



Psychometric validation of the Brazilian version of the interpersonal behavior questionnaire in physical education

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Abstract

Grounded on Self-Determination Theory, this study aimed to validate the internal structure and internal consistency of the Brazilian version of the Interpersonal Behavior Questionnaire in Physical Education (IBQ-PE-BRA) among Brazilian adolescents. A total of 500 students (51.2% female), aged 11–17 years ($M=13.82$, $SD=1.77$), completed the IBQ-PE-BRA. Confirmatory Factor Analysis supported the model's adequacy, and additional Item Response Theory analyses identified items with insufficient discrimination, indicating a low ability to differentiate between different levels of the construct. The internal consistency measure was satisfactory for the Autonomy-Supportive Behaviors, Competence-Supportive Behaviors, and Relatedness-Supportive Behaviors factors. On the other hand, the three types of need-thwarting behavior obtained unsatisfactory scores. The results of the present study provide important insights for researchers and professionals who intend to use the IBQ-PE-BRA as a tool for assessing students' perceptions of Physical Education teachers' behaviors.

Keywords Need-supportive styles · Need-thwarting styles · Controlling behavior · Internal structure validity · Reliability

In the Physical Education lesson, teachers have been identified as key figures in fostering students' motivation and learning-related outcomes (Vasconcellos et al., 2020; White et al., 2021). Previous research has shown that students' experiences in Physical Education are largely shaped by their interaction with their Physical Education teachers,

particularly through the variety of interpersonal behaviors that teachers use to guide students' learning and manage the classroom (Curran & Standage, 2017). Growing attention has been paid to the role that teachers' interpersonal behaviors may play in students' motivational and learning-related consequences in the Physical Education lesson. To

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shed light on the role that teachers' interpersonal behaviors play in Physical Education, much of the previous research has drawn upon contemporary psychological theories, particularly Self-Determination Theory (Ryan & Deci, 2017).

Self-Determination Theory represents a macro-theory focusing on the social environmental factors that either promote or hamper autonomous motivation over time (Ryan & Deci, 2017). Consonant with Self-Determination Theory (Rocchi et al., 2017), there are six distinguishable types of interpersonal behavior to be adopted by the teacher in the Physical Education lesson: (a) Autonomy-Supportive Behaviors, which offer choice and rationale for tasks to students, acknowledge their perspectives, and provide them with opportunities for initiative; (b) Competence-Supportive Behaviors, which provide students with helpful information and positive feedback for task achievement, express confidence in students' abilities, and encourage the development of their skills; (c) Relatedness-Supportive Behaviors, which demonstrate care, understanding, and a genuine interest in students' activities, fostering a personal connection; (d) Autonomy-Thwarting Behaviors, which utilize intimidating and controlling language, make demands with no justification, and use conditional rewards; (e) Competence-Thwarting Behaviors, which highlight failures, discourage efforts on challenging tasks, and cast doubts on students' capacity for improvement; and (f) Relatedness-thwarting behaviors, which involve keeping an emotional distance with students, excluding them from activities, and the lack of listening. These six types of interpersonal behavior are theorized as either need-supportive or need-thwarting, in the sense that autonomy-supportive, competence-supportive and Relatedness-Supportive Behaviors configure a need-supportive teaching style, while autonomy-thwarting, competence-thwarting and relatedness-thwarting behaviors constitute a need-thwarting style from the teacher.

Despite a growing international body of evidence on the motivational impact of teachers' interpersonal behaviors, Brazil still lacks validated instruments capable of assessing these dimensions in the specific context of Physical Education. The absence of a psychometrically sound tool prevents researchers and educators from systematically evaluating how Brazilian PE teachers' behaviors influence students' motivation and learning outcomes and limits cross-cultural comparisons with studies conducted in other countries. Given the distinct cultural, pedagogical, and institutional characteristics of Brazilian schools, such as diverse regional practices and the mandatory inclusion of PE across school levels, validation of a culturally adapted version of the Interpersonal Behavior Questionnaire (IBQ) is essential for ensuring measurement accuracy and contextual relevance.

Self-Determination Theory-based research has gathered solid support to consider need-supportive and

need-thwarting behaviors as distinct yet relatively related constructs instead of opposite ends of a single need-nurturing *continuum*. This meaningful body of evidence argues that low levels of need-supportive behaviors do not necessarily imply the presence of need-thwarting behaviors. Rather, low levels of need-supportive behaviors may simply indicate an absence of perceived need-supportive elements, such as fewer opportunities for choice, feedback and emotional support than desired, rather than the presence of controlling, chaotic, or cold teaching practices.

Furthermore, need-supportive and need-thwarting behaviors may coexist within a given context, each uniquely influencing different motivational processes and outcomes (Burgueño et al., 2022; Haerens et al., 2018; Leo et al., 2022; Ryan & Deci, 2017). Need-supportive behaviors would primarily energize the satisfaction of the basic psychological needs for autonomy (i.e., the sense of being a causal agent), competence (i.e., the perception of efficacy and goal mastery), and relatedness (i.e., meaningful connections with others), as well as to autonomous motivation (i.e., behavioral regulation based on psychological freedom, volition, and self-endorsement). These behaviors contribute to the *bright motivational path* described in Self-Determination Theory, which reflects human tendencies towards psychological growth, proactivity, and wellbeing (Ryan & Deci, 2017). Conversely, need-thwarting behaviors would largely facilitate frustration of the needs for autonomy (i.e., feelings of control by external or internal pressures), competence (i.e., perceptions of failure and inefficacy), and relatedness (i.e., feelings of loneliness and social rejection), as well as with controlled motivation (i.e., behavior regulated by feelings of pressure and coercion) and amotivation (i.e., the absence of behavioral regulation). These behaviors contribute to the *dark motivational path*, which leads to suboptimal functioning, passivity, and psychological distress (Ryan & Deci, 2017). In the Physical Education context, previous Self-Determination Theory-based research has consistently found positive relationships between the students' perception of need-supportive behaviors from Physical Education teachers and their need satisfaction, as well as their autonomous motivation (Behzadnia et al., 2018; Fin et al., 2019; Haerens et al., 2015, 2018). Conversely, the students' perception of need-thwarting behaviors from the teacher were positively associated with their need frustration, controlled motivation, and amotivation (Behzadnia et al., 2018; Haerens et al., 2015, 2018). Given that perceived need-supportive and need-thwarting teaching behaviors yield distinct motivational outcomes, there is a need to examine them as independent constructs in the Physical Education context.

To the best of our knowledge, no Self-Determination Theory-based instruments have been identified to assess students' perceptions of the six types of interpersonal

behaviors from the teacher in the Brazilian Physical Education context. The lack of such measures has hindered both a comprehensive understanding of the role Brazilian Physical Education teachers in promoting students' motivational and learning-related outcomes in a specific Physical Education lesson, throughout an academic year, or across different school levels. Additionally, this gap has limited comparative analyses between the roles of Brazilian Physical Education teachers and their counterparts in other countries.

