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Psychometric properties of behavioural Regulation in Exercise Questionnaire-4 in Chinese adolescents

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ABSTRACT

This study aims to determine the psychometric properties of the Chinese version of the Behavioural Regulation in Exercise Questionnaire-4 (C-BREQ-4) within the context of the adolescent population in China. A total of 846 Chinese adolescents (389 males and 457 females, comprising 411 secondary school students and 435 high school students), aged 12-18, with a mean (\bar{x}) age of 14.67 (± 1.45) years, participated in this study. The C-BREQ-4 was tested for convergent, discriminant, structural and criterion validity, internal consistency reliability, and cross-gender and grade invariance. Confirmatory factor analysis (CFA) revealed that the measurement model of the C-BREQ-4 with seven factors and 26 items had a good data fit. The 7-factor, 26-item C-BREQ-4 had good discriminant and convergent validity and internal consistency reliability. The correlation between the factors moderated by different motives supports the quasi-unitary model hypothesised by SDT, which provides support for the structural validity of the C-BREQ-4. Different association patterns were found between different motivational regulations and behavioural outcomes (physical activity; PA), a result that provides support for the criterion validity of the 7-factor, 26-item C-BREQ-4. Multi-group CFA showed evidence favouring the 7-factor, 26-item C-BREQ-4 remaining consistent across gender and grade levels. The C-BREQ-4 is a useful and robust measurement tool for assessing 7-factor motivational regulation in a Chinese adolescent population, adding evidence to the cross-cultural applicability of the BREQ-4. Furthermore, it can be used to better understand different types of motivational regulation in adolescent populations.

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Health Psychology; Sport Psychology; Sport and Exercise Science; Research Methods

1. Introduction

Regular physical activity (PA) is a very significant factor in maintaining individual health (World Health Organization (WHO), 2018), such as the prevention of cardiovascular disease, stroke, diabetes and non-communicable diseases such as osteoporosis and obesity. Moreover, it also helps with weight control (World Health Organization (WHO), 2018). Finally, it also improves maternal health and the quality of life of individuals (World Health Organization (WHO), 2018). Although it is well documented that PA has beneficial effects, physical inactivity continues to be a major public health problem around the world. The World Health Organization (WHO) (2018) states that over 75% of teenagers globally are not engaging in adequate PA. Lack of PA begins in adolescence (Weiss

& Ferrand, 2019), which is a critical stage of individual development. Developing PA habits during adolescence carries over into adulthood. Adolescence is a period marked by psychological and physiological changes, mainly characterised by increased autonomy in decision-making, major shifts in responsibilities and lifestyles, and the development and ingraining of PA habits, which may have a vital impact on the lifelong and intergenerational health of the individual (van Sluijs et al., 2021). Therefore, it is imperative to improve PA among adolescents globally.

Motivation is not only a critical determinant of an individual's participation in or withdrawal from PA (Ng et al., 2012; Teixeira et al., 2022). It is also a significant determinant of whether an individual will

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accept or participate in an intervention to increase PA levels and whether the newly implemented behavioural changes in PA will be sustainable (Kwasnicka et al., 2016).

