

Re-Applying the Basic Psychological Needs in Exercise Scale to Various Portuguese Exercise Groups: An Analysis of Bifactor Models and Contextual Invariance

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Abstract

This research explored the nature of basic psychological needs in physical activity settings by applying relatively advanced methodological procedures for psychometric assessment. We first re-examined the Basic Psychological Needs in Exercise Scale (BPNES) by reviewing its applicability for physical activity domains among Portuguese respondents. We demonstrated the use of Bifactor Confirmatory Factor Analysis (CFA) and Exploratory Structural Equation Modeling (ESEM) and discussed the practical implications of these models. Next, we tested contextual measurement invariance in order to examine needs universality. Our participants were gym exercisers ($n = 1935$), physical education students ($n = 1449$), and athletes ($n = 1631$), all of

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whom completed the adapted and validated version of the scale in their respective practice physical activity domains. All models under analysis displayed acceptable to excellent fit; the bifactor ESEM model displayed the best fit. We conducted ancillary bifactor measures to assess scale dimensionality and found that the BPNES is best interpreted as a multidimensional instrument. Through testing for multigroup analysis, the bifactor ESEM did not show contextual invariance. In conclusion, the BPNES should be predominantly used as a multidimensional instrument when assessing basic needs in separate physical activity domains. Basic psychological needs are perceived differently between seemingly similar physical activity contexts. Researchers should measure basic needs as a global factor and use context validated sub-scales.

Keywords

exercise, physical education, sport, need satisfaction, exploratory analysis, measurement invariance

Introduction

Among theories of motivation and behavior, Self-Determination Theory (SDT; Ryan & Deci, 2017) has been increasingly applied to health promotion domains to provide a better understanding of factors responsible for behavior commitment or withdrawal (Vlachopoulos & Neikou, 2007). According to SDT, self-determined behaviors originate from within and are fully endorsed by the individual, corresponding to optimal functioning and greater well-being (Deci & Ryan, 2000). Nevertheless, self-determined behavior is contingent on the degree to which Basic Psychological Needs (BPN) are satisfied. In other words, motivation is dependent on how someone experiences basic needs fulfillment.

SDT posits the existence of three universal needs, innate to all human beings, and suggests that these must be continuously satisfied for optimal behavior and psychological well-being (Ryan & Deci, 2017). The need for *Autonomy* reflects an individual's desire to be volitional and is experienced when individuals perceive their behavior as self-endorsed (Ryan & Deci, 2017). The need for *Competence* involves feeling effective and capable of improving and mastering new skills (Deci & Ryan, 2008). Last, the need for *Relatedness* refers to feeling connected with significant others (Deci & Ryan, 1985). These psychological needs are held to mediate the effect of contextual factors and the level of self-determined motivation in one's behavior (Ryan & Deci, 2017; Vallerand, 1997). In other words, the environment does not impact directly on motivation, but is accountable to how BPN are being satisfied. In this regard, BPN stands at the "heart" of SDT, and its assessment constitutes a crucial role when analyzing self-determined behavior (Deci & Vansteenkiste, 2004).

Measuring Basic Psychological Needs in Exercise

To date, several instruments have been developed and applied in order to assess BPN satisfaction. For example, Wilson et al. (2006) developed the Psychological Need Satisfaction in Exercise (PNSE) scale, and, more recently, Rodrigues et al. (2019) validated the Basic Psychological Need Satisfaction and Frustration Scale in Exercise (BPNSFS-E). However, the Basic Psychological Need in Exercise Scale (BPNES) created and validated by Vlachopoulos and Michailidou (2006) continues to be the most widely used instrument in assessing autonomy, competence, and relatedness satisfaction in physical activity domains. Thus, the BPNES has been translated and validated for several cultures, namely: Portuguese (Moutão et al., 2012), Spanish (Moreno-Murcia et al., 2012; Sánchez & Núñez, 2007), Greek (Vlachopoulos & Neikou, 2007), British (Vlachopoulos & Neikou, 2007), Brazilian (Costa et al., 2017), and Turkish (Vlachopoulos et al., 2013). In addition, research studies have consistently shown this instrument to be equivalent across gender (Vlachopoulos, 2008) and cultures (Cid et al., 2016; Costa et al., 2017; Vlachopoulos et al., 2010, 2013). Specifically in Portugal, this scale has been psychometrically evaluated in several domains, such as exercise (Moutão et al., 2012), physical education (Pires et al., 2010), and sports (Monteiro et al., 2016). Likewise, hierarchical models with constructs converging to a composite score (i.e., BPN satisfaction) have been tested and acknowledged by empirical studies (Moutão et al., 2012; Vlachopoulos & Neikou, 2007).

In some studies, this instrument has shown some content issues regarding item cross-loadings (Moutão et al., 2012; Pires et al., 2010). In these studies, item 9 has constantly loaded into more than one factor (i.e., autonomy and competence), showing that respondents may have problems interpreting this item or that it may have not been translated properly. This circumstance urges a new measurement analysis in order to support and retain the applicability of the parsimonious original 12-item scale. In addition, although this scale has shown measurement invariance between several group characteristics, to the best of our knowledge, no prior research has tested the contextual measurement invariance of the BPNES. In other words, studies have only shown measurement invariance between groups with explicit distinct demographic characteristics (e.g., female vs. male), but no research has addressed invariance within similar but different settings (e.g., exercise vs. sports). This research gap should be filled in order to support the theoretical universality of BPN constructs in all human beings, as proposed by Ryan and Deci (2017). We suspect that this insufficient contextual analysis may be related to the fact that few cultures have used and validated the BPNES in different domains. As previously mentioned, only Portugal has translated and validated the BPNES for use in exercise, physical education (PE), and sport contexts. Hence, scale invariance testing, at least for Portuguese use, is now needed and should be carried out by reviewing BPNES

measurement analysis from bottom-to-top, while performing several exploratory and confirmatory analysis, and introducing bifactor model specifications.