Internationally, Rocchi et al. (2017) recently developed the Interpersonal Behaviors Questionnaire (IBQ) within the general life domain. The IBQ is designed to assess how an individual (e.g., student) perceives interpersonal behaviors from a specific social agent (i.e., a Physical Education teacher), and to report the target social agent (e.g., Physical Education teacher) about their own interpersonal behaviors (IBQ-Self). In fact, the IBQ allows a focus not only on the study of competence-supportive and Relatedness-Supportive Behaviors, which have received limited attention to date, but also on a deeper analysis of need-thwarting behavior by distinguishing between three specific types, namely, autonomy-thwarting, competence-thwarting and relatedness-thwarting behaviors. The IBQ was developed through a rigorous series of studies (Rocchi et al., 2017) that yielded robust psychometric evidence supporting a 24-item, six-factor correlated model.

These studies also gathered evidence for the instrument's measurement invariance across gender, as well as its convergent and discriminant validity, reliability, and criterion validity. The instrument has since been adapted and psychometrically validated for samples with different sociolinguistic characteristics, including Canadian high school athletes (Camiré et al., 2019), Romanian professional athletes (Alexe et al., 2023), Italian middle school students (Buzzai et al., 2021), Portuguese exercisers (Rodrigues et al., 2021), Japanese (Xiao & Toyama, 2020) and Hungarian (Tóth-Király et al., 2022) adults, and Spanish Physical Education students (Burgueño & Medina-Casabón, 2021) and pre-service Physical Education teachers (Burgueño et al., 2023).

Although a substantial body of psychometric evidence was met for the IBQ's use, some shortcomings were found, such as high correlations between autonomy-supportive, competence-supportive, and relatedness-supportive behaviors, and between autonomy-thwarting, competence-thwarting, and relatedness-thwarting behaviors (Burgueño & Medina-Casabón, 2021). Additionally, the average variance extracted for the competence-supportive behaviors subscale was marginal (Buzzai et al., 2021). Previous research has also provided psychometric support for the six-factor correlated model over alternative one-factor, two-factor, and three-factor correlated models (Buzzai et al., 2021).

The validation of the Brazilian version of the IBQPE not only expands the psychometric evidence for the instrument but also strengthens research grounded in the principles of Self-Determination Theory (SDT) within the Brazilian educational and cultural context, becoming essential to consolidate the theoretical link between SDT and the instrument.

Bearing in mind that the translation and content validity of the Brazilian Physical Education version of the IBQ (IBQ-PE-BRA) has been completed by Bordoni Caldeira et al. (2023), the objective of the present research was to gather validity and reliability evidence for the use of the IBQ-PE-BRA in a sample of Brazilian students who participate in Physical Education.

Materials and methods

Participants and settings

A convenience sample of 500 students (244 male, and 256 female), aged between 11 and 17 years ($M=13.82$, $SD=1.77$), who were drawn from private and public schools across three states of Brazil. The distribution of participants by region and school level is presented in Table 1.

These students participated in Physical Education, a mandatory part of their curriculum. The Physical Education curriculum encompassed health-related physical activities, games and sports, dance and expressive activities, and outdoor physical activities, with class sizes ranging between 30 and 35 students. The participating students had to meet the following eligibility criteria: (a) demonstrating sufficient reading ability to respond to the questionnaires

Table 1 Demographic information of the sample

Demographic characteristic	<i>N</i>	%
Gender	Female	256 51.2%
	Male	244 48.8%
Region	Southeast	238 47.6%
	Northeast	262 52.4%
Education	Elementary School	375 75.0%
	High School	125 25.0%
Education Level	6th grade Elementary School	89 17.8%
	7th grade Elementary School	82 16.4%
	8th grade Elementary School	61 12.2%
	9th grade Elementary School	143 28.6%
	1st grade High School	55 11.0%
	2nd grade High School	46 9.2%
3rd grade High School	24 4.8%	

Note. $N=500$

independently, (b) being enrolled in a school where Physical Education is mandatory, and (c) providing signed written informed consent from their parents or legal guardians.

Instruments

Sociodemographic form

This form was designed to characterize and identify the study's participants, collecting data on a voluntary basis. The information gathered included participants' names, gender, ages, school types (public/private), and grades/classes. Participants self-administered the data collection to uphold their privacy, and the confidentiality of their names was rigorously maintained, with no disclosure under any circumstances.

Brazilian version of the interpersonal behavior questionnaire in physical education

To assess the students' perception of the teacher's interpersonal behaviors in Physical Education, the IBQ-PE-BRA was used after the stages of translation, cultural adaptation, and content validation (Bordoni Caldeira et al., 2023). The instrument is headed by the stem "In classes, my Physical Education teacher..." and followed by 24 items that, grouped into 4 items per factor, measure Autonomy-Supportive Behaviors (e.g., gives me the freedom to choose physical and sports activities); Competence-Supportive Behaviors (e.g., encourages me to improve my motor/physical skills); Relatedness-Supportive Behaviors (e.g., is interested in what I do during Physical Education classes); Autonomy-Thwarting Behaviors (e.g., pressures me to do things his/her way); Competence-Thwarting Behaviors (e.g., tells me that I probably made a mistake or got confused) and relatedness-thwarting behaviors (e.g., doesn't comfort me when I feel bad or uncomfortable). Items are rated on a 7-point Likert-type scale from *strongly disagree* (1) to *strongly agree* (7). The IBQ-PE-BRA in Portuguese is provided in Online Resource.

Procedures

This study encompassed three Brazilian states and four cities: Belo Horizonte (Minas Gerais), Ponto Novo (Bahia), Petrolina, and Recife (Pernambuco). The sample was intentional, consisting of adolescents from both public and private schools, totaling 11 public schools and 2 private schools.

The school selection process was purposive and followed a multi-step approach aimed at ensuring that schools met the criteria necessary to align with the study's goals, particularly in terms of age range and the mandatory inclusion

of Physical Education in their curriculum. The inclusion criteria included the presence of adolescents aged 11 to 17 in their enrolled student population and offering Physical Education as a mandatory part of the curriculum for all students within this age range. Schools that did not meet these criteria (e.g., schools with optional or specialized Physical Education programs) were excluded from the study.

All schools meeting these criteria were selected, and efforts were made to include as many institutions as possible. This approach aimed at maximizing volunteer participation and ensuring a representative sample. Subsequently, we scheduled meetings with the institutions' responsible parties to provide detailed information about the research and clarify any questions, leading to the signing of the schools' consent forms. After this preparatory phase, we commenced the data collection process.