Self-determination theory (SDT; Deci & Ryan, 1980, 2000), as an influential theory of motivation, is a metatheory of motivational, affective, and personality attributes of individuals that focuses on the attribution of causality to one's behaviour. As such, SDT has been widely used to study motivation in a PA or other exercise setting (Ng et al., 2012; Teixeira et al., 2012; Ryan et al., 2022). SDT focuses on the degree of behavioural willingness and individual determination. It stresses the self's dynamical function in the process of motive and views motivation as a continuous internal psychological dynamic that is constantly changing and developing (Ryan & Deci, 2000). It proposes a continuum of relative motivational autonomy based on the classic distinction between intrinsic and extrinsic motivation. This continuum includes a variety of different approaches to learned regulation (Ryan & Deci, 2017). Depending on the relative degree of autonomy, SDT distinguishes four different forms of regulation for extrinsic motivation, which range from controlled regulation (external and introjected regulation) to autonomous regulation (identified regulation and integrated regulation). Furthermore, the structure of the self-determination continuum implies that there are simple (ordered) correlation patterns between different types of motivation, with positive correlations between neighbouring motivations being stronger than those between motivations that are far apart (Ryan & Connell, 1989). On this continuum are, in order, intrinsic motivation (pleasure and satisfaction sans the involvement of external conditions) (Deci & Ryan, 2000), integrated regulation (identifying with the importance of one's behaviour and the behaviour becoming part of the self) (Ryan & Deci, 2020), identified regulation, (identifying with or endorsing the value of the activity) (Ryan & Deci, 2020), introjected regulation (perceived self-worth (e.g. self-confidence) versus threat (e.g. crime, shame)) (Fenner et al., 2013), external regulation (obtaining rewards or avoiding punishment) (Deci & Ryan, 2008) and, finally, amotivation (when individuals lack the intention to behave or act and are, therefore, undermotivated) (Deci & Ryan, 2008). According to the SDT, this continuum is mediated by three basic needs (i.e. autonomy, competence, and relatedness) that reflect the different reasons why individuals choose their behaviours (Ryan & Deci, 2000).

To assess the motivation to undertake physical exercise within the SDT framework, Mullan et al. (1997) developed the Behavioural Regulation in Exercise Questionnaire (BREQ) using the SDT framework as a guide. Although BREQ was developed using the SDT, it includes 15 items to evaluate four types of motivational regulation: external, introjected, identified, and intrinsic regulation. However, the first version of BREQ did not include amotivation and integrated regulation.

Markland & Tobin (2004) realised that BREQ was not sufficient to fully evaluate SDT motivation, so they developed BREQ-2. The BREQ-2 includes 19 items that assess five different types of motivational regulation. It adds amotivation assessment to BREQ. It has general applicability in the exercise domain and shows satisfactory evidence of construct validity in different cultural and linguistic contexts, such as English (D'Abundo et al., 2014), Greek (Moustaka et al., 2010) and Chinese (Liu et al., 2015). Despite the great success of BREQ-2 in the field of exercise, it is still conceptually different from SDT. SDT considers extrinsic motivation as having four different types of motivational regulation, namely external, introjected, identified and integrated regulation. But, BREQ-2 does not assess integrated regulation. Therefore, a six-factor BREQ-3, including integrated regulation, was developed (Wilson et al., 2006), in which four items evaluated the integrated regulation subscale. The BREQ-3 was subsequently tested by Gonzalez-Cutre et al. (2010) and showed good validity and reliability among Spanish adult exercisers, with invariance across gender and age. Subsequently, Cid et al. (2018) developed the Portuguese version of BREQ-3, which also showed satisfactory evidence of structural validity. Cavicchiolo et al. (2022) and Luo et al. (2022) tested the psychometric properties of BREQ-3 in Italy and China, respectively. The results of both studies showed satisfactory structural validity evidence for BREQ-3.

Measurement tools for motivational regulation have been continuously tested and extended to assess the SDT theoretical framework. However, the latest BREQ-3 assessment of introjected regulation focused only on the avoidance component of introjected regulation (Assor et al., 2009), which may have contributed to the continuous interval gap that exists in assessments aimed at introjected regulation (Assor et al., 2009; Howard et al., 2017). An incomplete assessment of introjected regulation may result in missing essential information on introjected regulation, leading to a decrease in reliability and predictive power (Assor et al., 2009; Howard et al., 2017).

Therefore, Assor et al. (2009) proposed two different subtypes of introjected regulation: an avoidance regulation meant to prevent poor self-value and an approached regulation meant to achieve great self-value. They defined introjected avoidance regulation as an individual's attempt to avoid a sense of inferiority, humiliation, or guilty feelings that result from failing to meet the introjection criterion (Assor et al., 2009). Introjected avoidance regulation is related to negative affect; for example, when a student feels guilt or shame because of poor grades, they study harder, thus exhibiting introjected avoidance regulation. On the other hand, introjected approach regulation is an individual's attempt to satisfy an introjection criterion to achieve or sustain a feeling of superior self-value, self-pride, and identity in society (Assor et al., 2009). Introjected approach regulation is associated with positive influence; for example, when an athlete puts more effort into a particular training session and feels confident and proud, the individual displays introjected approach regulation.

