercise Scale; BPNES, Vlachopoulos &  
176 Michailidou, 2006; Psychological Need Satisfaction in Exercise Scale; PNSES, Wilson,  
177 Rogers, Rodgers, & Wild, 2006). For investigations with athletes, researchers simply adapted  
178 such measures to make them relevant to the sport context (e.g., Gagne, Ryan, & Bargmann,  
179 2003; Hodge, et al., 2008).

180 To address the issue of the absence of a sport-specific measure, Ng and colleagues  
181 (2011) developed and provided initial validity evidence for the Basic Needs Satisfaction in  
182 Sport Scale (BNSSS). The 20-item measure comprises five dimensions assessing autonomy  
183 satisfaction (three factors: choice, internal perceived locus of causality- IPLOC, and volition),  
184 competence satisfaction, and relatedness satisfaction. The first empirical assessment of need  
185 frustration as a distinct construct was conducted by Bartholomew, Ntoumanis, Ryan, and  
186 Thøgersen-Ntoumani (2011) who developed and provided initial validity evidence for  
187 responses to the Psychological Need Thwarting Scale (PNTS). The researchers found support  
188 for a 12-item, three factor model assessing the frustration of each of the three basic  
189 psychological needs. Current assessment of these need states is limited to the measurement of  
190 satisfaction and frustration using the two aforementioned scales that have been developed  
191 based on different samples (i.e., the BNSSS with adult athletes and the PNTS with youth  
192 athletes), and have dissimilar scale anchors (1 = *not at all true* to 7 = *very true* for the  
193 BNSSS, and 1 = *strongly disagree* to 7 = *strongly agree* for the PNTS).

194 In non-sport contexts, researchers have recently examined both the positive and  
195 negative experiential need states simultaneously (e.g., Basic Psychological Need Satisfaction  
196 and Frustration Scale, BPNSFS, Chen et al., 2015; The Balanced Measure of Psychological

197 Needs, BMPN, Sheldon & Hilpert, 2012; The Need Satisfaction and Frustration Scale, NSFS,  
198 Longo, Gunz, Curtis, & Farsides, 2016). For example, the 24-item BPNSFS assesses  
199 autonomy satisfaction and frustration, competence satisfaction and frustration, and  
200 relatedness satisfaction and frustration. The scale developers provided evidence for the  
201 dimensionality of the responses to the measure across a culturally diverse sample. Although  
202 researchers have used this measure for investigations in sport (e.g., Li, Ivarsson, Lam, & Sun,  
203 2019), physical education (e.g., Haerens, Aelterman, Vansteenskiste, Soenens, & Petegem,  
204 2015), and exercise (Emm-Collison, Standage, & Gillison, 2016), items of non-sport specific  
205 measures might reflect experiences or situations that are not of particular relevance to athletes  
206 or sport.

207         Additionally, a number of conceptual issues have been associated with the items of  
208 the scales currently available for use in research on this topic, both in and outside of the sport  
209 domain. One key issue with many of the existing measures of need states is their employment  
210 of some items that assess the social context (in terms of need support or need thwarting),  
211 instead of assessing the feeling states (in terms of need satisfaction or need frustration). In the  
212 sport context, for instance, the BNSSS includes the item “There are people in my sport who  
213 care about me” as an item tapping relatedness satisfaction. However, this item entirely  
214 reflects the actions of others in the form of relatedness support, without assessing how these  
215 actions make one feel. Another example of an item assessing behaviors of others instead of  
216 one’s feeling states is “There were people telling me what I had to do” from the BMPN  
217 (Sheldon & Hilpert, 2012). Some items in the PNTS tap personal experiences of need  
218 frustration as a result of actions of others’ in one’s social contextual (e.g., “There are times  
219 when I am told things that make me feel incompetent”); they do not assess the social context  
220 per se (an example of the latter would be an item which would indicate that an athlete is told  
221 by their coach that they are incompetent). Being told that one is incompetent is not the same

222 as feeling incompetent because one might not necessarily lead to the other. Nevertheless,  
223 revisions to items of the PNTS so that they solely assess one's personal experiences of need  
224 frustration, would be advantageous.

225         Some existing measures have limited utility because they include items that conflate  
226 need frustration and need unfulfillment. For example, the BMPN includes the subscale of  
227 dissatisfaction, which is defined as the "salient absence of the experiences" of autonomy,  
228 competence, and relatedness satisfaction (p. 442). However, the subscale includes items  
229 tapping need frustration (e.g., "I had a lot of pressures I could do without"), as well as items  
230 potentially tapping need unfulfillment (e.g., "I felt unappreciated by one or more people"). As  
231 researchers have demonstrated need frustration to be a good predictor of "darker" outcomes  
232 (e.g., disordered eating, Bartholomew, Ntoumanis, Ryan, Bosch et al., 2011), a more accurate  
233 representation of the experience of need frustration might be achieved from a subscale  
234 comprising only of items that capture the "darker" or "more deleterious" experiential states.  
235 An illustrative example of an item capturing the experience of competence frustration would  
236 be an athlete who feels like a failure. Competence unfulfillment, on the other hand, would be  
237 more appropriately assessed by items reflecting feelings that arise from lack of competence  
238 fulfillment; an example being an athlete who feels he/she cannot do all of the tasks in  
239 training-

240         Confirmatory factor analysis (CFA) has been identified to be the most pertinent  
241 approach for scale development efforts in this area because it assumes one leverages a strong  
242 theoretical base (Hurley et al., 1997; Williams, 1995). As such, CFA has been employed as  
243 the primary analytical technique to test the factorial structure of the need states in the  
244 measures described in this section. However, due to the stringent requirement of zero cross-  
245 loadings between items and non-intended factors, CFA may lead to overestimated  
246 correlations between factors and undermining of discriminant validity evidence (Marsh,

247 Morin, Parker, & Kaur, 2014). For example, correlations as high as .83 have been observed  
248 among factors in the BNSSS and PNTS.

249 ESEM (Asparouhov & Muthen, 2009), bifactor modeling, and a combination of the  
250 two can aid in managing the limitations associated with the use of CFA (Morin, Arens, &  
251 Marsh, 2016). First, in ESEM, it is acknowledged that items are not solely associated with the  
252 dimension that they have been developed to assess; they are also related to other non-  
253 intended dimensions. Cross-loadings between items and non-intended factors are admissible  
254 in ESEM, such that factor loadings are not as overestimated as compared to those resulting  
255 from CFA. Second, bifactor models (Holzinger & Swineford, 1937; Reise, 2012) have utility  
256 in examining multidimensional instruments as they allow for concurrent estimation of one or  
257 more general-factors (e.g., need satisfaction) that explain the covariance among all items, as  
258 well as more specific-factors (e.g., autonomy, competence, and relatedness satisfaction)  
259 which explicate the commonality among item sub-dimensions over and above the general  
260 factor (Chen, Hayes, Carver, Laurenceau, & Zhang, 2012; Myers, Martin, Ntoumanis,  
261 Cemili, & Bartholomew, 2014). By juxtaposing bifactor models against CFA or ESEM  
262 models, researchers can ascertain whether general-factors alone are adequate, or if they  
263 function alongside specific-factors. Third, bifactor ESEM models (e.g., Sánchez-Oliva,  
264 Morin, Teixeira, Carraça, Palmeira, & Silva, 2017; Tóth-Király, Morin, Bóthe, Orosz, &  
265 Rigó, 2018) can be advantageous as they not only allow for the presence of cross-loadings  
266 between items and non-intended factors, but also simultaneously enable the assessment of  
267 general- and specific-factors.

## 268 **Present Research**

269 A systematically developed measure of all three need states, with items that are all  
270 pertinent to sport participation, is necessary for psychometrically sound assessments of these  
271 key constructs in sport and therefore a more comprehensive understanding of the athletic

272 experience. We aimed to develop and test the initial validity evidence for scores of the  
273 Psychological Need States in Sport-Scale (PNSS-S), a new multidimensional measure  
274 assessing athletes' experiences of need satisfaction, frustration and unfulfillment, separately  
275 for autonomy, competence, and relatedness. Over two studies, we aimed to assess validity  
276 evidence testing the internal structure (to determine the extent to which the items of a  
277 measurement instrument are in line with the construct of interest via factor analyses; Chan,  
278 2014) and relations to other variables (to examine nomological networks of antecedent and  
279 consequence variables surrounding the construct of interest using structural equation  
280 modeling) in accordance with the *Standards for Educational and Psychological Testing* (The  
281 *Standards*; developed by the American Educational Research Association [AERA], American  
282 Psychological Association [APA], and National Council on Measurement in Education  
283 [NCME], 2014). Additionally, we sought to examine evidence for reliability and discriminant  
284 validity of the subscale scores of the PNSS-S.

### 285 **Study 1**

286 The aim of Study 1 was to (a) develop a pool of items to assess need satisfaction,  
287 frustration, and unfulfillment among athletes, and (b) determine evidence for internal  
288 structure, internal consistency, and discriminant validity of the subscale scores of the new  
289 measure.