During the invitation of candidates to participate in the study, all of them were provided with the Informed Consent Form, with required legal guardians to sign, authorizing the participation of the adolescent in the research. Additionally, the students were given an Assent Form to read and sign if they agreed to participate. Once both forms were signed, and the eligibility criteria were met, the student became eligible to take part in the research. The research was submitted for review to the Ethics and Research Committee, with the registration number CAAE: 57003922.3.0000.5191. All procedures conducted in the research adhered to the ethical criteria for human research, as outlined in Resolution No. 466 of December 12, 2012, by the Brazilian National Health Council and the principles stated in the World Medical Association Declaration of Helsinki.

The objective of this stage was to verify whether the set of variables in the instrument truly represented the construct to be measured (Souza et al., 2017). This step was necessary to confirm the continued representativeness of the IBQ-PE-BRA maintains in measuring the intended construct, aiming to determine whether the latent constructs explained the covariance between the items of the IBQ-PE-BRA (Damásio, 2013). Additionally, the reliability of the structure was assessed by evaluating the internal consistency of the instrument, ensuring that the questionnaire relates to and measures the same construct using statistical analyses to measure the internal consistency indices of the IBQ-PE-BRA (Souza et al., 2017).

To ensure the reliability and validity of our data collection process, before data collection commenced, all school staff members who were involved in administering the questionnaires received comprehensive training, including guidelines were provided on how to address students' questions without introducing bias or influencing their responses and instructions for students, handling of completed forms, and protocols for addressing student queries. By incorporating

these measures, we aimed to ensure that the data collection process was reliable and that any potential sources of bias or inconsistency were minimized. These steps align with best practices in research methodology, as recommended by literature (American Educational Research Association et al., 2014). All participants were volunteers and completed the questionnaires independently and individually in a room with the presence of a school staff member who was not a teacher. When students had questions, they were instructed to raise their hands, and an administrator would approach to clarify any doubts. Completed questionnaires were collected, and a verification process was conducted to ensure that all questionnaires were filled out correctly. Finally, the data collection process was concluded.

Data analysis

The data were tabulated in Excel software and analyzed using the R programming language (R Core Team, 2025). Figures were created using Word and R programming language. To evaluate the validity evidence based on internal structure (American Educational Research Association et al., 2014), we used the Confirmatory Factor Analysis to investigate the plausibility of the factorial structure of IBQ-PE (Kline, 2015), based on previous studies, considering the six-factor solution found in Burgueño and Medina-Casabón (2021) in the Brazilian context. The usage of Item Response Theory, in turn, is justified by the need to investigate the items individual parameters, to ensure an in-depth analysis of the measure, considering the characteristics of each item (Pasquali, 2020) separately, instead of the full factor structure. Moreover, the internal consistency analysis were conducted to evaluate the correlation among the items of each latent factor separately.

A Confirmatory Factor Analysis approach was run using the lavaan package (Rosseel, 2012) to test the robustness of the six-factor correlated model proposed for the IBQ-PE. Before running the Confirmatory Factor Analysis, we ensured that the assumptions for factor analysis were met, including adequate sample size, multivariate normality, and the absence of multicollinearity among items. The Weighted Least Squares Mean and Variance Adjusted estimation method was used to estimate the model, which is suitable for Likert-scale items as they involve ordinal data (Li, 2016). The goodness of the model's fit was assessed by scores up to 5 for the coefficient between chi-squared and degrees of freedom (χ^2/df), values higher than 0.90 for Comparative Fit Index and Tucker-Lewis index, paired with scores lower than 0.080 for Standardized Root Mean Square Residual and Root Mean Square Error of Approximation (Kline, 2015). Standardized regression weights are acceptable with values over 0.40. Latent correlations show a good level of

discriminant validity when values are as high as 0.85 (Kline, 2015). To assess the instrument's invariance across gender, age, school level and region, multi-group Confirmatory Factor analyses were performed following the methodological approach by Milfont and Fischer (2010) that tests the tenability of configural invariance (i.e., no equality constraints), metric invariance (i.e., equality constrains in items' factor loading), scalar invariance (i.e., equality constrains in items' factor loading and intercept simultaneously) and residual invariance (i.e., equality constrains in items' factor loading, intercept and error variance, simultaneously). Changes of up to 0.010 in Comparative Fit Index paired with changes up to 0.015 in Root Mean Square Error of Approximation between each couple of progressively more constrained models are recommended to support the invariance assumption (Milfont & Fischer, 2010).

To examine the instrument's internal consistency, Cronbach's alpha, McDonald's omega, and Raykov's rho were computed for each of the six factors (Bland & Altman, 1997; Hayes & Coutts, 2020; Valentini & Damásio, 2016). Scores above 0.70 show a good reliability level. It's important to highlight that Cronbach's alpha was investigated to make it possible to compare results of this study with others, considering that this index is commonly used in scientific literature, even with its assumptions. The Cronbach's alpha index is based on two main assumptions that makes it fragile, the first one is the direct association with the number of items of a latent factor, as this number increases, the index tends to increase, making it impossible to compare items with different number of items among them (Damásio, 2013). The second assumption is that all the items of an instrument have the same amount of importance for the latent factor, and contradicts the concept of factor loading, which indicates how much an item is explained by the latent factor (Hair et al., 2009). The McDonald's omega and Raykov's rho, in turn, does not assume tau-equivalence among the items (Hayes & Coutts, 2020; Valentini & Damásio, 2016), and measures the internal consistency more accurately.

Furthermore, the H-index was used to evaluate the stability (or replicability) of the latent factors, with good values when above 0.70 (Ferrando & Lorenzo-Seva, 2018), to evaluate the extent to which factor is well represented by the group of the items. To investigate the convergent and discriminant validity, the Average Variance Extracted (AVE) was used, with good results when ≥ 0.50 (Hair et al., 2019), and the Fornell & Larcker criterion was evaluate, in order to assess if a latent factor is empirically different from the others, for this, the AVE was compared to the squared of the correlation of the latent factors, with good results when $AVE > \text{Correlation}^2$ (Hair et al., 2019).

The Item Response Theory paradigm was employed to investigate the individual parameters of the items,

including discrimination (a) and difficulty (b). The mirt package (Chalmers, 2012) was used, along with Samejima's Graded Response Model, who represents a family of Item Response Theory models that deals with ordered categories (Samejima, 1997). The discrimination parameter measures the item's ability to differentiate individuals with varying levels of latent trait (Hutz et al., 2015), while difficulty indicators indicate the level of latent trait required for an individual to have a 50% chance of endorsing one response category over another (Pasquali & Primi, 2003).