Teixeira et al. (2022), following the recommendations of Assor et al. (2009) and Howard et al. (2017), base the assessment of introjected regulation on both introjected avoidance regulation and introjected approach regulation. The 7-factor BREQ-4 was developed with 28 items, including a 4-item introjected approach regulation subscale. They conducted two studies to examine the psychometric properties of the BREQ-4. The first study investigated 806 exercisers (464 males and 342 females, with a mean (\bar{x}) age of 30.87 years) in health clubs in Portugal and showed that the 7-factor BREQ-4 (28 items) did not fit the data well. Therefore, the authors deleted one item in each factor, and the 21-item BREQ-4 showed good psychometric properties; furthermore, the factor structure of the 21-item BREQ-4 was invariant with respect to gender and type of activity (individual versus group activity). Their second study explored the association patterns between motivational regulation in SDT and the antecedents of goal content and basic psychological needs, satisfaction, and frustration. The findings supported the expected association patterns between self-determination theory and these antecedents. Their findings revealed that the 7-factor BREQ-4 had good psychometric properties.

Teixeira et al. (2022) study provides preliminary evidence for the application of the BREQ-4 (7-factor model) in the Portuguese context. At the same time, their study provides preliminary evidence for the introjected approach regulation scale, allowing for a better assessment of different forms of introjected

regulation and an understanding of the motivational quality of exercise practice. However, how applicable it is in other countries and cultures requires researchers to test its cross-cultural applicability in different countries and cultures (Teixeira et al., 2022). Currently, no study has assessed the BREQ-4 in a Chinese adolescent population; therefore, the objective of the current study was to investigate the psychometric properties of the BREQ-4 among a selected group of Chinese adolescents.

2. Methods

2.1. Participants

The participants in this study included students from secondary and high schools. A total of 916 questionnaires were distributed for this study, and 846 questionnaires were collected. The response rate was 92.4%. The age range of the students who participated in this survey was between 12-18 with a \bar{x} age of 14.67 (± 1.45) years, comprising 411 secondary school students (210 and 201 in grades seven and eight, respectively), 435 high school students (211 and 224 in grades ten and eleven, respectively). Of these participants, 389 were male and 457 were female.

This survey was conducted in April-May, 2023. Due to epidemic control measures, the researcher was not allowed to enter the school campus, so the questionnaire was administered by the physical education or classroom teacher of the surveyed school. All participants volunteered to participate in the questionnaire, which was completed anonymously and confidentially, and no information related to the survey was disclosed to anyone. Before completing the questionnaire, the physical education teacher or head of the class gave an introduction to the aims and objectives of the study. The questionnaire was completed in the classroom. Written informed consent was requested from participants' guardians. The participant was allowed to stop completing the questionnaire at any time if they felt uncomfortable doing so. The estimated completion time of this questionnaire was ten minutes. Finally, a small pilot test was conducted before proceeding with the formal distribution of the questionnaire in order to identify potential problems that could have hindered the actual data collection process. Therefore, this study used convenience sampling to select 60 secondary school students for pilot testing. The results of the pilot test showed that the questions were clear and easy to understand; therefore, no items were modified.

2.2. Measures

2.2.1. The Behavioural Regulation in Exercise Questionnaire-4 (BREQ-4)

Since the BREQ-4 developed by Teixeira et al. (2022) is not yet available in Chinese, this study required the translation of the English version of the BREQ-4 into the Chinese version (C-BREQ-4).

Before the translation was carried out, authorisation and consent were obtained from the researchers (Teixeira). Subsequently, the translation was started for the current study. Translation programs include forward and backward translation (Üstun et al., 2005). During forward translation, two bilinguals (English and Chinese) translated the English version of the questionnaire into the Chinese version. During backward translation, two other bilinguals translated the Chinese version of the questionnaire back into the English version. The quality of the backward-translated version was verified by comparing the backward-translated version with the original English version of the questionnaire. To further confirm the cultural appropriateness of the Chinese version of the questionnaire, it was presented to a panel of Chinese experts consisting of two sports psychologists, two physical education experts, and two youth PA experts. The panel reviewed and evaluated the Chinese version of the questionnaire. In the end, the final C-BREQ-4 was developed with the consensus of the six experts.