Methodological Advances: Factor Structure Analysis

Exploratory Factor Analysis (EFA) is one of the most frequently used statistical procedures in the behavioral and social sciences. However, it is also one of the most disapproved, due to its data driven and “exploratory” nature (Kahn, 2006; Preacher & MacCallum, 2003). This statistical method implies comparing multiple models for explaining variance, based on a variety of criteria, until the model with the greatest factor suitability to the data is retained. Worries about this exploratory process have led researchers, although erroneously, to limit their use of EFA and focus mainly, instead, on Confirmatory Factor Analysis (CFA). However, as stated by Marsh et al. (2014), the difference between EFA and CFA is that EFA freely estimates all cross-loadings, finally revealing a better suited factor structure than CFA. Hence, the recent latent modeling advances associated with CFA have not been available with EFA (Morin et al., 2016).

Examining scale development and validation, CFA has become the ever-present test of factor structures (Howard et al., 2018). Its major advantage in psychological assessment is the possibility of directly comparing relationships among constructs (Marsh et al., 2014). However, as stated by Howard et al. (2018), instruments that fail to meet appropriate fit adjustment standards in CFA are considered of little applicable worth. This has led to the need for the Independent Cluster Model in CFA (ICM-CFA) in which cross-loadings between items and non-target factors are presumed to be approximately zero. In several cases, item-level CFA has been too restrictive and has failed to provide clear support for instruments that apparently had been well established in EFA investigations (Marsh et al., 2010). Considering the advantages and disadvantages of EFA and CFA, one wonders why researchers continue to analyze CFA models, since they have been shown to present inadequate and biased results. One answer could be related to researchers’ mistaken belief that many recent advances in latent variable modeling require CFA (Marsh et al., 2010). In this research, we conducted Exploratory Structural Equation Modeling (ESEM), illustrating its better suitability compared to more the restricted CFA analysis in social sciences research.

ESEM (Asparouhov & Muthén, 2009; Marsh et al., 2014), a combination of EFA, CFA, and Structural Equation Modeling (SEM) into a single model, has proven to be an all-embracing methodology. Hence, ESEM encompasses assets from each technique into a single analytic measurement in which EFA factors integrating cross-loadings can cohabitate with factors defined according to ICM-CFA assumptions (Marsh et al., 2014).

As stated by Asparouhov and Muthén (2009): “*in ESEM, the loading matrix rotation gives a transformation of both measurement and structural coefficients. . . ESEM provides standard errors for all rotated parameters. Overall tests of model fit are also obtained.*” Likewise, unlike EFA analysis, which is typically followed by a CFA analysis, ESEM analysis does not require follow-up with a SEM model, since ESEM has all of the SEM features contained within it (Asparouhov & Muthén, 2009). In this regard, ESEM may improve model testing, compared to EFA, CFA, and SEM as separate statistical approaches. In this discussion and research example, we also address the emerging use of bifactor models and the multidimensionality present in complex measurement instruments (Morin et al., 2016).

In bifactor CFA models, each item loads directly on both a general factor and on specific factors. Hence, when analyzing the model, the general factor has its own loadings rather than indirect loadings via the specific factor, as happens in hierarchical models. Specific factors represent common factors measured by the items that potentially explain item response variance not accounted for by the general factor (Reise et al., 2010). Although hierarchical models are common in the literature, as shown by Byrne (2016), bifactor models are not. This may be due to the highly restrictive implicit norms that may be limited in practice (Morin et al., 2016). Nevertheless, a bifactor ESEM model can represent a more flexible way to analyze whether the presence of a global factor is more representative of the underlying data than the specification of three-correlated but distinct factors.

The novel incorporation of bifactor models in ESEM proved an opportunity to measure two sources of construct-relevant psychometric indicators (Morin et al., 2016). First, ESEM measures the bifactorial nature of the constructs being assessed, that is, the co-existence of a global factor (e.g., BPN satisfaction) and specific factors (e.g., autonomy, competence, and relatedness satisfaction) within the same measurement model. Second, the ESEM measures the feeble nature of indicators which tend to include at least some degree of relationship with non-target constructs (Morin et al., 2016). The bifactor ESEM method could represent the most comprehensive and flexible model possible, more than either EFA, CFA, or SEM alone; and ESEM can be implemented while relying on a confirmatory bifactor target rotation method (Morin et al., 2016; Rodriguez et al., 2016).