Moreover, the discrimination indicator has established cutoff points in the literature, as outlined by Pasquali (2020). Discrimination levels between 0.01 and 0.34 are considered very low, values between 0.35 and 0.64 are low, values between 0.65 and 1.34 are moderate, values between 1.35 and 1.69 indicate high discrimination, and values above 1.70 indicate very high discrimination. The difficulty levels of an item are measured on a metric from -3 to $+3$, where values closer to -3 indicate easy items, and values closer to $+3$ indicate difficult items (Pasquali & Primi, 2003).

Finally, Test Information Curves were analyzed, to represent the precision of the test across different levels of the latent trait. The intersection point between the red dashed line (residual) and the blue line (information) indicates the exact range where the test provided the most reliable measurement. Additionally, the peak of the blue curve represents the level at which the test measured the latent trait with the greatest precision.

It is important to highlight that the assumption of unidimensionality was assessed by confirming the factor structure of the measure, tested by Confirmatory Factor Analysis. The monotonicity of the model was assessed through the polynomial item characteristic curves, in which the response probability curves are expected to be ordered in the same way as the item response categories (Andrade et al., 2000; Sengul Avsar & Tavsancil, 2017).

Results

Confirmatory factor analysis

Initially, we assessed the assumptions of the Confirmatory Factor Analysis. The sample size was determined by the ratio of 20 observations (participants) per item (Kyriazos, 2018), in this case, the sample requirement would be 480 participants, and the study was conducted with 500 participants. Later the Mardia's test (Mardia, 1970) was analyzed to investigate the assumption of multivariate normality, with results indicating violations of the assumptions (Skewness=4620.56, $p < .001$; Kurtosis=29.20, $p < .001$). Besides, the multicollinearity of the items was assessed

by the analysis of the polychoric correlations among all the 24 items of IBQ-PE, with high correlations when ≥ 0.80 or above (Kline, 2015), the results showed that the higher bivariate correlation among the items did not reach this value (Items 14 and 21, $r = .607$). That said, it can be inferred that the sample size requirements and multicollinearity assumption was met, but the multivariate normality assumption was not, indicating the necessity of utilizing estimators that deals with this violation, such as Weighted Least Squares Mean and Variance adjusted, that was used in this study (Li, 2016).

The results of the Confirmatory Factor Analysis indicated a good fit of the model [$\chi^2(df=237)=525.402$, $p < .001$, $\chi^2/df=2.217$; CFI=0.943, TLI=0.934, SRMR=0.062, RMSEA=0.054 (90%CI=0.048–0.060)]. However, upon analyzing the factor loadings of the items in the IBQ-PE-BRA, it was observed that items I10 and I5 had weak factor loadings suggesting a low explanatory power of the latent variables for these specific indicators (Fig. 1; Table 2).

In terms of content, item I5 (“*Meu(minha) professor(a) de Educação Física me diz que provavelmente eu me enganei/confundi*” [“My Physical Education teacher tells me that I was probably mistaken/confused”]) addresses the competence-thwarting dimension, reflecting how feedback can undermine a student's sense of competence when it is dismissive or critical. Similarly, item I10 (“*Impõe suas opiniões*” [“Imposes their opinions”]) pertains to the autonomy-thwarting dimension, capturing instances where a teacher's controlling behavior suppresses students' sense of self-direction. Both items are theoretically aligned with Self-Determination Theory and play crucial roles in representing behaviors that thwart students' basic psychological needs within the Physical Education setting. Thus, removing them outright could result in the loss of important facets of the IBQ-PE-BRA. However, we acknowledge that the weak factor loadings observed in the Confirmatory Factor Analysis suggest that these items may not adequately represent the underlying latent constructs in their current form. Therefore, we propose revising the wording of these items in future studies to enhance their clarity and relevance, which could improve their psychometric performance.

Factorial structure of the Brazilian version of the interpersonal behavior questionnaire in physical education (IBQ-PE-BRA)

Additionally, the individual parameters of the items were assessed using Item Response Theory. The results of the model indicated that items I10 (Autonomy-Thwarting Behaviors) and I5 (Competence-Thwarting Behaviors) had insufficient discrimination ($a < 0.65$), suggesting low discriminatory power. Conversely, items I18

Table 2 Factor loadings and individual item parameters of the Brazilian version of the interpersonal behavior questionnaire in physical education (IBQ-PE-BRA)

	Items	a	b1	b2	b3	b4	b5	b6	bx	λ
ASB	I1	0.89	-0.96	-0.63	-0.33	0.59	1.04	1.49	0.20	0.40
	I7	2.05	-1.07	-0.86	-0.61	0.05	0.31	0.69	-0.25	0.69
	I13	2.17	-1.20	-0.96	-0.71	0.26	0.52	0.84	-0.21	0.68
	I19	1.70	-1.27	-1.05	-0.86	0.01	0.31	0.77	-0.35	0.65
CSB	I2	1.57	-1.90	-1.60	-1.25	-0.60	-0.26	0.25	-0.89	0.58
	I8	1.27	-1.90	-1.48	-1.14	-0.27	0.02	0.60	-0.69	0.50
	I14	1.83	-1.37	-1.08	-0.92	-0.14	0.17	0.58	-0.46	0.72
	I20	1.98	-1.15	-0.98	-0.78	0.01	0.30	0.55	-0.34	0.67
RSB	I3	1.58	-1.68	-1.33	-0.98	-0.22	0.10	0.46	-0.61	0.66
	I9	1.65	-0.87	-0.52	-0.30	0.39	0.55	0.95	0.04	0.61
	I15	1.99	-1.22	-1.06	-0.88	0.17	0.39	0.76	-0.31	0.64
	I21	2.02	-1.35	-1.17	-0.84	-0.29	0.09	0.47	-0.52	0.69
ATB	I4	1.42	-0.41	-0.09	0.25	0.86	1.16	1.61	0.57	0.54
	I10	0.55	-3.13	-2.29	-1.77	0.00	0.69	1.46	-0.84	0.29
	I16	1.34	-1.01	-0.56	-0.32	0.42	0.71	1.09	0.05	0.56
	I22	0.87	-0.99	-0.45	-0.11	1.16	1.58	2.07	0.54	0.47
CTB	I5	0.41	-1.70	-1.08	-0.41	2.50	3.44	4.74	1.25	0.25
	I11	1.22	0.50	0.89	1.05	1.81	2.00	2.27	1.42	0.41
	I17	2.04	0.10	0.37	0.55	1.14	1.30	1.49	0.82	0.72
	I23	1.19	-0.32	-0.02	0.21	1.21	1.36	1.65	0.68	0.47
RTB	I6	0.81	-0.23	0.26	0.48	1.61	1.94	2.32	1.07	0.38
	I12	0.87	-0.14	0.35	0.73	1.80	2.37	2.77	1.31	0.45
	I18	2.30	-0.24	-0.01	0.22	0.79	0.95	1.22	0.49	0.62
	I24	1.38	-0.20	0.09	0.33	1.07	1.31	1.53	0.69	0.57