The C-BREQ-4 consists of seven factors and 28 items. The question stem of this scale is, *'Why do you engage in exercise?'* It uses four items to measure amotivation (for example, *'I cannot see why I should bother exercising.'*), four items for external regulation (e.g. *'I feel under pressure from my family/friends to exercise.'*), four items for introjected avoidance regulation (e.g. *'I feel like a failure when I have not exercised in a while.'*), four items for introjected approach regulation (e.g. *'I feel better about myself when I continue to participate.'*), four items for identified regulation (e.g. *'I value the benefits of exercise.'*), four items for integrated regulation (e.g. *'I consider exercise to be part of my identity.'*), and four items for intrinsic regulation (e.g. *'I find exercise a pleasurable activity.'*). The questionnaire uses a 5-point Likert scale, ranging from one (not true for me) to five (very true for me).

2.2.2. The Chinese version physical activity questionnaire for adolescent (PAQ-A)

The Chinese version of PAQ-A (Li et al., 2015) is comprised of seven items assessing participation in a variety of physical activities during physical education classes, after school, evenings, and weekends.

PAQ-A is scored using a 5-point Likert scale; the \bar{x} of the seven items was the PAQ-A score. Item 1 assessed moderate to vigorous PA in the past week: this item consisted of 23 sub-questions assessing the frequency of the participant's sports activities such as running, table tennis, volleyball, etc. (0 times = 1; ≥ 7 times = 5), and the \bar{x} of the 23 sports was calculated as the final score for Item 1. Items 2-5 assessed individuals' level of participation in physical education classes after school, in the evening, and on weekends, with 1=low and 5=high. The number corresponding to the option is the score for that item. Item 6 assessed the youth's overall level of activity over the past week, with 1=low and 5=high, and Item 7 assessed the participant's PA behaviour on each day of the last week, with 1=never and 5=very often. The \bar{x} of the 7-day activity frequency was the final score for Item 7. Previous studies have found that PAQ-A shows good reliability and validity in PA surveys of Chinese adolescents (Li et al., 2015). Thus, PAQ-A is suitable for large samples of Chinese adolescents' PA surveys. The Cronbach alpha (CA) of PAQ-A in the current study was 0.86, indicating that PAQ-A has good internal consistency reliability.

2.3. Data analysis

Before analysing the data, the first step was to screen the data, during which missing values of data might be found. The data were manually checked, and the study data had no missing values. Second, descriptive statistics were performed on the C-BREQ-4 using IBM® Statistical Product and Service Solutions (SPSS®) version 24. Third, a confirmatory factor analysis (CFA) was conducted on the C-BREQ-4 using IBM® Analysis of Moment Structures (AMOS®) version 21 to test the hypothesised 7-factor structure of the BREQ-4. Considering the possibility of normality bias in the data, the researchers decided to use the maximum likelihood estimation and bootstrap methods suggested by Fritz & MacKinnon (2007) and Preacher & Hayes (2008) for the evaluation of the model.

In addition, several fit indices were chosen to assess if the model was fit for the data. These included chi-square (χ^2), comparative fit index (CFI), root mean square error of approximation (RMSEA) and its 90% confidence interval (90% CI), and standardised root mean square residual (SRMR). For CFI, a value closer to 1 is more suitable, while that approaching 0 is worse. Typically, CFI ≥ 0.90 is considered to be a good model fit (Wu, 2009). The RMSEA is often considered to be the most significant fitness information, and the smaller its value, the

better the model fit. Typically, RMSEA = <0.08 indicates a good model fit (Wu, 2009). For SRMR, the larger its value, the worse the model fit, and in general, SRMR = <0.05 indicates a good model fit (Wu, 2009).

Fourth, the internal consistency reliability, convergent validity, and discriminant validity of the C-BREQ-4 were examined. Two indicators, Cronbach alpha (CA) and composite reliability (CR), were used to assess internal consistency reliability.