Current Research

Grounded in SDT (Ryan & Deci, 2017), this study aimed to review the psychometric properties of the BPNES in a large sample of Portuguese participants engaged in several physical activity domains. Our first objective was to examine the BPNES factor structure, reviewing its applicability in the physical activity domain, by conducting bifactor CFA and ESEM analyses. To the best of our

knowledge, no study has yet directly compared these approaches for estimating the strength of a general factor in the physical activity domain. Specifically, the bifactor component of this research directly tests whether the items assessing BPN satisfaction load onto a single global factor, while also allowing an estimation of specific factors for each BPN. In other words, should SDT be fully corroborated, this global factor would be expected to prove a better suited estimate of the overall satisfaction of BPN than measuring each need separately. Our second objective was to test context invariance between sport, exercise, and physical education (PE). Tests of multi-group invariance have crucial implications for construct validity, as they tease apart the degree to which group differences in observed scores reflect actual differences in the latent constructs or may be attributable to other factors (Chen, 2008).

In the context of the foregoing literature review, we hypothesized that: (a) the BPNES would sustain factor validity in all models, showing that the BPNES is a reliable instrument for measuring BPN satisfaction as both a composite factor or as three-correlated specific factors; and (b) there would be BPNES measurement invariance in all three of these participants' physical activity domains, as stated theoretically within SDT (Ryan & Deci, 2017) and shown empirically in prior research with other groups (Vlachopoulos, 2008; Vlachopoulos et al., 2013).

Method

Participants

Data were collected from a convenience sample of 5,015 Portuguese participants engaged in different physical activity settings (see Table 1 for descriptive statistics). Concerning athletes, data were collected from footballers and swimmers, since they represent the two most practiced sports in Portugal (Seabra et al., 2007). PE participant responders were students ranging from sixth grade to high school. Lastly, gym exercisers were active members of private gym and health clubs.

We obtained informed consent from all individual participants included in the study. Parents and legal guardians who agreed to the participation of all participants under the age of 18 years gave written informed consent. In addition, the research protocol for this study was in accordance with the ethical

Table 1. Sample Characteristics.

	N	F	MIN-MAX	M ± SD
Athletes	1631	834	13-36	17.17 ± 3.66
Exercisers	1935	987	16-73	32.13 ± 1.49
Students	1449	962	10-19	13.63 ± 1.34

Note: N = sample size; F = Female; MIN-MAX = age range; M ± SD = age mean and standard deviation.

standards of our institutional research committee (reference number: UID/DTP/04045/2013) and adherent to the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Data was collected between January 2017 until March 2020 (before lockdown in Portugal).

Procedures

After gaining ethical approval for the study, we contacted sport coaches, school boards, and gym managers to request data collection. Regarding data collection procedures, all participants completed the BPNES before their physical activity training session or class. Trained researchers administered the instrument, providing general survey instructions prior to participants starting the survey. Time to complete the questionnaire was approximately seven minutes.

Instruments

All participants completed the BPNES (Vlachopoulos & Michailidou, 2006) as adapted and validated to their physical activity domain of practice. Specifically, athletes completed the sports version (Monteiro et al., 2016), students completed the PE version (Pires et al., 2010), and gym exercisers completed the exercise version (Moutão et al., 2012). The BPNES was used to measure the extent to which respondents perceived their basic psychological needs to have been fulfilled in their organized physical activity settings. The BPNES scale comprises 12 items divided into three subscales, with four items per subscale, to measure autonomy (e.g., “*I feel that the way I...is the way I want to*”), competence (e.g., “*I am able to meet the requirements of my ... program*”), and relatedness (e.g., “*My relationships with the people I...with are close*”) satisfaction. Responses were provided on a five-point Likert scale anchored from 1 (I do not agree at all) to 5 (I completely agree).

Statistical Analysis

Factor Structure

We performed all analyses using the Robust Maximum Likelihood (MLR) estimator available in Mplus 7.4 (Muthén & Muthén, 2010). Previous theoretical (Ryan & Deci, 2017) and empirical (Cid et al., 2019; Monteiro et al., 2016; Teixeira et al., 2018) studies have supported modeling the broad use of a global score (i.e., BPN satisfaction) or modeling according to specific factors (i.e., autonomy, competence, and relatedness). Therefore, we tested four configurations of the factor structure, namely: three-correlated factors through CFA and ESEM and a bifactor through CFA and SEM.

Regarding the maximal parameters to be estimated (i.e., 40 parameters in bifactor model specifications), Kline (2016) recommends a 10:1 ratio

(participants per parameter to be estimated), which was performed in present study. As a complementary sample size analysis, G*Power v3.1 software (Faul et al., 2009) was used to calculate the minimum required sample size, considering the following inputs: anticipated effect size of $f^2 = 0.01$, $\alpha = 0.05$, and statistical power = 0.95, suggesting a minimum of approximately 300 participants, which was respected in this study.

In CFA models, items were only allowed to load on their predefined factors, suppressing cross-loadings on unintended factors. In addition, all specific factors were allowed to correlate. In the ESEM model, we used oblique target rotations to test ESEM models. That is, factors were defined in a manner similar to the CFA models, but we allowed cross-loadings to be estimated without any restrictions while postulating them to be close to zero. In bifactor CFA models, items were loaded onto their predefined specific factors and onto a global factor, and all specific factors were allowed to correlate freely. In the bifactor ESEM model, we conducted the analysis similar to the bifactor CFA model, but we allowed all cross-loadings for the specific factors to be freely estimated using oblique rotations.