ASB=Autonomy-Supportive Behaviors; CSB=Competence-Supportive Behaviors; RSB=Relatedness-Supportive Behaviors; ATB=Autonomy-Thwarting Behaviors; CTB=Competence-Thwarting Behaviors; RTB=Relatedness-Thwarting Behaviors; a=Factor loading of the item, indicating its association with the factor; b1, b2, b3, b4, b5, b6=Difficulty parameters in the Item Response Theory model, representing points where response categories are equally probable; bx=discrimination; λ=Standardized loading, indicating the correlation between the item and the latent factor

(Relatedness-Thwarting Behaviors), I13, and I7 (Autonomy-Supportive Behaviors) demonstrated the highest indicators of discriminative power, representing very high discrimination ($a > 1.70$) (Pasquali, 2020). The difficulty parameters showed results close to the midpoint of the latent trait level ($\theta = 0$), with the easiest items having an average difficulty level of -0.89 (I2, Competence-Supportive Behaviors), -0.84 (I10, Autonomy-Thwarting Behaviors), and -0.61 (I3, Relatedness-Supportive Behaviors), while the most challenging items had an average difficulty level of 1.42 (I11, Competence-Thwarting Behaviors), 1.31 (I12, Relatedness-Thwarting Behaviors), and 1.25 (I5, Competence-Thwarting Behaviors).

Based on these findings, it is evident that the items that demonstrated weak results in the Confirmatory Factor Analysis also exhibited weak individual parameters (I5 and I10), indicating a need for reformulation of these indicators. Consequently, these items were excluded from the factorial structure of the instrument, leading to a significant improvement in the fit indices of the model [$\chi^2 (df = 194) = 319.826$, $p < .001$, $\chi^2/df = 1.649$; CFI=0.987, TLI=0.984, SRMR=0.049, RMSEA=0.038 (90%CI=0.030 - 0.045)].

Additionally, the direct comparison between the models revealed the superiority of the reduced model [$\Delta\chi^2 = 205.576$, $\Delta df = 43$, $p < .001$].

However, the analysis of the regression coefficients between the latent factors revealed that the Supportive Behaviors factors (Autonomy-Supportive Behaviors, Competence-Supportive Behaviors and Relatedness-Supportive Behaviors) showed strong and significant correlations with one another (> 0.92), suggesting issues of multicollinearity. Based on these findings, a four-factor solution was considered by grouping of Supportive Behaviour factors, as well as a two-factor solution considering both the grouping of Supportive and Thwarting Behaviour factors.

The results revealed that the four-factor solution demonstrated good fit indices, [$\chi^2 (df = 203) = 342.785$, $p < .001$, $\chi^2/df = 1.688$; CFI=0.984, TLI=0.982, SRMR=0.051, RMSEA=0.039 (90%CI=0.032 - 0.046)]. However, the correlation between SB with Autonomy-Thwarting Behaviors ($r = .025$, $p = .716$) and Competence-Thwarting Behaviors ($r = -.053$, $p = .368$) were non-significant, which is not theoretically plausible. Finally, the two-factor solution met the minimum fit index thresholds, though with slightly lower

values overall [$\chi^2(df=208)=465.592, p<.001, \chi^2/df=2.238; CFI=0.957, TLI=0.952, SRMR=0.064, RMSEA=0.055 (90\%CI=0.048 - 0.061)$]. The two-factor solution showed significant and negative correlation between Need-Supportive Behaviour and Need-Thwarting Behaviour ($r=-.193, p=.001$), indicating that theoretically the two-factor alternative model is more plausible than the four-factor alternative model.

Invariance analysis

Therefore, the reduced model of the IBQ-PE-BRA was utilized to analyze factorial invariance, considering the variables gender, region, and education level. The results confirm factorial invariance across gender, encompassing all four types of invariances (configural, metric, scalar, and residual). However, when examining invariance by region, only configural invariance was supported. This suggests that while the factorial structure remains consistent across groups, there is no equivalence in factor loadings, relationships between scores and latent traits, and residuals between the Southeast and Northeast regions. Moreover, it is worth noting that when testing factorial invariance by education level, students from Elementary School 2 and High School did not exhibit the expected equivalence. This implies that the two educational contexts have different factorial structures among groups, in addition to the factors mentioned in the comparison by Region in Brazil. Furthermore, factorial invariance across age groups was not supported by the analysis, indicating that the groups exhibit different response patterns to the instrument.

Besides, when considering the factorial invariance of the alternative two-factor model of IBQ-PE-BRA, the results showed configural invariance across gender,

region, education level, and age. Unfortunately, only the configural invariance was revealed since metric, scale, and residual invariance were not supported. This result indicates that the two-factor structure is equivalent among groups considering gender, region, educational level, and age, even if the factor loadings, intercepts and residuals are not (Table 3).

Internal consistency

Finally, the Internal Consistency analysis revealed satisfactory results for the Autonomy-Supportive Behaviors, Competence-Supportive Behaviors, and Relatedness-Supportive Behaviors factors exhibited strong internal consistency coefficients (Cronbach’s alpha, McDonald’s omega, Raykov’s rho) exceeding 0.70 in both the original and reduced versions. Conversely, Autonomy-Thwarting Behaviors, Competence-Thwarting Behaviors, and Relatedness-Thwarting Behaviors displayed weaker internal consistency coefficients below 0.70, indicating potential issues with reliability. Notably, even after removing vulnerable indicators in the reduced version, the internal consistency of the measure did not noticeably improve, particularly for the Autonomy-Thwarting Behaviors and Competence-Thwarting Behaviors factors (Table 4).

However, when considering the alternative models, the results showed that Supportive Behaviour has very good reliability results (Cronbach’s alpha=0.875, McDonald’s omega=0.877, Raykov’s rho=0.878, H=0.886, AVE=0.377), and Thwarting Behaviour has acceptable results (Cronbach’s alpha=0.732, McDonald’s omega=0.705, Raykov’s rho=0.727, H=0.762, AVE=0.222). This result suggests that the general factors of Supportive Behaviour and Thwarting Behaviour had more internal consistency than the individual factors.