Both CA and CR = >0.7 can be used as measures of good internal consistency (Souza et al., 2017; Tavakol & Dennick, 2011; Terwee et al., 2007). To establish convergent validity, we used factor loadings (FLs) and the average variance extracted (AVE). Factor loadings are between 0 and 1, and the FLs and AVE should be >0.50 to achieve convergent validity (Souza et al., 2017; Ab Hamid et al., 2017). Discriminant validity was tested using Fornell & Larcker (1981) method; the square root of the AVE of each construct was compared to the correlation of constructs. Discriminant validity was good if the square root of the AVE of the two constructs was higher than the correlation between them. Fifth, a multi-group CFA was used to test the measurement invariance of the BREQ-4 in Chinese adolescents. Measurement invariance of the scale across gender and grade groups (secondary school and high school) was tested through a series of multi-group CFAs with increasingly stringent equality constraints imposed on the model parameters, as suggested by Van de Schoot et al. (2012). The models were compared according to Cheung & Rensvold (2002) and Chen (2007), who suggested that CFI and RMSEA be compared to see if the difference between them was <0.01 and 0.015, respectively. If the values were <0.01 and 0.015, respectively, it was considered to be an indication of invariance. Additionally, the structural validity of the BREQ-4 was tested, i.e. correlations between neighbouring motivational regulation on the continuum are stronger than correlations between non-neighbouring motivational regulation, thus supporting the single model hypothesised by the SDT. Finally, Teixeira et al. (2022) study only examined the pattern of associations between the BREQ-4 and the antecedents of goal content and basic psychological needs, satisfaction, and frustration; therefore, there is a need to examine the pattern of associations between the BREQ-4 and the behavioural outcome (PA), which could provide support for the criterion validity of the C-BREQ-4.

3. Results

3.1. Descriptive statistics

As seen in Table 1, the \bar{x} was lowest and highest for amotivation and intrinsic regulation, respectively. This indicates that the \bar{x} for autonomous motivation was higher than that of control motivation and amotivation scores. As shown in Table 1, the skewness and kurtosis for all variables were between -2 to +2 and -7 to +7, as suggested by Hair et al. (2010). Therefore, the data in this study were univariate and normally distributed.

3.2. Confirmatory factor analysis (CFA)

The results of the CFA showed that the C-BREQ-4 model for seven factors and 28 items was fitted to the data as follows: $\chi^2(df)=1400.990(329)$, $p<0.001$, CFI = 0.916, RMSEA = 0.062 (0.059-0.065), and SRMR = 0.054. The standardised FLs for all items ranged from 0.42-0.91. The standardised FLs of Items AM1 and IAR1 were 0.44 and 0.42, respectively, and their FLs were <0.5, so the Items AM1 (*'I don't see why I should have to exercise.'*) and IAR1 (*'I feel proud of myself when I persist.'*) were deleted, and the remaining 26 items in the C-BREQ-4 were subjected to a secondary CFA test. The results of fitting the C-BREQ-4 model to the data for the seven factors and 26 items were as follows: $\chi^2(df)=955.428(278)$, $p<0.001$, CFI = 0.944, RMSEA = 0.054 (0.05-0.057), SRMR = 0.032. The standardised FLs for all items were 0.66-0.93 (Table 1) and were statistically significant ($p<0.001$). This indicates that the 7-factor, 26-item C-BREQ-4 model is satisfactory.

3.3. Internal consistency reliability

As seen in Table 1, the CR and CA of the seven factors of the C-BREQ-4 were >0.7; therefore, the C-BREQ-4 has good internal consistency reliability.

3.4. Convergent and discriminant validities

Table 1 shows the FLs and AVE of the seven factors of the C-BREQ-4. As the 26 items were >0.50, they have sufficient convergent validity. Table 2 shows the square root of the factor AVE of the seven factors of the C-BREQ-4. As its 26 items were higher than the correlation between the factors, the C-BREQ-4 with seven factors and 26 items has sufficient discriminant validity; that is, the C-BREQ-4 has a different structure.

Table 1. Mean, standard deviation, Skewness, Kurtosis, standardized factor loadings, average variance extracted, composite reliability and Cronbach's Alpha coefficient of C-BREQ-4.