### 290 **Method**

#### 291 **Participants**

292 The sample consisted of 301 competitive athletes ( $N_{male} = 92$ ,  $N_{female} = 209$ ), with an  
293 average age of 20.27 years ( $SD = 7.36$ ), recruited in the United Kingdom ( $n = 195$ ) and in  
294 Australia ( $n = 106$ ). Athletes competed in a variety of individual and team sports such as  
295 Australian football, soccer, swimming, and netball. One hundred and seventy-nine athletes

296 were competitive at the club level, 19 at the university level, 47 at the regional/state level, 27  
297 at the county level, 20 at the national level, and six at the international level at the time of the  
298 study. Three athletes did not report the level at which they competed. Athletes reported an  
299 average competitive experience of 9.43 years ( $SD = 7.29$ ), trained on average 2.47 times a  
300 week ( $SD = 1.56$ ), and had been training with their current main coach for 1.95 years ( $SD =$   
301 3.16).

## 302 **Measure**

303 **PNSS-S (Psychological Need States in Sport-Scale).** The PNSS-S items were  
304 designed to examine athletes' experiences of satisfaction, frustration, and unfulfillment of  
305 their three basic psychological needs for autonomy, competence, or relatedness. Sixteen items  
306 were written to assess the satisfaction of the needs. The content of these items was informed  
307 by existing self-report measures of need satisfaction in sport or similar contexts (e.g.,  
308 BNSSS, Ng et al., 2011; BPNES, Vlachopoulos & Michailidou, 2006; PNSES, Wilson,  
309 Rogers, Rodgers, & Wild, 2006, autonomy items collated by Standage, Duda, & Ntoumanis,  
310 2003; the competence subscale of the Intrinsic Motivation Inventory, IMI, McAuley, Duncan,  
311 & Tammen, 1980, and the acceptance subscale of the Need for Relatedness Scale, NRS - 10,  
312 Richer & Vallerand, 1998). Items began with the stem "In my main sport, I...". An example  
313 of an item assessing autonomy satisfaction is "have the freedom to make training decisions".  
314 Items were carefully written to avoid explicit references to the social context (e.g., "feel  
315 supported").

316 Items of the PNTS (Bartholomew, Ntoumanis, Ryan, & Thøgersen-Ntoumani, 2011)  
317 were refined so as to reflect the "darker" experience of need frustration while avoiding  
318 references to the social context (e.g., "feel useless" and "feel isolated"). Only one of the  
319 PNTS items was retained; five others were updated in terms of their wording. Nine



320 completely new items were written. Thus, a total of 15 items were written to assess need  
321 frustration.

322 Finally, 15 items for need unfulfillment were developed by our research team. Need  
323 unfulfillment was defined as the feeling state of one's needs being set aside or neglected  
324 (Cheon et al., 2019) and "feeling that something is not as good as it should be"  
325 (Bartholomew, Ntoumanis, Ryan, & Thøgersen-Ntoumani, 2011, p. 78). Based upon this  
326 operational definition, an initial pool of items was developed by the first author in  
327 collaboration with two senior academic experts of the research team. These items were then  
328 reviewed by the rest of the research team who made suggestions for improving these items  
329 and/or proposed alternative items. All authors agreed that the final set of items demonstrated  
330 sufficient face and content validity evidence. An example for competence unfulfillment is  
331 "feel that I am not good enough". Recommendations by DeVellis (2012) informed the item  
332 writing process. Items were kept brief, were not double-barreled, did not borrow heavily from  
333 any one existing measure, did not tap multiple needs, and did not explicitly refer to the social  
334 context. The initial item pool is listed in Supplementary File 1.

335 A 7-point response scale with the anchors 1 = *strongly disagree*, 4 = *neither disagree*  
336 *nor agree*, 7 = *strongly agree* was employed. The 7-point response format is congruent with  
337 previous measures assessing these constructs in sport (e.g., Bartholomew, Ntoumanis, Ryan,  
338 & Thøgersen-Ntoumani; Ng et al., 2011). Seven-point rating scales are also in line with  
339 survey takers' preferences and perform well in terms of their discriminative power (Preston  
340 & Coleman, 2000). Prior to survey administration, participants were advised to consider their  
341 experiences in competition and in training and indicate the degree to which they disagreed or  
342 agreed with each statement. Participants were assured that there were no right or wrong responses  
343 to encourage honest responses.

344 **Procedure**

345 Ethical approval was obtained for both studies in this paper from the first author's  
346 university ethics committee. Subsequently, sports club committee members and coaches were  
347 contacted in order to explain the purpose of the study and to invite their athletes to  
348 participate. In some cases, athletes were contacted directly. Athletes were eligible if they  
349 trained with a coach at least once a week, competed regularly during the sport season, and  
350 were over 14 years of age. Participation in the study was voluntary. Parental consent was  
351 sought for participants in the age group 14-17 years. All athletes completed a consent form  
352 prior to taking the survey, which was administered in person either before or after a training  
353 session.

#### 354 **Data Analyses**

355 The factorial structure of the new measure was examined using CFA, ESEM, and  
356 bifactor CFA and ESEM. The factor structures tested were theoretically justifiable and  
357 targeted the three states of satisfaction, frustration, and unfulfillment as well as just the two  
358 states of satisfaction and frustration (see Table 1, Models 1-24, and Supplementary File 2)  
359 separately for the needs of autonomy, competence, and relatedness. Statistical analyses were  
360 conducted in Mplus 8.0 (Muthén & Muthén, 1998 - 2017).

361 For CFA models, latent factors were permitted to correlate, with cross-loadings of  
362 items on unintended factors being constrained to zero. Similar to CFA, in the case of ESEM  
363 models, items were allowed to load on their predefined latent factors, but cross-loadings were  
364 freely estimated, albeit they were targeted to be as close as possible to zero using target  
365 rotations (Browne, 2001). For the bifactor CFA models, items could load on their predefined  
366 general-factors (G-factors) and specific-factors (S-factors). S-factors were designated as  
367 orthogonal to one another, and to the G-factor(s). If a model had multiple G-factors, these  
368 were estimated as correlated. Lastly, bifactor ESEM models were operationalized in manner

369 similar to the bifactor CFA models, with the exception of employing orthogonal bifactor  
370 target rotation for the S-factors (Reise, 2012).

371 Goodness-of-fit was evaluated using the  $\chi^2$  goodness-of-fit index, Comparative Fit  
372 Index (CFI), Tucker-Lewis index (TLI), Root Mean Square Error of Approximation  
373 (RMSEA), and Standardized Root Mean Square (SRMR). Adequate and excellent model-to-  
374 data fit was indicated by CFI and TLI values of or greater than .90 and .95 respectively, and  
375 RMSEA and SRMR values of or smaller than .08 and .06, respectively (Hooper, Coughlan, &  
376 Mullen, 2008; Hu & Bentler, 1999; Marsh, Hau, & Grayson, 2005; Marsh, Hau, & Wen,  
377 2004). The strength of factor loadings was informed by the recommendations put forth by  
378 Comrey and Lee (1992) (i.e.,  $> .71$  = “excellent”,  $> .63$  = “very good”,  $> .55$  = “good”,  $> .45$  =  
379 “fair”,  $< .30$  = “poor”). The internal consistency of the subscale scores was determined  
380 through an assessment of Raykov’s composite reliability coefficient (RHO; Raykov, 1997).  
381 In line with the recommendation by Nunnally (1978), internal consistency estimates greater  
382 than .70 were deemed adequate. Factor correlations were examined for evidence of  
383 discriminant validity (Brown, 2015), with values of or over .80 suggesting substantial overlap  
384 amongst the factors of the measure (John & Benet-Martinez, 2000).

## 385 Results

### 386 Item Distribution

387 Prior to the factor analyses, data were scanned for univariate normality. Median  
388 values for skewness and kurtosis for the 46 items were .581 and .816 respectively, and ranged  
389 from -2.00 to 3.41 for skewness, and -1.00 to 8.00 for kurtosis. Given the presence of a few  
390 large values, data were analyzed using a robust maximum likelihood estimator (MLR). MLR  
391 yields robust fit indices and standard errors in the case of non-normal data and operates well  
392 when categorical variables with a minimum of five response categories are employed  
393 (Bandalos, 2014; Rhemtulla, Brosseau-Laird, & Savalei, 2012).

394 **Configurations Involving the Three Need States (Satisfaction, Frustration, and**  
395 **Unfulfillment)**

396 Results of the factor analyses for need satisfaction, frustration, and unfulfillment are  
397 reported in Table 1. In total, 12 models pertaining to various configurations of the three need  
398 states were tested. Most of these models demonstrated poor model-data fit, some did not  
399 converge, and problems were encountered with other models for which information relevant  
400 to model fit (e.g., standard errors) could not be calculated. Increasing the number of iterations  
401 and changing the convergence criteria failed to resolve problems with model convergence  
402 and model fit (more details are available from the lead author upon request). An examination  
403 of the parameter estimates of the models that did converge indicated several items with poor  
404 standard factor loadings ( $<.30$ ) and cross-loadings on unintended factors ( $>.20$ ) that were  
405 larger than the target factor loadings. At this stage, items assessing the new dimension of  
406 need unfulfillment were also examined on their own (i.e., without those assessing need  
407 satisfaction and frustration). Model results are presented in Supplementary File 4. The three-  
408 factor ESEM solution demonstrated promise, although it did not reach an acceptable TLI  
409 level. Internal consistency estimates based on this model were found to be adequate, with  
410 Raykov's composite reliability coefficient for autonomy unfulfillment = .71, competence  
411 unfulfillment = .75, and relatedness unfulfillment = .80. These results indicated that the issue  
412 was not that the need unfulfillment items were inappropriate, but that there was no evidence  
413 to demonstrate that need unfulfillment could be modeled as a distinct need state when tested  
414 alongside the need satisfaction and frustration. As no support was found for any configuration  
415 involving the three need states, the focus of the study shifted to assessing the two experiential  
416 states of need satisfaction and frustration (for which there is considerable support in the  
417 literature, e.g., Chen et al., 2015).