Chi-square statistics are commonly used for testing measurement model fit. However, due to their sensitivity to sample size and model specifications (Hair et al., 2019), we considered several common goodness-of-fit indexes to assess model adequacy, namely the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square error of Approximation (RMSEA) and its respective Confidence Interval at 90% (CI 90%), and Standardized Root Mean Residual (SRMR). For the CFI and TLI, values ≥ 0.90 and ≥ 0.95 are typically interpreted to reflect acceptable and excellent fit, respectively (Byrne, 2016; Hair et al., 2019; Marsh et al., 2004). For the SRMR and RMSEA, values of ≥ 0.80 and ≥ 0.60 were indicative of reasonable and good fit to the data respectively (Marsh et al., 2004, 2013). However, Marsh et al. (2013) emphasized that these are rough guidelines, since applications of ESEM and bifactor models are scarce, and the relevance of these indices and the proposed cutoff scores are not clear.

For assessing internal consistency in the three-correlated model solutions, we calculated Raykov's composite reliability coefficient (Raykov, 1997) for the subscale scores, considering values ≥ 0.70 as acceptable (Nunnally, 1978). For bifactor models, we considered the omega composite reliability coefficient (McDonald, 1970), since it has the advantage of taking into account the strength of association between items and the specific factors, as well as item-specific measurement error (Gignac & Watkins, 2013; Padilla & Divers, 2016).

Multigroup Analysis

Model selection for multigroup analysis between context were assessed according to the Satorra-Bentler Scaled chi-square difference test (Satorra & Bentler,

2010). Significant differences between constrained and freely estimated model were considered, indicating a preference for the freely estimated model for measurement invariance analysis.

To test measurement invariance between contexts, the best model fit resulting from the factor structure analysis was initially examined in all groups separately. Then several levels of measurement invariance were measured according to Morin et al. (2016) and Liu et al. (2017). There are essentially four levels of measurement invariance and each of these levels builds upon the previous level by introducing additional equality constraints on the model parameters to achieve stronger forms of invariance. As each set of new parameters is tested, the parameters known to be invariant from previous levels are constrained. Hence, the process of analyzing measurement invariance was essentially the testing of a series of increasingly restrictive hypotheses. These levels were: configural invariance (i.e., factor structure is the same between groups; same items associated with the same factors); weak factorial invariance (i.e., factor structure and factor loadings are equal between groups); strong invariance (i.e., item factor structure, factor loadings, and item thresholds are equal between groups), and; strict factorial invariance (i.e., item factor structure, factor loadings, item thresholds, and item residuals are equal between groups).

Model comparisons were made according to several assumptions: (a) differences in CFI and TLI would be ≤ 0.010 for configural invariance (Marsh et al., 2010), supplemented by a change of ≤ 0.015 in RMSEA or a change of ≤ 0.030 in SRMR would indicate invariance; (b) for weak factorial, strong and strict factorial invariance, e, a change of ≤ 0.010 in CFI, supplemented by a change of ≤ 0.015 in RMSEA or a change of ≤ 0.010 in SRMR would indicate acceptable criteria for invariance (Chen, 2008). It is worth mentioning that these are rules of thumb since the application of multigroup analysis using bifactor CFA or ESEM are uncommon (Marsh et al., 2013). Among the indexes presented for acceptable measurement invariance, CFI was chosen as the main criterion because RMSEA and SRMR tend to over reject an invariant model when sample size is small, particularly when using SRMR for testing loading or residual variance invariance (Chen, 2008).

Results

Factor Structure

Fit indexes of the four models for the BPN psychometric properties are exhibited in Table 2. The three-correlated factors of CFA achieved an acceptable level of fit to the data. Hence, the three-correlated factors of the ESEM model, and the bifactor CFA and the bifactor ESEM model solutions achieved excellent fit (CFI and TLI $< .950$; and RMSEA $> .060$).

Table 2. Model Fit Indexes.

Model	χ^2	df	CFI	TLI	SRMR	RMSEA [90% CI]
1. Three-correlated factors CFA	775.208*	51	.946	.930	.042	.053 [.050, .057]
2. Three-correlated factors ESEM	226.873*	33	.985	.971	.014	.034 [.030, .039]
3. Bifactor CFA	467.921*	42	.968	.950	.030	.045 [.041, .049]
4. Bifactor ESEM	141.566*	24	.991	.976	.010	.031 [.026, .036]
5. Bifactor ESEM – Athletes	159.839*	24	.969	.915	.016	.059 [.050, .068]
6. Bifactor ESEM – Exercisers	55.071*	24	.994	.983	.010	.026 [.017, .035]
7. Bifactor ESEM – Students	83.903*	24	.985	.958	.015	.041 [.032, .051]

Note: χ^2 = chi-square test; df = degrees of freedom; CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; SRMR = Standardized Root Mean Square Residual; RMSEA = Root Mean Squared Error of Approximation; 90% CI = 90% Confidence Interval of RSMEA.

* $p < .001$.

Table 3. Correlation Matrixes.

	Three-correlated factor models			Bifactor models		
	1	2	3	1	2	3
1. Autonomy	1	.54**	.64**	1	.21**	.18*
2. Competence	.55**	1	.33**	.49**	1	-.14
3. Relatedness	.76.**	.40**	1	.85**	.53**	1

Note: correlations between factors in CFA models are below oblique line; correlations between factors in ESEM models are above oblique line;

** $p < .001$; * $p < .05$.

Table 3 shows correlation matrixes, and Table 4 displays factor loadings from the three-correlated factors of the CFA and ESEM models. All correlations were significant, and items loaded accordingly to targeted factors in both models, showing values greater than 0.50. In the ESEM model, we found several cross-loadings. However, cross-loadings displayed differences below 0.15, presenting an acceptable indication of distinct factors. With respect to the composite reliability coefficients, results show scores above acceptable in the three-correlated factors of CFA (CR = .77 to .83) and ESEM (CR = .73 to .83) solutions.