Table 3 Factorial invariance of the Brazilian version of the interpersonal behavior questionnaire in physical education (IBQ-PE-BRA) among groups of Gender, Region, education Level, age

AFCMG	6 factor solution				2 factor solution			
	Configural	Metric	Scale	Residual	Configural	Metric	Scale	Residual
	Gender							
ΔCFI	0.907	0.005	0.001	0.002	0.967	0.011	0.001	0.001
ΔRMSEA	0.046	0.000	0.001	0.001	0.042	0.005	0.001	0.000
	Region							
ΔCFI	0.923	0.023	0.004	0.014	0.982	0.025	0.002	0.944
ΔRMSEA	0.044	0.005	0.000	0.003	0.033	0.017	0.000	0.005
	Education Level							
ΔCFI	0.899	0.001	0.004	0.006	0.973	0.016	0.002	0.006
ΔRMSEA	0.048	0.001	0.000	0.001	0.041	0.009	0.000	0.004
	Age							
ΔCFI	0.894	0.001	0.007	0.014	0.977	0.022	0.003	0.013
ΔRMSEA	0.049	0.002	0.000	0.002	0.037	0.014	0.000	0.006

CFI=Comparative Fit Index; RMSEA=Root Mean Square Error of Approximation; AFCMG=Multigroup Confirmatory Factor Analysis; Δ=Delta

Table 4 Internal consistency of the factorial solutions found for the Brazilian version of the interpersonal behavior questionnaire in physical education (IBQ-PE-BRA)

Factors	IBQ-PE-BRA original version					IBQ-PE-BRA reduced version				
	α	ω	ρ	H	AVE	α	ω	ρ	H	AVE
ASB	0.69	0.70	0.70	0.73	0.37	0.69	0.70	0.70	0.72	0.37
CSB	0.71	0.72	0.72	0.73	0.39	0.71	0.72	0.72	0.73	0.39
RSB	0.74	0.74	0.75	0.75	0.42	0.74	0.74	0.75	0.75	0.42
ATB	0.52	0.53	0.53	0.55	0.23	0.57	0.53	0.53	0.53	0.27
CTB	0.50	0.53	0.53	0.62	0.24	0.56	0.59	0.55	0.69	0.34
RTB	0.57	0.58	0.58	0.60	0.27	0.57	0.58	0.58	0.60	0.27

ASB=Autonomy-Supportive Behaviors; CSB=Competence-Supportive Behaviors; RSB=Relatedness-Supportive Behaviors; ATB=Autonomy-Thwarting Behaviors; CTB=Competence-Thwarting Behaviors; RTB=Relatedness-Thwarting Behaviors; α = Cronbach's alpha; ω =McDonald's omega; ρ = Raykov's rho; H=Stability index; AVE: Average Variance Extracted

Convergent and discriminant analysis

Regarding the convergent and discriminant analysis of the models, the Average Variance Extracted was assessed, but neither the six-factor nor the two-factor solution showed results above 0.50, indicating fragile convergent validity. Table 5 shows the results of the Fornell & Larcker criterion of the reduced six-factor solution, and indicates that the square of the correlation among ASB with CSB and RSB showed higher results when compared to the AVE. For CSB, the square of the correlation with RSB showed higher results. When analyzed the ATB factor, the square of the correlation with CTB and RTB had higher results when compared to the AVE of the factor, and for CTB, the square of the correlation with RTB factor indicated higher results. These results indicate that the Supportive factors (S) presented high correlations, and low discriminant validity, the same occurs for the Thwarting factors. The square of the correlation between the Supportive factors with the Thwarting factors showed low results, indicating that these factors are not correlated.

From a psychometric standpoint, the suboptimal AVE values and high inter-factor correlations within the supportive and thwarting dimensions warrant careful consideration regarding the interpretability of the six subdimensions in applied research. Specifically, the AVE values below 0.50 indicate that the latent factors explain less than half of the variance in their indicators, and that the high squared

inter-factor correlations (particularly among the three supportive subdimensions and among the three thwarting subdimensions) suggest substantial conceptual and empirical overlap between constructs that are theoretically distinct within Self-Determination Theory. This overlap challenges the interpretability of subscale-level scores when used in isolation, particularly in applied or diagnostic contexts.

This pattern, which has been consistently observed in prior IBQ adaptations across different cultural contexts (Burgueño & Medina-Casaubón, 2021; Rocchi et al., 2017b; Rodrigues et al., 2021) suggests that while the six-factor structure is theoretically grounded in Self-Determination Theory, researchers should exercise caution when interpreting subscale-level scores in isolation. The higher-order two-factor structure (Supportive vs. Thwarting behaviors) demonstrated more adequate discriminant validity and appears psychometrically more appropriate and robust, for applied settings where subscale-level differentiation is not the primary research question.

For the two-factor solution, the Average Variance Extracted results showed results below 0.50, indicating that the two-factor solution did not show good convergent validity. Besides, the analysis of the Fornell & Larcker criterion indicated that these factors had good discriminant validity results. That result was expected, since the correlation of the Supportive and Thwarting factors, evaluated in Table 5, had very low results (Table 6).

Table 5 Fornell & larcker criterion for the Brazilian version of the interpersonal behavior questionnaire in physical education (IBQ-PE-BRA), in the reduced six-factor solution

Factors	ASB	CSB	RSB	ATB	CTB	RTB
ASB	0.37					
CSB	0.86	0.39				
RSB	0.87	0.91	0.42			
ATB	0.01	0.00	0.01	0.27		
CTB	0.00	0.02	0.00	0.42	0.34	
RTB	0.12	0.17	0.09	0.44	0.56	0.27

The diagonals are the Average Variance Extracted (AVE) of the factors, and the other results are the square of the correlation among the factors

Table 6 Fornell & Larcker criterion for the Brazilian version of the interpersonal behavior questionnaire in physical education (IBQ-PE-BRA), in the second-factor solution

Factors	Supportive	Thwarting
Supportive	0.38	
Thwarting	0.03	0.22

The diagonals are the Average Variance Extracted (AVE) of the factors, and the other results are the square of the correlation among the factors

Item characteristic curves

Subsequently, the Item Characteristic Curves revealed that, for the Autonomy-Supportive Behaviors factor, item I1 showed the lowest amount of measured information, while item I13 exhibited the highest amount of measurement. As for the Competence-Supportive Behaviors factor, item I8 displayed the worst performance, while item I20 demonstrated the best performance within the factor. Regarding the Relatedness-Supportive Behaviors factor, item I3 exhibited poorer behavior, while item I21 displayed better quality. On the other hand, the Autonomy-Thwarting Behaviors factor yielded poor results for item I10, whereas item I4 showed better quality compared to the others. When evaluating the Autonomy-Thwarting Behaviors dimension, the results indicate that item I5 exhibited the poorest behavior, while item I17 was more precise. Finally, the analysis of the Item Characteristic Curves for the Relatedness-Thwarting Behaviors factor identified items I6 and I12 as the worst performers, with quite similar behavior, while item I18 presented a significantly higher amount of information (Fig. 2).