418 <Insert Table 1 here>

**419 Configurations Involving the Two Need States (Satisfaction and Frustration)**

420 Of the 12 models that were tested pertaining to the two need states, only one model  
421 (Model 22; Bifactor ESEM with two G- and six S-factors) demonstrated acceptable fit [ $\chi^2 =$   
422 458.463 (262),  $p < .001$ , CFI = .95, TLI = .91, SRMR = .02, RMSEA = .05 (90% CI .04,  
423 .056)]. However, an examination of the factor loadings indicated that the G-factor of need  
424 frustration had only two salient significant loadings above .30, whereas the G-factor of need  
425 satisfaction had no items with significant factor loadings. Further examination of the S-  
426 factors indicated that autonomy satisfaction S-factor had no items with significant factor  
427 loadings, making this model unsuitable. Factor loadings for bifactor models are presented in  
428 Supplementary File 3. One model that seemed promising, even though it did not reach an  
429 acceptable TLI level, was Model 18 (Six-factor correlated ESEM model). In this model, all  
430 factors demonstrated at least three items with significant loadings over .30 on their target  
431 factors, only a few items exhibited unintended cross-loadings which were smaller than target  
432 factor loadings, and all factor correlations were in expected directions.

433 At this stage, a decision was made to first examine one-factor CFAs for the factors in  
434 this model, systematically remove problematic items, and then re-run the six-factor ESEM  
435 model with the best performing items. For these analyses, CFA was seen as an appropriate  
436 approach, given that the goal was to select items with strong primary factor loadings to  
437 ultimately inform the final six-correlated factor ESEM model. In doing so, for all the CFAs,  
438 model misspecification was identified through assessments of standardized factor loadings  
439 and modification indices, in a manner similar to item reduction approaches used in previous  
440 SDT-based scale development procedures (e.g., Rocchi, Pelletier, Cheung, Baxter, &  
441 Beaudry, 2017). Alongside these statistical criteria, the conceptual coverage of the items was  
442 also considered (i.e., ensuring that the remaining items captured autonomy, competence, and  
443 relatedness). Items with standardized factor loadings below .30, as well as items with

444 multiple (two or more) moderate-sized or large modification indices (over 10) were taken  
445 into consideration for deletion. As such, 10 of the 31 items were deleted in a systematic  
446 manner in several iterations. The resultant one-factor models had excellent fit (see Table 2).

447 <Insert Table 2 here>

448 Subsequently, the six-correlated factor ESEM model was re-tested with the remainder  
449 of the 21 items from the six one-factor CFA models (see Table 2). This revised model  
450 demonstrated good fit [ $\chi^2(99) = 171.110, p < .001, CFI = .97, TLI = .94, SRMR = .02,$   
451  $RMSEA .05$  (90% CI .04, .06)]. With the exception of two items (one each for competence  
452 satisfaction and relatedness satisfaction), standardized factor loadings were significant and  
453 above .30 (range .28 to .89; see Table 3). Few cross-loadings greater than .20 on unintended  
454 factors were present. Subscale correlations ranged from -.18 to .60 and were in the expected  
455 directions (see Table 4). Raykov's composite reliability coefficients are also reported in  
456 Table 4. Barring competence satisfaction (.66) and relatedness satisfaction (.52), these were  
457 over .70 for all factors.

458 <Insert Table 3 here>

459 <Insert Table 4 here>

460 The two items with standardized factor loadings below .30 ("I feel that I am  
461 improving", and "I feel valued") were deleted, and 10 new items were written in an effort to  
462 have a more equal number of items per subscale. It was expected that these new items would  
463 also help improve estimates for the two subscales with internal consistency estimates under  
464 .70 when examined in a new sample of athletes in Study 2.

## 465 Study 2

466 The aims of Study 2 were two-fold. First, we aimed to test the revised item pool from  
467 Study 1 with an independent sample of athletes. Second, we also aimed to test the

468 nomological network of the six dimensions of the psychological need states by examining  
469 their relations with perceived coach interpersonal behaviors and positive and negative athlete  
470 outcomes. Based on previous literature linking perceptions of coach need support and  
471 thwarting to athlete need satisfaction and frustration (e.g., Pulido, Sanchez-Oliva, Sanchez-  
472 Miguel, Amado, & Garcia-Calvo, 2018; Rocchi, Pelletier, & Desmarais, 2017), it was  
473 hypothesized that perceived coach autonomy support would primarily predict athlete  
474 autonomy satisfaction, perceived coach competence support would primarily predict athlete  
475 competence satisfaction, and perceived coach relatedness support would primarily predict  
476 athlete relatedness satisfaction. Contrastingly, it was hypothesized that perceived coach  
477 autonomy thwarting would primarily predict athlete autonomy frustration, perceived coach  
478 competence thwarting would primarily predict athlete competence frustration, and perceived  
479 coach relatedness thwarting would primarily predict athlete relatedness frustration.

480 In terms of the relations between the need states and athlete outcomes, based on  
481 previous literature in sport and other domains (e.g., Bartholomew, Ntoumanis, Ryan, &  
482 Thøgersen-Ntoumani, 2011; Chen et al., 2015; Gunnell, Crocker, Wilson, Mack, & Zumbo,  
483 2013), it was hypothesized that satisfaction of each of the three needs would predict the  
484 positive athlete outcomes of dedication and positive affect independently. Contrastingly, the  
485 frustration of each of the three needs was hypothesized to predict the negative athlete  
486 outcomes of exhaustion and negative affect independently.

## 487 **Method**

### 488 **Participants**

489 The sample consisted of 333 competitive athletes recruited in Australia ( $N_{male} = 183$ ,  
490  $N_{female} = 150$ ), with an average age of 19.99 years ( $SD = 5.43$ ). Athletes represented a number  
491 of individuals and team sports such as Australian football, basketball, and athletics. One  
492 hundred and ninety-nine athletes competed at the club level, 81 at the state level, 39 at the

493 national level, and 14 competed internationally. They had been competing in their sports for  
494 8.75 years ( $SD = 5.32$ ), had been training with their main coaches for 2.07 years ( $SD = 1.67$ )  
495 on an average of 2.51 times per week ( $SD = 1.62$ ).

#### 496 **Procedure**

497 Athletes were recruited using procedures similar to those described in Study 1. In  
498 addition to collecting data in person, the questionnaire was also made available online, via  
499 Qualtrics, and was advertised through social media. All participating athletes were eligible to  
500 go into a prize draw to win shopping vouchers. Undergraduate student athletes ( $n = 5$ ) at the  
501 School of Psychology at the first author's university were offered course credit (2 points) for  
502 participation.

#### 503 **Measures**

504 **Athlete need satisfaction and frustration.** The 29-item PNSS-S developed in Study  
505 1 was used to assess athletes' states of satisfaction and frustration across the three basic  
506 psychological needs. Similar to Study 1, athletes were requested to consider their general  
507 experiences in their main sport, and indicate the extent to which they disagreed or agreed  
508 with each statement using a 7-point response format (1 = *strongly disagree*, 4 = *neither*  
509 *disagree nor agree*, 7 = *strongly agree*).

510 **Coach interpersonal behaviors.** The 24-item Interpersonal Behaviors Questionnaire  
511 in Sport (IBQ in Sport; Rocchi, Pelletier, & Desmarais, 2017) was implemented to examine  
512 athletes' perceptions of their coaches' interpersonal behaviors. The measure consists of six  
513 factors representing supportive and thwarting coach behaviors pertaining to the three basic  
514 psychological needs. The items began with the stem "My Coach...". Illustrative items from  
515 the competence supportive and thwarting subscales include "Provides me valuable feedback",  
516 and "Points out that I will likely fail", respectively. Athletes indicated their disagreement or  
517 agreement with each statement using a 7-point response scale (1 = *do not agree at all* to 7 =



518 *completely agree*). The six-factor structure of the IBQ in Sport was tested using ESEM.  
519 Model-to-data fit was found to be excellent [ $\chi^2(147) = 280.033, p < .001, CFI = .98, TLI =$   
520  $.96, SRMR = .01, RMSEA = .05$  (90% CI .04, .06)]. Raykov's reliability estimates for the  
521 subscale scores ranged from .82 to .91.

522 **Positive outcomes.** The dedication subscale of the Athlete Engagement Questionnaire  
523 (AEQ; Lonsdale, Hodge, & Jackson, 2007) was employed to assess dedication, which reflects  
524 "a desire to invest effort and time towards achieving goals one views as important" (p. 472).  
525 The subscale consists of four items, to which participants responded using a 5-point rating  
526 scale (1 = *almost never* - 5 = *almost always*). An example item is "I am determined to achieve  
527 my goals in sport". Fit for the one-factor CFA model was excellent [ $\chi^2(2) = .511, p < .001,$   
528  $CFI = 1.000, TLI = 1.012, SRMR = .00, RMSEA = .00$  (90% CI .00, .07)]. Ravkov's  
529 composite reliability coefficient for the subscale score was .91.