Results from the bifactor CFA and ESEM models are exhibited in Table 5. In the bifactor CFA model, results items tended to load greater on the global factor ($\lambda = .41$ to .68; $M = .53$), compared to the specific factors ($\lambda = .06$ to .63; $M = .36$). Specifically, autonomy and relatedness items tended to load greater on the global factor compared to competence items which were more indicative of its specific factor. With respect to the omega composite reliability, values

Table 4. Factor Loadings of Three-Correlated Factors Models.

	CFA		ESEM	
	λ	AUTO λ	COMP λ	RELA λ
<i>Autonomy</i>	<i>.77</i>	<i>.73</i>		
Item 1	.65**	.76**	-.04*	-.08**
Item 4	.71**	.71**	.04**	-.01
Item 7	.69**	.54**	-.06**	.24**
Item 10	.63**	.51**	.12**	.06*
<i>Competence</i>	<i>.83</i>		<i>.83</i>	
Item 2	.73**	.07**	.72**	-.08**
Item 5	.77**	-.01	.78**	-.01
Item 8	.68**	-.05*	.67**	.10**
Item 11	.75**	-.04	.77**	.02
<i>Relatedness</i>	<i>.78</i>			<i>.74</i>
Item 3	.72**	.18**	.07**	.52**
Item 6	.69**	-.10**	-.05**	.85**
Item 9	.70**	.25**	.08**	.45**
Item 12	.65**	-.08	.01	.74**

Note: AUTO = Autonomy; COMP = Competence; RELA = Relatedness; λ = factor loadings; target loadings are in bold; composite reliability coefficients are in italic; ** $p < .001$; * $p < .05$.

showed higher scores in the global factor ($\omega = .72$) compared to the specific factors ($\omega_{\text{autonomy}} = .01$; $\omega_{\text{competence}} = .10$; $\omega_{\text{relatedness}} = .07$).

In the bifactor ESEM model, items tended to load similarly on the global factor ($\lambda = .37$ to $.64$; $M = .50$), compared to the specific factors ($\lambda = .23$ to $.70$; $M = .49$). However, similar to the bifactor CFA model, autonomy and relatedness satisfaction items tended to show higher factor loadings on a global factor compared to competence satisfaction (see Table 5). With respect to the omega composite reliability, values showed higher scores in the global factor ($\omega = .92$) compared to the specific factors ($\omega_{\text{autonomy}} = .15$; $\omega_{\text{competence}} = .90$; $\omega_{\text{relatedness}} = .56$). Intriguingly, correlations between specific constructs were all significant in the bifactor CFA model but not in the bifactor ESEM model (see Table 4). Considering current results from the bifactor models, deeper analyses were needed to understand item dimensionality.

Ancillary Bifactor Measures

To obtain an ancillary bifactor measure using standardized estimates, standardized values were fed back into Mplus as starting values. Regarding dimensionality, several criteria were considered, namely: (a) General Explained Common Variance (ECV_{GEN}) and Specific (ECV_{SPECIFIC}); (b) Percent of Uncontaminated

Table 5. Factor Loadings and Uniqueness of Bifactor Models.

	Bifactor CFA				Bifactor ESEM					
	SF λ	GF λ	δ	IECV β	AUTO λ	COMP λ	RELA λ	GF λ	δ	IECV β
<i>Autonomy</i>										
Item 1	.49**	.59**	.42**	.60	.42**	-.01	-.02	.60**	.47**	.67
Item 4	.19**	.68**	.50**	.93	.26**	.05*	-.01	.66**	.49**	.87
Item 7	.11*	.67**	.54**	.97	.10	-.08**	.12*	.67**	.52**	.98
Item 10	.06	.63**	.60**	.99	.11	.06	-.04*	.64**	.58**	.97
<i>Competence</i>										
Item 2	.60**	.41**	.47**	.32	.09*	.61**	-.05*	.40**	.46**	.30
Item 5	.66**	.42**	.39**	.29	.11**	.69**	.02	.38**	.37**	.23
Item 8	.53**	.43**	.54**	.40	-.15**	.52**	-.02	.46**	.50**	.44
Item 11	.63**	.42**	.43**	.31	-.07*	.61**	-.04*	.43**	.43**	.33
<i>Relatedness</i>										
Item 3	.36**	.59**	.52**	.73	.17**	.06**	.43**	.53**	.50**	.60
Item 6	.63**	.46**	.40**	.35	-.07*	-.10**	.56**	.48**	.40**	.42
Item 9	.27**	.64**	.52**	.85	-.02	.01	.27**	.64**	.52**	.85
Item 12	.53**	.45**	.52**	.41	-.05	-.04*	.51**	.46**	.52**	.45

Note: SF = Specific Factor; GF = Global Factor; AUTO = Autonomy; COMP = Competence; RELA = Relatedness; IECV β = Individual Explained Common Variance coefficients; λ = factor loadings; δ = uniqueness; target loadings are in bold.