Variable	M	SD	Skewness	Kurtosis	Loading	AVE	CR	a
AM	1.81	0.85	1.33	1.92		0.70	0.87	0.85
AM2 (I can't see why I should bother exercising)					0.72			
AM3 (I don't see the point in exercising)					0.93			
AM4 (I think exercising is a waste of time)					0.84			
ER	2.04	0.93	0.84	0.13		0.57	0.84	0.84
ER1 (I exercise because other people say I should)					0.78			
ER2 (I take part in exercise because my friends/family/ partner say I should)					0.84			
ER3 (I exercise because others will not be pleased with me if I don't)					0.68			
ER4 (I feel under pressure from my friends/family to exercise)					0.70			
IVR	2.68	0.90	0.47	-0.19		0.52	0.81	0.81
IVR1 (I feel guilty when I don't exercise)					0.70			
IVR2 (I feel ashamed when I miss an exercise session)					0.78			
IVR3 (I feel like a failure when I haven't exercised in a while)					0.73			
IVR4 (I get restless if I don't exercise regularly)					0.68			
IAR	3.38	1.01	-0.27	-0.62		0.57	0.80	0.80
IAR2 (Because I want to prove to myself that I'm able to persist)					0.73			
IAR3 (I can only be satisfied with myself when I continue to participate)					0.75			
IAR4 (I feel better about myself when I continue to participate)					0.79			
IDR	3.67	0.98	-0.64	-0.20		0.57	0.84	0.84
IDR1 (I value the benefits of exercise)					0.78			
IDR2 (It's important to me to exercise regularly)					0.74			
IDR3 (I think it is important to make the effort to exercise regularly)					0.73			
IDR4 (I value exercise for the benefits of its practice)					0.77			
ITR	3.72	0.90	-0.36	-0.43		0.63	0.87	0.87
ITR1 (I exercise because it is consistent with life goals)					0.70			
ITR2 (I consider exercise to be part of my identity)					0.84			
ITR3 (I consider exercise a fundamental part of who I am)					0.84			
ITR4 (I consider exercise consistent with my values)					0.79			
INR	3.77	0.99	-0.51	-0.59		0.69	0.90	0.90
INR1 (I exercise because it's fun)					0.79			
INR2 (I enjoy my exercise sessions)					0.85			
INR3 (I find exercise a pleasurable activity)					0.88			
INR4 (I get pleasure and satisfaction from participating in exercise)					0.81			
PA	2.74	0.79	0.38	-0.19				0.86

Note: n: 846; AM: amotivation; ER: external regulation; IVR: introjected avoidance regulation; IAR: introjected approach regulation; IDR: identified regulation; ITR: integrated regulation; INR: intrinsic regulation; PA: physical activity; AVE: average variance extracted; CR: composite reliability; a: Cronbach's Alpha coefficient.

Table 2. Average variance extracted, the square root of the average variance extracted and factor correlations of C-BREQ-4.

Variable	AVE	\sqrt{AVE}	AM	ER	IVR	IAR	IDR	ITR	INR
AM	0.7	0.84	-	0.73**	0.02	-0.08*	-0.16**	-0.38**	-0.24**
ER	0.57	0.76		-	0.14**	-0.05	-0.14**	-0.29**	-0.18**
IVR	0.52	0.72			-	0.58**	0.38**	0.30**	0.46**
IAR	0.57	0.76				-	0.60**	0.47**	0.50**
IDR	0.57	0.76					-	0.59**	0.64**
ITR	0.63	0.79						-	0.66**
INR	0.69	0.83							-

Note: n: 846, AM: amotivation; ER: external regulation; IVR: introjected avoidance regulation; IAR: introjected approach regulation; IDR: identified regulation; ITR: integrated regulation; INR: intrinsic regulation; AVE: average variance extracted, \sqrt{AVE} =the square root of the AVE, *P < 0.05, **P < 0.01.