530 The 10-item positive affect subscale of the 20-item short version of the Positive and  
531 Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) was used as a second  
532 positive outcome. Athletes indicated the extent to which they had experienced emotions such  
533 as "excited" and "proud" over the past month using a 5-point scale ranging from (1 = *very*  
534 *slightly or not at all* - 5 = *extremely*). Fit for the one-factor CFA model was good [ $\chi^2(35) =$   
535  $93.069, p < .001, CFI = .96, TLI = .95, SRMR = .03, RMSEA = .07$  (90% CI .05, .09)].  
536 Ravkov's composite reliability coefficient for the subscale score was .93.

537 **Negative Outcomes.** The emotional and physical exhaustion subscale of the Athlete  
538 Burnout Questionnaire (ABQ; Raedeke & Smith, 2001) was administered as a negative  
539 athlete outcome. Participants responded to five items using a 5-point response format (1 =  
540 *almost never* - 5 = *almost always*). An example of an item is "I have been feeling physically  
541 worn out from my sport". Fit for the one-factor CFA model was excellent [ $\chi^2(5) = 10.862, p$

542 < .001, CFI = .99, TLI = .98, SRMR = .02, RMSEA = .06 (90% CI .00, .12)]. Raykov's  
543 composite reliability coefficient for the subscale score was .91.

544 The 10-item positive affect subscale of 20-item short version of the Positive and  
545 Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) was employed as the  
546 second negative athlete outcome. Athletes were requested to indicate the extent to which they  
547 had experienced emotions such as "upset" and "nervous" over the past month using the same  
548 5-point response format as the positive affect subscale. Fit for the one-factor CFA model was  
549 poor [ $\chi^2$  (35) = 130.507,  $p$  < .001, CFI = .87, TLI = .83, SRMR = .06, RMSEA = .09 (90% CI  
550 .07, .12)]. Raykov's composite reliability coefficient for the subscale score .83.

## 551 Data Analyses

552 **Scale structure, reliability, and discriminant validity evidence.** The revised six-  
553 factor ESEM solution was tested<sup>2</sup> to examine whether the factor structure held when assessed  
554 with a new sample of athletes. Similar to Study 1, a multifaceted approach informed model-  
555 to-data fit, Raykov's reliability coefficient served as an estimate of internal consistency, and  
556 correlations between the subscales served as evidence of discriminant validity.

557 **Structural equation modeling (SEM).** Four separate analyses were conducted to  
558 examine the relations between a) dimensions of need support and need satisfaction, b)  
559 dimensions of need satisfaction and the outcomes of dedication and positive affect, c)  
560 dimensions of need thwarting and need frustration, and d) dimensions of need frustration and  
561 the outcomes of exhaustion and negative affect. Researchers have previously taken a similar  
562 approach in order to avoid issues of multicollinearity that may arise from including all the  
563 variables in the same analysis (e.g., Chen et al., 2015). We faced problems with net  
564 suppression effects when attempting to analyse all variables together<sup>3</sup>. All analyses were  
565 completed in Mplus 8.0.

566

## Results

567 Data were screened for normality before conducting the main analyses. Median values  
568 for skewness and kurtosis were -.306 and 1.544, respectively. Skewness values ranged from -  
569 1.868 to 1.971, and kurtosis values ranged from -1.137 to 4.637. As such, all analyses were  
570 conducted using MLR.

### 571 **Scale Structure, Reliability, and Discriminant Validity Evidence**

572 Fit indices for the six-factor ESEM model were indicative of good fit [ $\chi^2$  (247) =  
573 438.72,  $p < .001$ , CFI = .97, TLI = .95, SRMR = .02, RMSEA = .05 (90% CI .04, .06)].  
574 Standardized factor loadings were found to be statistically significant and ranged from .35 to  
575 .86. Six items had significant cross-loadings over .20 on unintended factors (e.g., “I am able  
576 to overcome challenges”, a competence satisfaction item, had a cross loading of .35 on the  
577 autonomy satisfaction subscale, and the autonomy frustration item “feel excessive pressure”  
578 had a cross-loading of .29 on the competence frustration subscale). However, in all such  
579 instances, cross-loadings were lower than intended factor loadings, and hence not considered  
580 to be overly problematic. Factor correlations were in the expected directions, and internal  
581 consistency estimates were above the recommended value of .70 for all subscales scores.  
582 Standardized factor loadings, cross-loadings, item means, standard deviations, skewness,  
583 kurtosis are reported in Table 5. Factor correlations and internal consistency estimates are  
584 reported in Table 6.

585 <Insert Table 5 here>

586 <Insert Table 6 here>

### 587 **SEM**

588 First, a correlational analysis was conducted to explore the associations between the  
589 variables (see Table 7). Next, the relations between the variables entered in the SEM were  
590 examined. Model-to-data fit was found to be acceptable [ $\chi^2$  (267) = 745.712,  $p < .001$ , CFI =  
591 .93, TLI = .90, SRMR = .04, RMSEA = .07 (90% CI [.07, .08]) in the case of the six-factor

592 model with three subscales pertaining to perceptions of coaches' need supportive behaviors  
593 and the three athlete need satisfaction subscales. Autonomy satisfaction was primarily  
594 predicted by perceived autonomy support, competence satisfaction was primarily predicted  
595 by perceived competence support, and relatedness satisfaction was primarily predicted by  
596 perceived relatedness support. Standardized path coefficients for the structural portion of the  
597 model are reported in Figure .

598 <Insert Table 7 here>

599 <Insert Figure here>

600 Model-to-data fit was found to be acceptable [ $\chi^2(343) = 765.357, p < .001, CFI = .93,$   
601  $TLI = .92, SRMR = .04, RMSEA = .06$  (90% CI .05, .07)] for the five-factor model with the  
602 three athlete need satisfaction subscales and two outcomes of dedication and positive affect.  
603 Dedication was significantly predicted by autonomy and competence satisfaction, and  
604 positive affect by competence and relatedness satisfaction. Standardized path coefficients for  
605 the structural portion of the model are reported in Figure .

606 <Insert Figure here>

607 Model-to-data fit was found to be excellent [ $\chi^2(244) = 354.479, p < .001, CFI = .98,$   
608  $TLI = .97, SRMR = .02, RMSEA = .04$  (90% CI .03, .04)] in the case of the six-factor model  
609 with three subscales pertaining to perceptions of coaches' need thwarting behaviours and the  
610 three athlete need frustration subscales. Autonomy frustration was primarily predicted by  
611 perceived autonomy thwarting, and competence frustration was primarily predicted by  
612 perceived competence thwarting. Unexpectedly, relatedness frustration was marginally better  
613 predicted by perceived competence thwarting than by perceived relatedness thwarting.  
614 Standardized path coefficients for the structural portion of the model are reported in Figure .

615 <Insert Figure here>

616 Model-to-data fit was found to be acceptable [ $\chi^2$  (345) = 585.433,  $p < .001$ , CFI = .95,  
617 TLI = .94, SRMR = .04, RMSEA = .05 (90% CI .04, .05)] for the five-factor model with the  
618 three athlete need frustration subscales and two outcomes of exhaustion and negative affect.  
619 Exhaustion was significantly predicted by autonomy and competence frustration, and  
620 negative affect by autonomy, competence, and relatedness frustration. Standardized path  
621 coefficients for the structural portion of the model are reported in Figure .

622 <Insert Figure here>

## 623 Discussion

624 Since the development of the PNTS (Bartholomew, Ntoumanis, Ryan, & Thøgersen-  
625 Ntoumani, 2011), SDT-based research on psychological needs has increasingly demonstrated  
626 the importance of focusing on both experiences of need satisfaction and need frustration.  
627 Recently, researchers have also argued for the utility of assessing a third need state, that of  
628 unfulfillment. These theoretical developments have resulted in continued refinement of the  
629 terminology used in this area as well as attempts to develop measures that operationalize  
630 these key constructs. The present work aimed to further extend these efforts and address the  
631 conceptual and psychometric issues that have been associated with existing measures in this  
632 area. Specifically, given the absence of a sport-specific measure to examine experiences of  
633 both need satisfaction and need frustration, and the growing interest in the potential utility of  
634 assessing need unfulfillment, we aimed to develop a new multidimensional measure assessing  
635 athletes' experiences of satisfaction, frustration, and unfulfillment, separately for autonomy,  
636 competence, and relatedness needs.