** $p < .001$; * $p < .05$.

Correlations (PUC); and (c) Individual Explained Common Variance (IECV_{GEN}). These analyses were carried out in both bifactor CFA and bifactor ESEM models.

ECV_{GEN} is a unidimensional index, explaining the proportion of common variance across items explained by the general factor. According to Stucky and Edelen (2015), $ECV \geq 0.85$ suggests that an instrument is sufficiently unidimensional to warrant a one-factor model. After reusing standardized values in the model, results for the bifactor CFA showed: $ECV_{GEN} = 0.56$; $ECV_{autonomy} = 0.24$; $ECV_{competence} = 0.22$; and $ECV_{relatedness} = 0.18$. For the bifactor ESEM model, a comparable pattern appeared: $ECV_{GEN} = 0.57$; $ECV_{autonomy} = 0.04$; $ECV_{competence} = 0.25$; and $ECV_{relatedness} = 0.14$. In this regard, it seems that the BPNES may present multidimensional specifications.

Higher PUC values are representative of less bias in structural coefficients, meaning that it is more permissible to treat the scale as unidimensional (Reise, Scheines, et al., 2013). When PUC scores are >0.80 , ECV_{GEN} values are less important in predicting bias; when PUC values are <0.80 , ECV_{GEN} values >0.60 , and $\omega_H >0.70$, the presence of some multidimensionality may not be severe enough to disqualify interpreting the instrument as primarily unidimensional (Reise, Bonifay, et al., 2013). As stated by Rodriguez et al. (2016), when ECV and PUC are >0.70 , relative bias will be slight and the common variance

Table 6. Multigroup analysis of the Bifactor ESEM specification.

Model	χ^2	$\Delta\chi^2$	df	Δdf	CFI	ΔCFI	TLI	ΔTLI	RMSEA	$\Delta RMSEA$
<i>Exercise – Physical Education</i>										
Configural Invariance	137.620*	–	48	–	.990	–	.973	–	.033	–
Weak Factorial Invariance	325.145*	187.525	80	22	.979	.011	.953	.020	.041	.009
<i>Physical Education–Sport</i>										
Configural Invariance	242.736*	–	48	–	.977	–	.936	–	.051	–
Weak Factorial Invariance	536.503*	293.767	80	22	.945	.032	.909	.027	.061	.010
<i>Sport–Exercise</i>										
Configural Invariance	208.311*	–	48	–	.983	–	.954	–	.043	–
Weak Factorial Invariance	432.025*	223.714	80	22	.963	.020	.939	.015	.050	.007
<i>Across all groups</i>										
Configural Invariance	151.373*	–	72	–	.984	–	.955	–	.043	–
Weak Factorial Invariance	893.006	741.633	136	64	.944	.040	.918	.037	.058	.015

Note: χ^2 = chi-square; $\Delta\chi^2$ = difference in χ^2 ; df = degrees of freedom; Δdf = differences in df; CFI = Comparative Fit Index; ΔCFI = differences in CFI; RMSEA = Root Mean Squared Error of Approximation; $\Delta RMSEA$ = differences in RMSEA.

* $p < .001$.

can be seen as essentially unidimensional. In this regard, we used the Hammer (2016) calculator to assess the PUC value. Examining the current results for the bifactor CFA ($PUC = .73$; $ECV_{GEN} = .56$; $\omega = .72$) and the bifactor ESEM ($PUC = .73$; $ECV_{GEN} = .57$; $\omega = .90$), the BPNES may be a multidimensional instrument since indexes are below or relatively equal to cutoffs.

The $IECV_{GEN}$ tells how strongly each item measures the general dimension. As cutoffs, values near 1 indicate that an item only reflects the general dimension, and values > 0.50 indicate that an item reflects the general dimension more than a specific dimension (Stucky and Edelen (2015). Examining these results, six of the 12 items measured the general dimension more than the specific dimension (see Table 4). In fact, five items were very strong measures of the general factor: specifically, three items assessing autonomy and two measuring relatedness. Once more, current results showed that the BPNES could be better represented as a multidimensional instrument.

Multigroup Analysis

After calculating the Satorra-Bentler Scaled chi-square difference test between the bifactor CFA and bifactor ESEM models ($CD = 1.61$; $TRd = 299.82$; $\Delta df = 18$; $p < .001$), the bifactor ESEM model was used to test measurement invariance between groups, since it provided a better fit to the data. Results failed to confirm our hypothesis, since the model did not display invariance criteria (see Table 6). As seen, multi-group analysis between contexts did not achieve weak factorial invariance (ΔCFI and $\Delta TLI > .01$; $\Delta RMSEA > .015$); hence, we did not move ahead to the strong invariance assumption analysis.

Discussion

Based on SDT (Ryan & Deci, 2017) and its relationship to BPN, our current study explored the multidimensionality of the BPNES (Vlachopoulos & Michailidou, 2006) among different participants engaged in several physical activity domains, and, secondarily, tested BPNES applicability across Portuguese exercisers, students, and athletes in its ability to support the universality tenets of BPN satisfaction. We performed our analysis based on a recently developed bifactor ESEM approach that combines EFA, CFA, and SEM to conduct a more comprehensive test of the universality of SDT constructs. Overall, our results provided support for the applicability of the BPNES within the physical activity domains, considering a global factor (i.e., BPN satisfaction) as a primarily measure.