Test information curves

On the other hand, when considering the Test Information Curves, the Autonomy-Supportive Behaviors factor showed a measurement range of approximately -3.0 to $+3.0$, with a peak of precision around $+1.0$. When investigating the Competence-Supportive Behaviors factor, the results indicated a range between -4.0 and $+2.5$, with a peak of precision at approximately -0.5 . Similarly, the Relatedness-Supportive Behaviors factor exhibited a measurement range of approximately -3.8 to $+2.9$, with the peak of precision at $+0.5$. Subsequently, the measurement range of the latent trait level for the Autonomy-Thwarting Behaviors dimension was analyzed, indicating a range of -2.8 to $+3.7$, with the peak of precision at $+0.2$ theta. On the other hand, when considering the Competence-Thwarting Behaviors factor, the range varied between -1.9 and $+3.9$, with the peak of precision at $+0.4$. Lastly, the Relatedness-Thwarting Behaviors factor had a measurement range between -2.1 and $+4.0$, approximately, with the peak of precision at $+1.0$ (Fig. 3).

Discussion

The objective of this research was to gather validity and reliability evidence for use of the IBQ-PE-BRA in the Brazilian Physical Education context in a sample of adolescent students. The results presented in this study provided evidence of satisfactory internal validity and reliability, despite some limitations being acknowledged. Overall, the IBQ-PE-BRA demonstrated itself as a psychometric instrument that satisfactorily measures the intended constructs. The results of the Confirmatory Factor Analysis initially support for the factor structure of the IBQ-PE-BRA. The model demonstrated a good fit to the observed data, indicating that the latent variables effectively accounted for the indicators. This finding is consistent with the original version of the IBQ-PE (Burgueño & Medina-Casabón, 2021) and other adaptations in various contexts (Alexe et al., 2023; Burgueño & Medina-Casabón, 2021; Buzzai et al., 2021; Rocchi et al., 2017a; Rodrigues et al., 2021; Xiao & Toyama, 2020).

However, further analysis of the factor loadings revealed that two items, I10 and I5, displayed weak factor loadings and did not contribute significantly to their respective factors. As a result, these items were excluded from the factorial structure of the instrument, leading to an improved fit for the reduced models. Consequently, the reduced model demonstrated that all factor loadings were above >0.30 , indicating that each item represented adequately the intended theoretical factor, as observed in the original IBQ-PE and other adaptations in different contexts (Alexe et al., 2023; Burgueño & Medina-Casabón, 2021; Buzzai et al., 2021; Rocchi et al., 2017a; Rodrigues et al., 2021; Xiao & Toyama, 2020).

The multi-group analysis examined the equivalence of the IBQ-PE-BRA instrument across different groups. The results indicated that the factorial structure of the IBQ-PE-BRA was adequate across genders, supporting the comparability of scores between males and females, consistent with findings from previous studies (Alexe et al., 2023; Burgueño & Medina-Casabón, 2021; Buzzai et al., 2021; Rocchi, Pelletier, Cheung, Rocchi et al., 2017a, b; Rodrigues et al., 2021; Xiao & Toyama, 2020). However, when considering regional differences in Brazil, only configural invariance was supported. This suggests that the factor loadings, relationships between scores and latent traits, and residuals were not equivalent between the Southeast and Northeast regions. Similarly, the analysis of invariance by education level revealed differences in the factorial structure between students in Elementary School and High School. This finding implies that the instrument may operate differently in these two educational contexts, which have not been extensively explored in previous studies (Alexe et al., 2023; Burgueño & Medina-Casabón, 2021;

Buzzai et al., 2021; Rocchi, Pelletier, Cheung, Rocchi et al., 2017a, b; Rodrigues et al., 2021; Xiao & Toyama, 2020). Regarding internal consistency, the Autonomy-Supportive Behaviors, Competence-Supportive Behaviors, and Relatedness-Supportive Behaviors factors demonstrated satisfactory reliability, as assessed by Cronbach's alpha, McDonald's omega, and composite reliability indicators, exceeding the recommended threshold of 0.70. However, the Autonomy-Thwarting Behaviors, Competence-Thwarting Behaviors, and Relatedness-Thwarting Behaviors factors showed questionable internal consistency, falling below the recommended threshold. It is worth noting that previous studies examining translated versions of the IBQ, including the IBQ-PE, have reported satisfactory reliability in all factors using Cronbach's alpha (Alexe et al., 2023; Buzzai et al., 2021; Rocchi, Pelletier, & DesmaraiRocchi et al., 2017a, b; Rocchi, Pelletier, Cheung, Rocchi et al., 2017a, b; Xiao & Toyama, 2020) and Average Variance Extracted (Burgueño & Medina-Casaubón, 2021; Buzzai et al., 2021; Rocchi, Pelletier, Cheung, Rocchi et al., 2017a, b; Rocchi, Pelletier, & DesmaraiRocchi et al., 2017a, b; Rodrigues et al., 2021; Xiao & Toyama, 2020). Nevertheless, it is known that Cronbach's alpha index depends on the number of items considered in the analysis (Hayes & Coutts, 2020), indicating that measurements with three or four items (as this study) often shows results below the established cut-off point. On the other hand, when considered the general factors of Supportive Behaviour and Thwarting Behaviour (by grouping the individual factors), the results indicated adequate internal consistency, supporting the hypothesis that the number of items has a positive correlation with indicators such as Cronbach's alpha.

It is important to acknowledge that even in the reduced model of the IBQ-PE-BRA, the Autonomy-Thwarting Behaviors, Competence-Thwarting Behaviors, and Relatedness-Thwarting Behaviors factors did not show a significant improvement the internal consistency. Although the coefficients for these factors in our study may not meet ideal thresholds according to certain guidelines (Hair et al., 2009; Nunnally & Bernstein, 1994), they can be still considered acceptable for research purposes, particularly when considering psychological constructs (Gouveia et al., 2009).

Furthermore, the investigation for alternative models of IBQ-PE-BRA indicated that the two-factor solution is plausible, with acceptable fit indexes, significant negative correlations between Supportive Behaviour and Thwarting Behaviour general factors, and improved internal consistency compared to the six-factor solution. Additionally, for the multigroup analysis, results showed that the two-factor solution showed configural invariance among gender, region, educational level and age, but no group has shown metric, scale or residual invariance. The results suggests

that the alternative model is robust and plausible, and can be used to investigate the general factors of Supportive Behaviour and Thwarting Behaviour.