### 637 Dimensionality of the Need States

638 One of our aims was to clearly conceptualise and systematically assess need  
639 unfulfillment, the third state which has garnered increasing interest over the recent years

640 (e.g., Cheon et al., 2019; Costa et al., 2015), alongside those of need satisfaction and need  
641 frustration. We tested various theoretically plausible configurations of the three need states  
642 using CFA, ESEM, and bifactor analyses, yet none of the representations pertaining to the  
643 simultaneous assessment of satisfaction, frustration, and unfulfillment were supported by the  
644 data. At this stage, the evidence for the existence of need unfulfillment as a distinct construct  
645 appears to be mixed. Support for its existence is based on Costa et al.'s (2015) finding via  
646 MTMM analysis that need unfulfillment is empirically distinct from need satisfaction and  
647 frustration. Furthermore, in the case of the need of autonomy, unfulfillment was shown to  
648 have unique utility in predicting disengagement, an outcome of diminished functioning by  
649 Cheon et al. (2019). However, findings from our paper indicate a lack evidence that need  
650 unfulfillment is distinct from need satisfaction and frustration. In addition, Costa et al. (2015)  
651 found need unfulfillment to have poor predictive value. Perhaps the items we created to  
652 assess need unfulfillment were not operationalised in a manner that rendered them adequately  
653 distinguishable from those of need satisfaction and frustration. Although the items were  
654 clearly distinct to our research team, it is possible that athletes are not able to see such  
655 distinctions and, therefore, perhaps this line of work has limited practical value.

656 In light of the extant supporting literature for a model involving the two need states of  
657 satisfaction and frustration (e.g., Chen et al., 2015), we subsequently shifted the focus of the  
658 study towards developing and providing initial validity evidence for the first sport-specific  
659 measure of these two need states. Of all the theoretically justifiable configurations that were  
660 tested, a six-factor solution ESEM involving the satisfaction and frustration of each of the  
661 three basic psychological needs, appeared promising. Our analyses began with ESEM, before  
662 testing single factor CFA solutions, as we were mindful that the three psychological needs  
663 have been shown to be empirically interrelated in the SDT literature (Ryan & Deci, 2017),  
664 with the potential for items to cross-load on additional factors. As CFAs have strict

665 requirements of zero-cross loadings of items on non-intended factors (Asparouhov &  
666 Muthén, 2009), starting out with single-factor CFAs would have resulted in the loss of  
667 conceptually relevant items that cross-loaded on non-target constructs. Following some  
668 modifications in Study 1, the cross-validation of the revised model was supported in Study 2.

669 In essence, the results indicated that athletes' responses to the PNSS-S items could be  
670 best explained by a model comprising six dimensions of autonomy satisfaction and  
671 frustration, competence satisfaction and frustration, and relatedness satisfaction and  
672 frustration, scores of all of which were internally reliable. Aligned with similar findings from  
673 non-sport-specific contexts (e.g., Chen et al., 2015; Cordeiro, Paixao, Lens, Lacante, &  
674 Luyckx, 2016; Longo et al., 2016), results of this research suggest that athletes' need states  
675 are comprised of six dimensions that are distinct, yet correlated, and should hence be assessed  
676 independently.

### 677 **Evidence for Nomological Network**

678 In an effort to provide initial evidence for the nomological network surrounding the  
679 subscales of the PNSS-S, we examined the relations between the need states, perceived coach  
680 interpersonal behaviours, and positive and negative athlete outcomes. Autonomy,  
681 competence, and relatedness satisfaction were primarily predicted by their corresponding  
682 contextual factors of perceived coach autonomy, competence, and relatedness support,  
683 respectively. In contrast, autonomy and competence frustration were primarily predicted by  
684 their corresponding contextual factors of perceived coach autonomy, and competence  
685 thwarting, respectively. These findings are in line with theory (e.g., Deci & Ryan, 2000;  
686 Vansteenkiste & Ryan, 2013) and previous investigations linking perceptions of interpersonal  
687 behaviors to the need states (e.g., Pulido et al., 2018; Rocchi, Pelletier, & Desmarais, 2017).

688 Contrary to our hypothesis, relatedness frustration was slightly better predicted by  
689 perceived competence thwarting, as compared to relatedness thwarting. An examination of

690 the items of the relatedness thwarting subscale of the IBQ in sport (Rocchi, Pelletier, &  
691 Desmarais, 2017) could help explain this finding. The subscale includes items that are better  
692 representative of what Cheon et al. (2019) refer to as need indifference (e.g., “My coach is  
693 distant when we spend time together”), as opposed to actively thwarting of it (e.g., an  
694 example of such an item would be “My coach rejects me”). In comparison to need thwarting,  
695 which involves active undermining of others’ basic psychological needs, need indifference is  
696 proposed to only “set aside” others’ needs (Cheon et al., 2019). Resultantly, need indifference  
697 may not predict need frustration with the same strength as need thwarting behaviors.  
698 Competence thwarting may have emerged as a stronger predictor of relatedness frustration  
699 given that the need for competence has been found to be particularly salient in the context of  
700 sport (e.g., Adie, Duda, & Ntoumanis, 2012). Additionally, as the need-specific dimensions  
701 of interpersonal behaviors are stipulated to be interrelated (e.g., Ryan, 1991; Ryan & Deci,  
702 2017), competence thwarting may have emerged as a stronger predictor as a result of the  
703 inadequacy of the relatedness thwarting subscale.

704 In terms of the relations between the dimensions of the need states and athlete  
705 outcomes, the satisfaction of autonomy and competence needs predicted athlete dedication in  
706 a significant manner, whereas the satisfaction of competence and relatedness needs predicted  
707 positive affect in a significant manner. Dedicating time and energy to sport-related  
708 aspirations and deriving positive emotions from sport engagement are likely consequences  
709 for athletes who experience a sense of self-directedness, effectance, and connectedness in  
710 their sport. The satisfaction of all three basic psychological needs is considered to be  
711 indispensable for well-being (Deci & Ryan, 2000), and researchers have previously examined  
712 athlete experiences of need satisfaction as key motivational precursors to athlete engagement  
713 (Curran, Hill, Hall, & Jowett, 2014; Lonsdale et al., 2007), and positive affect (Mack et al.,  
714 2011).



715           The results indicated that the relations between relatedness satisfaction and athlete  
716 dedication, and autonomy satisfaction and positive affect, were non-significant. In their  
717 investigation of the antecedents of athlete engagement in sport, Hodge, Lonsdale, and  
718 Jackson (2009) did not find the need for relatedness to play a substantial role in terms of  
719 predicting engagement (of which dedication is a key component), when compared to the  
720 other two needs. Moreover, Reinboth et al. (2004) found relatedness to be unrelated to athlete  
721 outcomes. Cognitive Evaluation Theory (CET), a sub-theory of SDT, emphasises the distal  
722 role of relatedness satisfaction in the maintenance of intrinsic motivation (Deci & Ryan,  
723 2000). It is likely that subsequent outcomes (such as dedication and engagement) are also  
724 implicated (Reinboth et al., 2004). Autonomy satisfaction has previously been found to be  
725 unrelated to positive affect in sport and related domains when assessed using the positive  
726 emotions subscale of the PANAS (e.g., Gunnell et al., 2013; Mack et al., 2011; McDonough  
727 & Crocker, 2007). It might be the case that the items of the PANAS are better suited to  
728 capture the positive emotions resulting from the experiences of effectance/mastery and  
729 connectedness with others, over those resulting from feeling volitional or self-directed in  
730 one's sporting pursuits.

731           In terms of the relations between need frustration subscales and negative outcomes,  
732 autonomy and competence frustration predicted athlete exhaustion in a significant manner,  
733 whereas frustration of each of the three needs predicted negative affect in a significant  
734 manner. Feeling isolated, being forced to have to train in certain ways, and thinking of  
735 oneself as a failure are likely to predispose athletes to extreme fatigue and adverse emotions,  
736 and need frustration has been shown to be implicated in these maladaptive athlete outcomes  
737 (e.g., Bartholomew, Ntoumanis, Ryan, & Thøgersen-Ntoumani, 2011). In line with the results  
738 reported by Hodge et al. (2008) regarding the weak role of the need for relatedness in the  
739 development of athlete burnout (of which exhaustion is key component), we found a non-

740 significant relation between relatedness frustration and exhaustion. This result, along with the  
741 non-significant association between relatedness and dedication, highlights the distal role of  
742 the need for relatedness in the development of athlete outcomes.

743         The consistency and strength with which the experiential states pertaining to the need  
744 for competence predicted positive and negative athlete outcomes as compared to autonomy  
745 and relatedness satisfaction and frustration add to the evidence for its salience in sport and  
746 related settings (e.g., Adie et al., 2012; Gunnell et al., 2013; Ntoumanis, 2001; Reinboth,  
747 Duda, & Ntoumanis, 2004; Standage et al., 2003). In sum, these results correspond to  
748 propositions outlined in SDT (e.g., Vansteenkiste & Ryan, 2013) and subsequent findings in  
749 support of need satisfaction and need frustration being distinct constructs, with need  
750 satisfaction dimensions mainly predicting indices of well-being, and need frustration  
751 dimensions mainly predicting indices of ill-being (e.g., Bartholomew et al., 2011b; Chen et  
752 al., 2015).