We believe that our findings may stand as important evidence for researchers interested in gaining a deeper understanding of motivation research grounded in SDT, which is particularly important in Portugal where research in sport and exercise psychology is flourishing. No prior study, however, had examined the BPNES psychometric properties in a Portuguese population using bifactor model specifications and tested the scale across several domains in the physical activity context.

Factor Structure

Our first step was to review the factor structure of the BPNES, assessing several distinct models. Starting with the three-correlated factors from CFA and ESEM, both models fit the data well, according to several authors (Byrne, 2016; Marsh et al., 2004). Interestingly, composite reliability scores from the CFA factors were similar to the targeted factors in the ESEM model. Items loaded according to targeted factors in both models, showing values greater than 0.50, explaining at least 25% of variance (Hair et al., 2019). In the ESEM model, although several items showed significant cross-loadings, no cross-loadings displayed differences above 0.15, presenting an acceptable indication of distinct factors, as stated by several prior authors (Byrne, 2016; Hair et al., 2019). Looking at composite reliability coefficients, our results showed scores to be above acceptable in the three-correlated factors in CFA and SEM models (see Table 3). Sánchez-Oliva et al. (2017) showed similar results, both for goodness-of-fit indexes and composite reliability coefficients when analyzing BPN satisfaction at work. Hence, the acceptable model fit of the three-correlated CFA models is in line with findings in previous BPNES measurement studies in exercisers and athletes (Monteiro et al., 2016; Moutão et al., 2012; Vlachopoulos, 2008).

With respect to the bifactor models, both CFA and ESEM exhibited excellent fit to the data, as suggested by Morin et al. (2016). Past literature conducting

bifactor CFA and ESEM models considering SDT constructs have shown comparable results (Cece et al., 2019; Myers et al., 2014; Sánchez-Oliva et al., 2017) regarding model fit. Thus, both methods seem to be robust when examining the factor structure of a measure of motivation grounded in SDT. Present findings revealed that BPNES items provided a better reflection of participants' global BPN satisfaction than of their specific need for autonomy, competence, and relatedness. This statement is based on the fact that, in the bifactor CFA model, six out of 12 items measured the general dimension more than the specific dimension. Moreover, five items were very strong measures of the general factor, specifically three items assessing autonomy and two measuring relatedness. In addition, omega coefficient and PUC values have shown possible multidimensional specifications, according to several authors (Gignac & Watkins, 2013; Rodrigues et al., 2016). Interestingly, similar patterns were exhibited by the bifactor ESEM model in which the same items tended to represent more a global factor than a targeted specific factor.

The relevance of testing bifactor models is that it allows us for the assessment of both global and specific factors (Morin et al., 2016) of SDT constructs (Ryan & Deci, 2017). The multidimensionality of the BPN seems to make sense, reflecting the global extent to which physical activity participants perceive their basic needs to be satisfied when engaging in physical activity. This is consistent with the notion that, all three needs are essential for ideal motivation (Deci & Ryan, 2000) and that optimal well-being is only achieved by the satisfaction of all needs, while satisfying only one or two would be not sufficient (Deci & Ryan, 2000). In other words, human beings operate best when they experience all needs as a unifying construct, in which neglecting one could result in undesirable consequences (Ryan & Deci, 2017).

In bifactor model specifications, it is recommended to employ Omega coefficients since "*Its value is influenced by all modeled sources of common variance*" (Rodrigues et al., 2016, p. 145). Results showed that the global factor displayed acceptable internal consistency in both CFA and ESEM models, whereas the specific factors presented scores below cutoff ($<.70$). Considering the total variance of item loadings there is some evidence that items tend to load more a global factor and that items tend to measure more a global factor than the specific needs factors. However, items loaded significantly both the global as well as the specific factors in both bifactor model specifications. This is theoretically representative of the high correlations between basic psychological needs satisfaction (Ryan & Deci, 2017) where the satisfaction of only one need is insufficient for personal development and well-being. Additionally, it is worth to remind that composite reliability coefficients were above cutoffs (Raykov, 1997) in the examination of the CFA and ESEM models. These results show that different statistical tests may display some differences regarding internal consistency but overall, results tend to support the reliability of measuring

needs as independent factors, as well as a global score of basic psychological needs satisfaction.

Multigroup Analysis

A central and crucial aspect of the current study, and one that has been overlooked in the SDT literature, was our assessment of contextual invariance. To ensure that comparisons between groups were reliable, we studied participants from several similar physical activity domains, namely exercise, sports, and PE. As our results showed, multigroup analysis demonstrated a non-invariance measurement by the BPNES across all groups, specifically, invariance analysis ceased at the weak factorial criteria. Hence, differences in TLI and CFI were above cutoffs as suggested by several authors (Chen, 2007; Cheung & Rensvold, 2002; Marsh et al., 2010). This level explains that in order to achieve invariance, factor structure and factor loadings should be equal between groups, which was not respected. In other words, athletes, exercisers, and PE students perceive each need satisfaction differently. Current findings opposes the universality tenets of BPN satisfaction among all human beings, as proposed theoretically (Ryan & Deci, 2017) and shown empirically in prior exercise studies (Vlachopoulos, 2008; Vlachopoulos et al., 2013). These authors have shown BPN to be perceived equivalently in different groups, independent of age, gender, and cultural background. Nevertheless, to the best of our knowledge, this was the first attempt to test multi-group analysis between physical activity domains. Thus, our current results could be explained statistically or by natural context.