3.5. Construct validity

The results of the correlations between factors show (Table 2) that on the 7-factor self-determination continuum, the positive correlations between neighbouring factors are higher than the correlations between non-neighbouring factors. As shown in Table 2, identified regulation is positively correlated with integrated regulation (0.59), and identified regulation is positively correlated with intrinsic regulation (0.64). Therefore, only the positive correlation between identified and intrinsic regulation is stronger than the positive correlation between identified and integrated regulation. The

correlation coefficients between neighbouring factors in the other C-BREQ-4 were higher than those between non-neighbouring factors, which suggests that the present study provides partial support for the structural validity of the C-BREQ-4 (that is, the quasi-unitary model of the SDT hypothesis is supported).

3.6. Invariance across gender and grades

As seen in Table 3, the CFA results for the baseline model for cross-sex comparisons (unconstrained model; Model 1) were: χ^2 (df)=1344.392(558), $p < 0.001$,

Table 3. Measurement invariance of C-BREQ-4 across gender and grade.

group	model	χ^2	DF	CFI	RMSEA	SRMR	Models Compared	Δ CFI	Δ RMSEA
gender	Model 1	1344.392	558	0.935	0.041	0.042	–	–	–
	Model 2	1380.206	576	0.934	0.041	0.042	Model 2 against Model 1	0.001	0.000
	Model 3	1433.717	603	0.932	0.040	0.048	Model 3 against Model 2	0.002	0.001
	Model 4	1473.724	629	0.930	0.040	0.048	Model 4 against Model 3	0.002	0.000
grade	Model 1	1323.071	558	0.937	0.040	0.041	–	–	–
	Model 2	1344.793	576	0.936	0.040	0.041	Model 2 against Model 1	0.001	0.000
	Model 3	1401.153	603	0.934	0.040	0.057	Model 3 against Model 2	0.002	0.000
	Model 4	1492.705	629	0.928	0.040	0.056	Model 4 against Model 3	0.006	0.000

Note: $n_{\text{Male}}=389$, $n_{\text{Female}}=457$, $n_{\text{Secondary school students}}=411$, $n_{\text{High school students}}=435$, Model 1= Unconstrained model, Model 2= Measurement weights model, Model 3= Structural covariances model, Model 4= Measurement residuals model, χ^2 =chi-square test, DF=degrees of freedom, CFI=comparative fit index, RMSEA=root mean square error of approximation, SRMR=standardized root mean residual, Δ CFI=differences in CFI, Δ RMSEA=differences in RMSEA.

CFI = 0.935, RMSEA = 0.041 (0.038-0.044), and SRMR = 0.042. Model 1 showed a good degree of fit. On the basis of the baseline model, the test of equivalence of FLs of the two sample models for boys and girls was conducted (FLs were constrained to be equal; Model 2), and Model 2 showed a good degree of fit. The CFA and RMSEA differences between Model 2 and Model 1 (Δ CFI = 0.001; Δ RMSEA = 0.000) were <0.01 , which indicated that there was no difference in FLs across genders in Chinese adolescents. On the basis of the absence of variability in FLs, a test of equivalence of factor variances and covariances of the two-sample model for boys and girls was conducted (factor variances and covariances were constrained to be equal; Model 3), and Model 3 showed a good degree of fit. The CFA and RMSEA variance between Model 3 and Model 2 (Δ CFI = 0.002; Δ RMSEA = 0.001) were <0.01 , which indicated that there was no difference in factor variance and covariance across genders for Chinese adolescents. Finally, based on the absence of variance in the factor variances and covariances, a test of residual variance equivalence was conducted (residual variances were constrained to be equal; Model 4), and Model 4 also showed a good fit. The CFA and RMSEA difference between Model 4 and Model 3 (Δ CFI = 0.002; Δ RMSEA = 0.000) were <0.01 , which indicated that there was no difference in the residual variance across genders among Chinese adolescents. In conclusion, the findings suggest that the FLs, factor variances and covariances, and residuals of the 7-factor, 26-item C-BREQ-4 measurement model are invariant across the genders of Chinese adolescents (i.e. the C-BREQ-4 possessed cross-gender invariance).