### 753 **Limitations, Future Directions, and Conclusion**

754         The results of these studies should be interpreted in light of a few caveats. First, the  
755 cross-sectional nature of the design raises issues of common method variance and prevents  
756 any causal inferences (e.g., Podsakoff, Mackenzie, Lee, & Podsakoff, 2003). Researchers  
757 could overcome this issue by employing longitudinal or experimental research designs and  
758 objective assessments of athlete outcomes (e.g., objective performance, biological indices of  
759 well-being; cf. Quested, Bosch, Burns, Cumming, Ntoumanis, & Duda, 2011). Second, we  
760 provided validity evidence based on internal structure and relations to other variables, but did  
761 not test the evidence for face and content validity. This was done bearing in mind that some  
762 of the original questionnaires that informed the item development process had consulted with  
763 athletes/expert panels (e.g., Bartholomew, Ntoumanis, Ryan, & Thøgersen-Ntoumani, 2011;  
764 Ng et al., 2011). For researchers interested in further examining the third need state of need

765 unfulfillment, testing items with athletes would prove especially useful in understanding how  
766 they differentiate between the three need states (e.g., using think-aloud protocols). Given that  
767 athletes' responses to the items did not distinguish between the constructs of need  
768 unfulfillment, need satisfaction and need frustration, researchers might also benefit from  
769 employing differential data analytic strategies. For example, item response theory (IRT) may  
770 aid the understanding of how athletes respond to the each of the items, and has been  
771 suggested to be suitable approach in the case of research examining the key constructs  
772 embedded within the SDT framework (Standage et al., 2019).

773         Despite these limitations, the present study adds to the literature on motivation in  
774 sport. The PNSS-S is theoretically underpinned measure that captures both the dark and the  
775 bright sides of the athletic experience, via the assessment of the satisfaction and frustration of  
776 athletes' needs for autonomy, competence, and relatedness. Further, in the spirit of open  
777 science and transparency, we recorded our unsuccessful efforts to measure the unfulfillment  
778 of the three needs. Incorporating the new scale in future research alongside the constructs of  
779 interpersonal behaviors, motivation regulations, and outcomes of adaptive and maladaptive  
780 functioning should, therefore, provide a more nuanced understanding of these important and  
781 distinct psychological need states in sport.

782

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## Footnotes

1. Bartholomew et al. (2011) referred to need frustration as “need thwarting” in that manuscript. Thereafter, the term “need frustration” was widely adopted in the SDT literature to refer to one’s personal experience, whereas “need thwarting” was used to refer to the undermining actions of significant others in one’s social context).
2. We also tested all the other models from Study 1 involving the different configurations of need satisfaction and frustration (i.e., Models 13-24). Models 16, 20-23 did not converge. Models 13 and 17 were rejected on the basis of inadequate model-to-data fit. Models 14 and 15 had adequate fit, however, they were rejected due to high correlations between factors. Model 19 demonstrated adequate fit, however, only had one significant loading on the S-factor of competence satisfaction. More importantly, the factor correlation between the two G-factors was -.93, leading to the discriminant validity of the two factors being questioned. The standard errors of the model parameter estimates could not be computed in the case of Model 24.
3. At a request of an anonymous reviewer we ran two additional models in Study 2, with need satisfaction and positive as well as negative outcomes (dedication, positive affect, exhaustion and negative affect), and need frustration and positive as well as negative outcomes (dedication, positive affect, exhaustion and negative affect). There was no evidence of suppression effects for either model. Fit for the model with need frustration and all outcomes was acceptable [ $\chi^2 = 1457.823 (817)$ ,  $p < .001$ , CFI = .93, TLI = .92, SRMR = .05, RMSEA = .05(90% CI .04, .05)]. Competence frustration and relatedness frustration negatively predicted dedication, and autonomy frustration and competence frustration negatively predicted positive affect in a significant manner.

In terms of need satisfaction and negative outcomes, both competence satisfaction and relatedness satisfaction negatively predicted exhaustion and negative affect in a significant manner. However, fit for this model was just under acceptable levels [ $\chi^2 = 1755.823$  (857),  $p < .001$ , CFI = .90, TLI = .89, SRMR = .05, RMSEA = .06(90% CI .05, .06)].

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Table 1

*Goodness-of-fit Statistics for Alternative CFA, ESEM, and Bifactor Models (Study 1)*

Model	$\chi^2$	<i>p</i>	<i>df</i>	CFI	TLI	SRMR	RMSEA [90% CI]
Models involving three need states							
1. Three-factor CFA	2824.822	<.001	986	.70	.69	.08	.08[.08, .08]
2. Nine-correlated factors CFA	2286.183	<.001	953	.78	.77	.08	.07[.06, .07]
3. H-CFA (Three-H, nine-L)	2479.336	<.001	977	.76	.74	.08	.07[.07, .07]
4. H-CFA (one-H,nine-L)	2687.855	<.001	980	.72	.71	.09	.08[.07, .08]
5.Three-factor ESEM	2684.475	<.001	900	.71	.67	.06	.08[.08, .08]
6. Nine-correlated factors ESEM	1319.624	<.001	657	.89	.83	.03	.06[.05, .06]
7. Bifactor CFA (correlated three-G, nine-S)					DNC		
8. Bifactor CFA (one-G, nine-S)	2494.206	<.001	943	.75	.72	.08	.07 [.07, .08]
9. Bifactor CFA (one-G three-S)	2691.925	<.001	946	.72	.69	.13	.08[.07, .08]
10. Bifactor ESEM (correlated three-G, nine-S)	1116.509	<.001	608	.92	.86	.02	.05[.05, .06]
11. Bifactor ESEM (one-G, nine-S)					_*		

12. Bifactor ESEM (one-G, three-S)								_*
Models involving two need states								
13. Two-factor CFA	1406.126	<.001	433	.75	.73	.08	.09	.09[.08, .09]
14. Six-correlated factors CFA	1045.020	<.001	419	.84	.82	.07	.07	.07[.06, .08]
15.H-CFA (two-H, six-L)	1183.338	<.001	427	.81	.79	.08	.08	.08[.07, .08]
16. H-CFA (one-H, six-L)								DNC
17. Two-Factor ESEM	1336.331	<.001	404	.76	.73	.07	.09	.09[.08, .09]
18. Six correlated-factors ESEM	556.471	<.001	294	.93	.89	.02	.05	.05 [.05, .06]
19. Bifactor CFA (two-G, six-S)								DNC
20. Bifactor CFA (one-G, six-S)								DNC
21. Bifactor CFA (one-G, two-S)	1164.733	<.001	403	.81	.78	.13	.08	.08[.07, .08]
22. Bifactor ESEM (correlated two-G, six-S)	458.463	<.001	262	.95	.91	.02	.05	.05[.04, .06]
23. Bifactor ESEM (one-G, six-S)								_*
24. Bifactor ESEM (one-G, two-S)	1028.655	<.001	375	.83	.79	.04	.08	.08[.07, .08]

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*Note.*  $\chi^2$  = Chi-square test of exact fit; CFI = Comparative Fit Index; TLI = Tucker–Lewis index; RMSEA = Root Mean Square Error of Approximation; 90% CI = 90% confidence interval of the RMSEA; CFA = confirmatory factor analysis; H-CFA = Hierarchical CFA; H-factor = higher order factor estimated as a part of hierarchical model; L-factor = lower order factor estimated as a part of hierarchical model; ESEM = exploratory structural equation modeling; G-factor = global factor estimated as part of a bifactor model; S-factor = specific factor estimated as part of a bifactor model; DNC = did not converge; -\* = The standard errors of the model parameter estimates could not be computed. The model may not be identified.

Table 2

*Model Fit for Single-factor CFAs and Subsequent Six-factor ESEM (Study 1)*

Models	$\chi^2$	<i>df</i>	<i>p</i>	CFI	TLI	SRMR	RMSEA [90% CI]
AF CFA							
Initial (5)	15.97	5	.007	.95	.91	.03	.08 [.04, .013]
Final (3)	.000	0	.000	1.00	1.00	.01	.00 [.00, .00]
CF CFA							
Initial and final (4)	2.145	2	.34	1.00	1.00	.01	.02 [.00, .12]
RF CFA							
Initial (6)	19.293	9	.023	.96	.93	.03	.06 [.02, .10]
Final (4)	1.951	2	.377	1.00	1.00	.01	.00[.00, .11]
AS CFA							
Initial (5)	31.520	5	.000	.90	.80	.07	.13[.09, .18]
Final (3)	.000	0	.000	1.00	1.00	.00	.00[.00, .00]
CS CFA							

Initial (5)	29.006	5	.000	.93	.86	.05	.13[.08, .17]
Final (4)	1.935	2	.380	1.00	1.00	.01	.00[.00, .11]
RS CFA							
Initial (6)	17.028	9	.048	.98	.96	.03	.05[.00, .09]
Final (3)	.000	0	.000	1.00	1.00	.00	.00[.00, .00]
Final six-factor ESEM	171.110	99	.000	.97	.94	.02	.05[.04, .06]

*Note.*  $\chi^2$  = Chi-square; CFI = comparative fit index; TLI = Tucker-Lewis Index; SRMR = Root Mean Square Residual; RMSEA = Root Mean Square Error of Approximation; () = number of items in model; Initial = the model with all items; Final = the model with the problematic items removed; *AS* = autonomy satisfaction; *AF* = autonomy frustration; *CS* = competence satisfaction; *CF* = competence frustration; *RS* = relatedness satisfaction; *RF* = relatedness frustration CFA = confirmatory factor analysis. ESEM = exploratory structural equation modeling.