From a theoretical standpoint, these results reinforce the multidimensional nature of interpersonal behaviors described by Self-Determination Theory (SDT; Deci & Ryan, 2000; Ryan & Deci, 2017), highlighting the coexistence of supportive and thwarting teaching practices as distinct but interrelated constructs. The moderate negative correlations found between these general dimensions support the SDT assumption that need-supportive and need-thwarting behaviors represent independent yet interacting motivational mechanisms (Vansteenkiste et al., 2020). Importantly, partial invariance across educational levels and regions suggests that the perception of teachers' interpersonal behaviors is sensitive to contextual and cultural nuances, a finding consistent with recent cross-cultural SDT research (Howard et al., 2017; Tian & Shen, 2023). Thus, the present validation contributes to extending SDT's applicability to the Brazilian educational context, where social hierarchies and pedagogical traditions may influence the experience of autonomy, competence, and relatedness in the classroom.

From a methodological perspective, the partial invariance found between regions underscores the complexities of cross-cultural psychometric validation (Byrne & van de Vijver, 2017; Milfont & Fischer, 2010). Cultural, linguistic, and educational differences may affect the interpretation of items, particularly those reflecting interpersonal control or emotional distance. These findings support the notion that achieving strict invariance is rare and that approximate or partial invariance may still yield meaningful comparative insights (Putnick & Bornstein, 2016). Moreover, the two-factor higher-order model observed in this study provides a parsimonious and psychometrically stable representation that may facilitate cross-cultural comparisons and theoretical integration within SDT research (Burgueño et al., 2024).

The validated Brazilian version of the IBQ-PE provides researchers, educators, and policymakers with a reliable tool to assess teachers' interpersonal behaviors in Physical Education. Its application can support teacher training initiatives and contribute to the promotion of motivationally supportive learning environments.

Limitations and directions for further research

Considering the complexity of human cognitive processes, the validation of a psychometric instrument should be considered an ongoing process. Future research should address the uncertainties stemming from the limitations of this study. First, the use of purposive sampling in this research limits the generalizability of the findings. Therefore, future studies

should reassess the psychometric properties of the Brazilian Physical Education version of the IBQ with diverse student populations across different geographic regions and educational levels (e.g., primary, vocational, or higher education).

Second, while the current study provides an initial body of psychometric evidence supporting the IBQ-PE-BRA, further research is required to expand the validity and reliability evidence for the Brazilian version of the instrument. This includes gathering evidence for convergent validity, criterion validity, and/or temporal stability. Third, new studies should aim to refine specific items, particularly items I10 and I5, to ensure they better capture the specific type of teacher behavior intended according to the students' perception. Additionally, efforts should be made to enhance item content to improve the marginal internal consistency values observed in the Autonomy-Thwarting Behaviors, Competence-Thwarting Behaviors, and Relatedness-Thwarting Behaviors subscales in the present study.

Fourth, it is important to acknowledge that the current study provides validity evidence primarily based on internal structure, internal consistency, and item-level functioning within a staged validation framework aligned with the Standards for Educational and Psychological Testing (American Educational Research Association et al., 2014). Criterion-related validity evidence, including predictive and concurrent relations with theoretically relevant constructs such as basic psychological need satisfaction and frustration, autonomous and controlled motivation, student engagement, and well-being outcomes, was not examined in the present investigation. This represents an important limitation for understanding the practical utility of the IBQ-PE-BRA in applied research contexts. Consequently, users should interpret the current findings as providing preliminary psychometric support for the measure's use. Future research should prioritize establishing criterion-related validity evidence by examining whether IBQ-PE-BRA scores predict or correlate with theoretically expected outcomes, consistent with Self-Determination Theory propositions, before the instrument can be confidently recommended for high-stakes applied use, intervention evaluation, or individual-level assessment.

Implications for educational practice

The new Brazilian Physical Education version of the IBQ enables researchers to gain a deeper understanding of the differentiated role that each teacher's interpersonal behaviors may have on the development of students' need-based experiences and motivation, as well as their affective, behavioral, and cognitive outcomes in the Physical Education lesson. This multidimensional instrument will help provide teachers with useful and practical information regarding both the potential benefits derived from the adoption of

need-supportive behaviors to promote this type of teaching strategy and possible risks linked to need-thwarting behaviors. In this way, this tool may help optimize teaching strategies to enhance learning in Physical Education.

Furthermore, the broader use of the IBQ-PE-BRA may encourage institutional policies oriented toward teacher autonomy and student-centered pedagogy, supporting the creation of learning environments that nurture psychological well-being and academic engagement (Burgueño et al., 2024). Integrating the IBQ-PE-BRA into teacher evaluation and training systems can also contribute to monitoring and improving teaching quality based on empirical indicators aligned with SDT principles.

Based on the psychometric evidence presented in this study, we offer the following recommendations for researchers and practitioners considering the use of the IBQ-PE-BRA:

- (a) When the research question explicitly requires differentiated analyses of autonomy, competence, and relatedness support or thwarting on student outcomes, researchers may use the six-factor structure with appropriate caution, explicitly acknowledging the limitations in subscale-level convergent and discriminant validity in their interpretations and conclusions.
- (b) We recommend prioritizing the higher-order two-factor solution (Supportive vs. Thwarting behaviors) in most applied, correlational, and intervention-based research contexts, as this model demonstrated superior discriminant validity and more robust psychometric properties. This model demonstrates superior discriminant validity between the supportive and thwarting dimensions and provides more robust psychometric properties for meaningful group comparisons and correlational analyses.
- (c) For intervention studies, program evaluations, or applied educational settings where parsimony and clear interpretability are prioritized, the two-factor solution (Supportive vs. Thwarting) offers a more psychometrically defensible approach to assessing teachers' interpersonal behaviors. This approach reduces the risk of overinterpreting subtle differences between closely related subdimensions that may not be reliably distinguished by the current measure.

Conclusions

The results of the present study provide an initial body of evidence supporting the IBQ-PE-BRA as a measure of students' perceptions of teachers' behavior in the Physical Education lesson. However, addressing the identified limitations could further enhance the instrument. Despite some

limitations identified in this study, and recognizing that the validation of an instrument is an ongoing process over time, this research lays the groundwork by suggesting that the Brazilian version of the IBQ could serve as a valuable tool for exploring whether all six types of teachers' interpersonal behaviors similarly influence need-based experiences and motivational quality. This instrument offers the potential for a comprehensive investigation into how students perceive these six types of interpersonal behavior from their teacher in the Physical Education lesson.

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Data availability All data, including data transparency, and code for the analytical methods used in this study have been openly shared and made accessible through the Open Science Framework (OSF) (available at https://osf.io/bpvn3/?view_only=c61b5e4c37fa4dc7a16702a2c4ab0394).

Declarations

Ethics approval This study was reviewed and approved by the Ethics and Research Committee of the University of Pernambuco, *Centro Integrado de Saúde Amaury de Medeiros* (CISAM/UPE), under registration number 5.469.421/CAAE 57003922.3.0000.5191.

Informed consent Informed consent Informed consent was obtained from all legal guardians and participants included in the study.

Competing interests No potential conflict of interest was reported by the authors.

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