From a statistical point-of-view, as previously mentioned, autonomy and relatedness item means were relatively different across groups; specifically, autonomy and relatedness satisfaction displayed higher means among exercisers compared to athletes and PE students. Gym exercisers seemed to experience a higher need for volitional choices when training (e.g., exercise selection, training schedule sequence, which day to train) and for social interactions (e.g., chatting with others, increasing social bonds with new members) compared to athletes and PE students. Interestingly, autonomy and relatedness items also converged more to a global factor, compared to competence satisfaction items which tend to converge better to its specific factor. We speculate that these results could be related, leading to the non-invariance between contexts. Nevertheless, all groups experienced relatively similar competence satisfaction. As shown in past literature, this need represents a crucial component when it comes to more autonomous forms of motivation in the sport (Lonsdale et al., 2009), exercise (Sylvester et al., 2014), and PE (Sun et al., 2017) context.

In an empirical matter, although these contexts share the same basis (i.e., physical activity), social factors and the nature of the contexts could influence respondents' interpretation of BPN satisfaction. Basic needs are influenced by the social-contextual-environment (Ryan & Deci, 2017); that is, active

engagement with people and the surrounding impact are how needs are fulfilled. Therefore, athletes' perceptions of coaches' interpersonal behaviors (Rocchi & Pelletier, 2018), exercisers' perceptions of fitness instructors' supportive behaviors (Klain et al., 2015; Ntoumanis et al., 2017), and PE students' perceptions of teachers' motivational climate (Cid et al., 2019) directly predict the satisfaction of their basic needs. Thus, individuals in key positions (i.e., coaches, fitness instructors, and PE teachers) in these contexts can have differentiated behaviors when interacting with their pupils. For example, coaches, in addition to teaching sport-specific skills, communicate with athletes to push them to achieve higher performance in competitions (Bloom et al., 2014). On the other hand, PE teachers are focused on creating learning environments that optimize student motivation and maximize young people's attitudes, intentions and physical activity (Hagger et al., 2002; Warburton, 2017). In gym and health clubs, fitness professionals are attentive to promoting regular exercise participation; hence their communication style is associated with gym members behavior persistence (Ntoumanis et al., 2017). Thus, current findings of BPNES context invariance could be explained by the nature of the context. Examining basic terminology, exercise "*is a subcategory of Leisure-Time Physical Activity in which planned, structured, and repetitive bodily movements are performed to improve or maintain one or more components of physical fitness*" (Howley, 2001). Hence, exercisers participate in regular physical activity without constraints whenever they plan their sessions. On the other hand, in PE and sport contexts, individuals are conditioned to schedules.

In sports there is a competitive component associated with physical exercise, in which winning is a fundamental element, sometimes pushing athletes to extreme behavior, such as drug enhancement abuse. However, PE students might compete with each other for social recognition or group affiliation with no external end reward (e.g., prize, award) associated with their physical fitness and performance. In gym and health club activities, there is virtually no competitiveness between members, because managers and fitness professionals generally do not compare and award gym members by better body composition (e.g., higher muscle mass percentage) or by improved behavior (e.g., higher gym frequency).

Limitations and Directions for Further Research

Limitations of this research should be acknowledged. First, the cross-sectional design of the present study limits our ability to interpret possible daily variations in BPN satisfaction among respondents. As previous studies have shown, BPN may fluctuate over time (Cordeiro et al., 2016; Quested et al., 2013; Vansteenkiste & Ryan, 2013). Therefore, we suggest that future studies measure the temporal stability of the BPNES in various physical activity domains. Second, forthcoming studies should conduct practical experiments manipulating

BPN to determine if similar results are obtained with or without such interventions. As stated by Martinez et al. (2013), longitudinal research should be used to determine any casual-effect between BPN satisfaction and such outcomes as motivation and behavior commitment. Third, because of convenience sampling, we did not measure for intra-contextual equivalence. For example, we did not consider separate aspects of the physical exercise experience or competition experience among sport athletes. In addition, varied age ranges between groups in these different contexts could have influenced the current results. Although this study was grounded on assumed universality tenets of BPN satisfaction and prior empirical studies showing BPNES invariance between sports type (Monteiro et al., 2016) or gender among exercisers (Vlachopoulos, 2008), the invariance of these personal-contextual characteristics should be measured in future multigroup analysis.

Conclusion

In sum, the present study with Portuguese respondents, supported the use of the BPNES as a predominantly multidimensional instrument for assessing autonomy, competence, and relatedness satisfaction as a global factor in physical activity domains. Researchers should consider these results when assessing BPN satisfaction in different contexts and should use these contexts as mediators between contextual-social factors and behavioral regulations. As our results showed, BPN satisfaction varies to some degree between individuals, meaning that researchers should select the appropriate instrument for the context under analysis. In addition, we recommend that future studies on BPN assessment do not combine participants from different contexts into one single group, since we found non-invariance measurement by the BPNES across similar but distinct domains. Scale assessment is a complex and continuously improving process and should not be viewed as a strict and definitive approach. This study opens doors to future instrument examination, using more advanced statistical methodologies, showing their strengths and weaknesses when defining items and targeted constructs.

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