Table 3

*Standardised Factor Loadings and Cross-loadings (Study 1)*

Items	<i>M</i>	<i>SD</i>	Skewness	Kurtosis	Factor Loadings					
					AF	CF	RF	AS	CS	RS
<i>STEM: In my sport, I...</i>										
feel pushed to behave in certain ways	2.17	1.57	1.26	.56	<b>.61***</b>		.22**			
feel forced to follow training decisions	2.87	1.79	.38	-1.29	<b>.84***</b>					
feel forced to do training tasks that I would not choose to do	2.50	1.7	.80	-.54	<b>.71***</b>					
feel like a failure	1.80	1.22	1.88	3.30		<b>.58***</b>				-.20**
feel useless	1.57	1.12	2.26	4.69		<b>.80***</b>				
feel incapable	1.71	1.2	1.94	3.37		<b>.56***</b>		.21*		
feel hopeless	1.48	1.1	2.82	8.00		<b>.79***</b>				
feel disliked	1.50	1.08	2.66	7.13				<b>.73***</b>		
feel excluded	1.71	1.36	2.19	4.20				<b>.36**</b>		

Items	<i>M</i>	<i>SD</i>	Skewness	Kurtosis	Factor Loadings					
					AF	CF	RF	AS	CS	RS
<i>STEM: In my sport, I...</i>										
feel isolated	1.51	1.11	2.46	5.42			<b>.63***</b>			
feel ignored	1.63	1.13	2.22	4.90			<b>.77***</b>			
feel free to make choices with regards to the way I train	5.18	1.55	-0.54	-.53				<b>.60*</b>		
have a say in how things are done	4.77	1.66	-.42	-.57				<b>.89**</b>		
have the freedom to make training decisions	4.77	1.55	-.28	-.56				<b>.69**</b>		
feel that I am capable	5.77	1.21	-1.08	.99		-.30*			<b>.58***</b>	
feel skilled	5.41	1.2	-.68	.50					<b>.86***</b>	
feel that I am improving	5.71	1.18	-1.05	1.22					<b>.34**</b>	<b>.44***</b>
am able to overcome challenges	5.64	1.07	-.83	.98					<b>.40**</b>	<b>.26***</b>
feel supported	5.86	1.14	-1.07	1.26			-.38***			<b>.64***</b>
feel valued	5.54	1.18	-.93	1.25					<b>.54***</b>	<b>.28*</b>
feel cared for	5.66	1.22	-.76	.07						<b>.54***</b>

Items	<i>M</i>	<i>SD</i>	Skewness	Kurtosis	Factor Loadings					
					AF	CF	RF	AS	CS	RS
<i>STEM: In my sport, I...</i>										

*Note.* \* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ . Target factor loadings are in bold. For clarity purposes, only significant cross-loadings over .20 are reported; AS = autonomy satisfaction, AF = autonomy frustration, CS = competence satisfaction, CF = competence frustration, RS = relatedness satisfaction, RF = relatedness frustration.



Table 4

*Internal Consistency and Factor Correlations (Study 1)*

Subscales	Raykov's	1	2	3	4	5	6
	rho						
(1) AS	.78	-					
(2) AF	.77	-.52***	-				
(3) CS	.66	.49***	-.13	-			
(4) CF	.78	-.18**	.44***	-.39	-		
(5) RS	.52	.41***	-.32***	.28**	-.30***	-	
(6) RF	.75	-.34***	.32***	-.35***	.60***	-.26**	-

*Note.* \* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ ; AS = autonomy satisfaction; AF = autonomy frustration; CS = competence satisfaction; CF = competence frustration; RS = relatedness satisfaction; RF = relatedness frustration.

Table 5

*Factor Loadings, Standard Errors, Means, SDs, Kurtosis and Skewness for PNSS-S Items (Study 2)*

Items	Factor loadings						SE	Means	SD	Skewness	Kurtosis
	AS	AF	CS	CF	RS	RF					
<i>STEM: In my sport, I...</i>											
Feel free to make choices with regards to the way I train	<b>.71</b>						.07	5.52	1.97	-1.36	1.58
Have a say in how things are done	<b>.35</b>	-.32					.11	5.19	1.39	-.88	.15
Have the freedom to make training decisions	<b>.52</b>	-.25	.27				.10	5.19	1.39	-.94	.42
Pursue goals that are my own	<b>.71</b>						.08	5.81	1.22	-1.52	2.82
Feel like I can be myself	<b>.63</b>					-.22	.08	5.70	1.30	-1.27	1.47
Feel pushed to behave in certain ways		<b>.72</b>					.05	2.61	1.56	.92	-.26
Feel forced to follow training decisions	-.22	<b>.69</b>					.05	2.86	1.57	.69	-.57
Feel forced to do training tasks that I would not choose to do		<b>.53</b>					.05	2.45	1.45	1.10	.44

Items	Factor loadings						SE	Means	SD	Skewness	Kurtosis
	AS	AF	CS	CF	RS	RF					
<i>STEM: In my sport, I...</i>											
Feel excessive pressure		<b>.56</b>		.29			.06	2.54	1.52	1.05	.19
Must do what I am told		<b>.76</b>		-.21			.05	3.16	1.83	.47	-1.14
Feel that I am capable			<b>.79</b>				.10	5.83	1.16	-1.65	3.36
Feel skilled			<b>.54</b>				.08	5.53	1.17	-1.24	1.95
Am able to overcome challenges	.35		<b>.40</b>				.09	5.76	1.06	-1.57	3.76
Feel confident that I can do well			<b>.45</b>	-.26			.08	5.60	1.12	-1.35	2.38
Feel that I am good			<b>.86</b>				.10	5.62	1.22	-1.39	2.26
Feel like a failure				<b>.58</b>			.09	2.24	1.29	1.24	1.01
Feel useless				<b>.67</b>			.08	2.13	1.21	1.47	2.32
Feel incapable				<b>.71</b>			.10	2.10	1.23	1.51	2.16
Feel hopeless				<b>.77</b>			.10	1.95	1.17	1.65	2.91
Feel supported					<b>.76</b>		.08	6.07	1.25	-1.87	3.28
Feel cared for					<b>.84</b>		.07	5.91	1.22	-1.52	2.24

Items	Factor loadings						SE	Means	SD	Skewness	Kurtosis
	AS	AF	CS	CF	RS	RF					
<i>STEM: In my sport, I...</i>											
Feel connected					<b>.84</b>		.07	5.86	1.16	-1.40	2.08
Feel accepted					<b>.81</b>		.06	5.95	1.16	-1.65	3.19
Like the people around me					<b>.65</b>		.08	5.98	1.16	-1.72	3.42
Feel disliked					<b>.80</b>		.06	2.25	1.23	1.54	2.92
Feel excluded					<b>.74</b>		.05	2.26	1.28	1.51	2.48
Feel isolated					<b>.73</b>		.07	2.32	1.40	1.53	2.48
Feel ignored					<b>.84</b>		.05	2.28	1.30	1.36	1.84
Feel dismissed					<b>.69</b>		.08	2.17	1.22	1.56	2.71

*Note.* Factor loadings in this table are all significant at  $p < .01$ . Target loadings are in bold. For clarity purposes, only cross-loadings over .20 are reported. AS = autonomy satisfaction, AF = autonomy frustration, CS = competence satisfaction, CF = competence frustration, RS = relatedness satisfaction, RF = relatedness frustration.

Table 6

*Factor Correlations and Internal Consistency for PNSS-S subscales (Study 2)*

Subscales	Raykov's rho	1	2	3	4	5	6
(1) AS	.73	-					
(2) AF	.79	-.40	-				
(3) CS	.76	.54	-.37	-			
(4) CF	.78	-.53	.41	-.67	-		
(5) RS	.89	.61	-.43	.67	-.68	-	
(6) RF	.87	-.45	.27	-.52	.70	-.68	-

*Note.* Factor correlations are significant at  $p < .01$ . AS = autonomy satisfaction, AF = autonomy frustration, CS = competence satisfaction, CF = competence frustration, RS = relatedness satisfaction, RF = relatedness frustration. Raykov's composite reliability coefficients are presented on the diagonal of the correlation matrix.

Table 7

*Correlations Between Variables (Study 2)*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 AS	-															
2 AF	-.63**	-														
3 CS	.69**	-.50**	-													
4 CF	-.60**	.60**	-.77**	-												
5 RS	.63**	-.58**	.72**	-.71**	-											
6 RF	-.48**	.45**	-.64**	.74**	-.68**	-										
7 ASup	.76**	-.52**	.67**	-.59**	.63**	-.57**	-									
8 AThw	-.57**	.80**	-.47**	.54**	-.51**	.40**	-.58**	-								
9 CSup	.62**	-.42**	.73**	-.67**	.66**	-.58**	.71**	-.45**	-							
10 CThw	-.57**	.54**	-.70**	.85**	-.67**	.68**	-.65**	.56**	-.75**	-						
11 RSup	.66**	-.59**	.66**	-.60**	.79**	-.53**	.63**	-.55**	.69**	-.61**	-					

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
12 RThw	-.59**	.63**	-.63**	.65**	-.72**	.64**	-.60**	.61**	-.63**	.65**	-.79**	-				
13 Dedication	.57**	-.46**	.67**	-.63**	.57**	-.58**	.63**	-.43**	.63**	-.63**	.51**	-.52**	-			
14 Exhaustion	-.48**	.57**	-.55**	.66**	-.54**	.57**	-.52**	.48**	-.49**	.61**	-.47**	.54**	-.49**	-		
15 PA	.59**	-.56**	.65**	-.63**	.65**	-.52**	.59**	-.51**	.61**	-.60**	.62**	-.61**	.60**	-.57**	-	
16 NA	-.52**	.51**	-.60**	.66**	-.59**	.59**	-.55**	.46**	-.55**	.62**	-.54**	.55**	-.54**	.58**	-.59**	-

*Note.* AS = autonomy satisfaction; AF = autonomy frustration; CS = competence satisfaction; CF = competence frustration; RS = relatedness satisfaction; RF = relatedness frustration; ASup = autonomy support; Athw = autonomy thwarting; CSup = competence support; CThw = competence thwarting; RSup = relatedness support; RThw = relatedness thwarting; PA = positive affect; NA = negative affect.

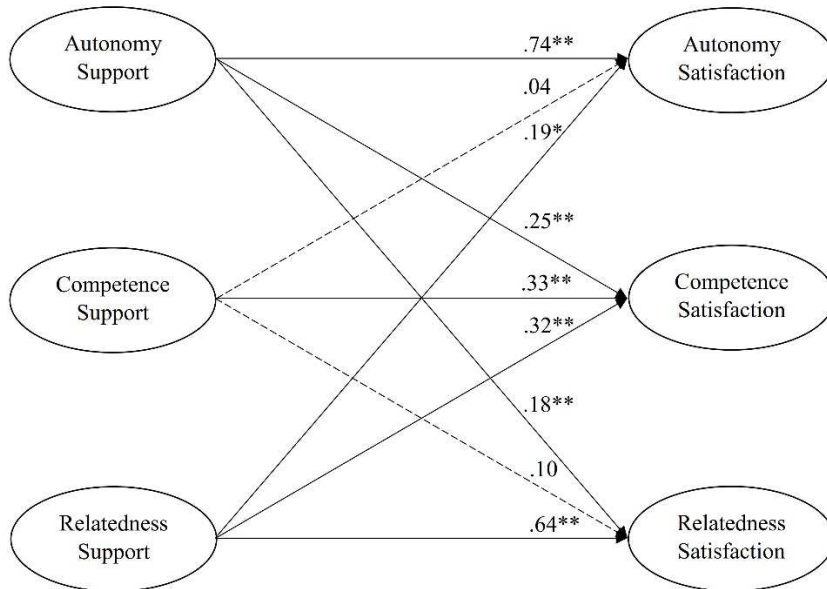


Figure 1. SEM with autonomy, competence, and relatedness support and autonomy, competence, and relatedness satisfaction

Note. Solid lines indicate significant paths; dotted lines indicate non-significant paths.

\*\* $p < .01$ ; \*  $p < .05$



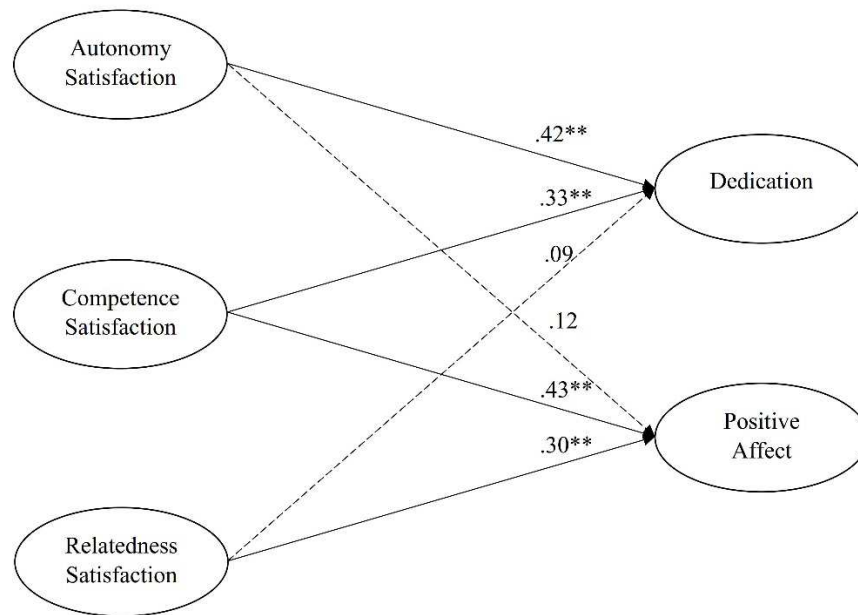
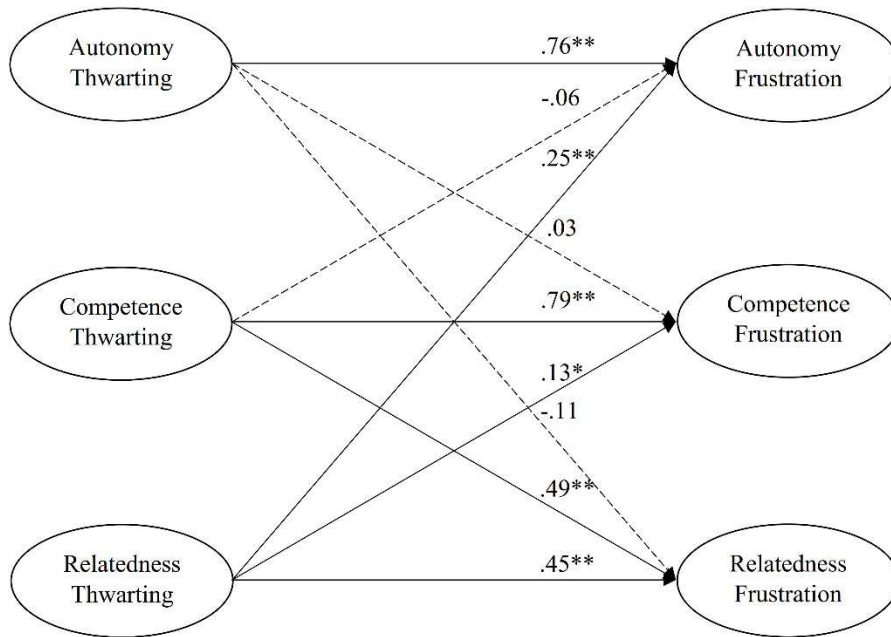


Figure 2. SEM with autonomy, competence, and relatedness satisfaction and positive outcomes

Note. Solid lines indicate significant paths; dotted lines indicate non-significant paths.

\*\* $p < .01$  ; \*  $p < .05$



*Figure 3.* SEM with autonomy, competence, and relatedness thwarting and autonomy, competence, and relatedness frustration

*Note.* Solid lines indicate significant paths; dotted lines indicate non-significant paths.

\*\* $p < .01$  ; \*  $p < .05$

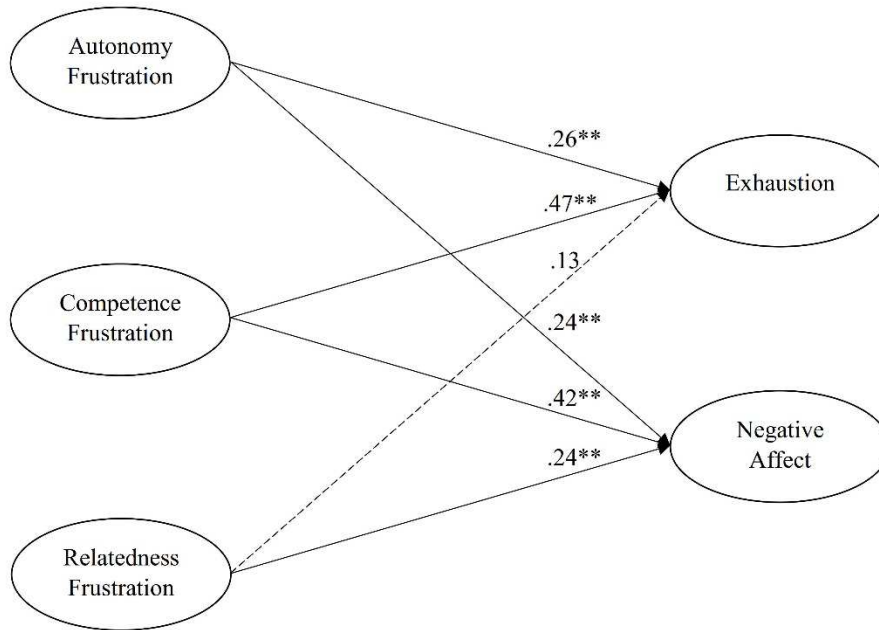


Figure 4. SEM with autonomy, competence, and relatedness frustration and negative outcomes

Note. Solid lines indicate significant paths; dotted lines indicate non-significant paths.

\*\* $p < .01$ ; \*  $p < .05$

- Psychological need states proposed to comprise satisfaction, frustration, and unfulfillment.
- An attempt to develop a new tripartite measure of athlete need states was described.
- No empirical support was found for a tripartite conceptualisation of need states.
- Lack of evidence for need unfulfillment as the third need state is discussed.
- Development and initial validation of a measure of athletes' experiences of satisfaction and frustration of the three needs is presented.

**AUTHOR DECLARATION**

Declarations of interest: none

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