Similarly, the 7-factor, 26-item C-BREQ-4 was tested for invariance across grades. As seen in Table 3, the CFA test results for the baseline model (unconstrained model; Model 1) for cross-grade (middle and high school) comparisons were: $\chi^2(\text{df})=1323.071(558)$, $p<0.001$, CFI = 0.937, RMSEA = 0.040 (0.038-0.041), and SRMR = 0.041. Model 1 showed a good fit. Based on the baseline model, a test of equivalence of FLs

for the two sample models for middle school and high school was conducted (FLs were constrained to be equal; Model 2), and Model 2 showed a good degree of fit. The CFA and RMSEA variance between Model 2 and Model 1 (Δ CFI = 0.001 and Δ RMSEA = 0.000) were <0.01 , which indicated that there was no difference in FLs across grades among Chinese adolescents. On the basis of the absence of variability in FLs, a test for equivalence of factor variances and covariances between the two sample models for middle school and high school was conducted (factor variances and covariances were constrained to be equal; Model 3), and Model 3 showed a good degree of fit. The CFA and RMSEA variance between Model 3 and Model 2 (Δ CFI = 0.002; Δ RMSEA = 0.000) were <0.01 , which indicated that the factor variances and covariances did not differ across grades for Chinese adolescents. Finally, based on the non-difference in factor variances and covariances, a test of residual variance equivalence was conducted (residual variances were constrained to be equal; Model 4), and Model 4 also showed a good fit. The CFA and RMSEA variance between Model 4 and Model 3 (Δ CFI = 0.006; Δ RMSEA = 0.000) were <0.01 , which indicated that there was no difference in residual variance across grade levels among Chinese adolescents. The results across grades suggest that the FLs, factor variances and covariances, and residuals of the 7-factor, 26-item C-BREQ-4 measurement model are invariant across Chinese adolescents' grades (i.e. the C-BREQ-4 possessed across grade invariance). In summary, the findings support the invariance of the 7-factor, 26-item C-BREQ-4 across genders and grades.

3.7. Correlation between the Chinese version of behavioural regulation in exercise questionnaire-4 (C-BREQ-4) and behavioural outcomes (physical activity (PA))

As seen in Table 4, PA negatively correlated with amotivation and external regulation and did not

Table 4. Correlations between C-BREQ-4 scores and physical activity.

	AM	ER	IVR	IAR	IDR	ITR	INR
PA	−0.35***	−0.34***	0.03	0.09**	0.12**	0.36***	0.28***

Note: AM: amotivation; ER: external regulation; IVR: introjected avoidance regulation; IAR: introjected approach regulation; IDR: identified regulation; ITR: integrated regulation; INR: intrinsic regulation; PA: physical activity, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

correlate with introjected avoidance regulation. It positively correlated with introjected approach regulation, identified regulation, integrated regulation, and intrinsic regulation. The pattern of correlations in the present study supports the findings of Teixeira et al. (2022) that introjected approach regulation defines a tighter transition line between controlled motivation (introjected avoidance regulation) and autonomous motivation (identified regulation). These findings are consistent with previous findings (Ng et al., 2012; Rodrigues et al., 2018), which provide support for the criterion validity of the 7-factor, 26-item C-BREQ-4.

4. Discussion

The purpose of this study was to examine the psychometric properties of the C-BREQ-4 in a population of Chinese adolescents. Therefore, this study investigated the reliability, convergent validity, discriminant validity, construct validity, criterion validity, and cross-gender and grade invariance of the C-BREQ-4 in a sample of Chinese adolescents using a different sample.

Descriptive statistics revealed that the \bar{x} of introjected approach regulation was higher than that of introjected avoidance regulation and that it was close to the \bar{x} of autonomous motivation. This finding is consistent with the results of Teixeira et al. (2022) and supports the SDT hypothesis that autonomous motivation is important for sustained PA behaviours because individuals regulate their behaviours through more autonomous and less controlled types of motivation during long-term PA (Teixeira et al., 2012).

The CFA showed that FLs for items AM1 (*I do not see why I should have to exercise.*) and IAR1 (*I feel proud of myself when I persist.*) did not meet the <0.5 criterion. Therefore, these two items were deleted, and the C-BREQ-4 model with seven factors and 26 items fitted the data well. Item AM1 was similarly found to be problematic in the study by Teixeira et al. (2022), which also suggests that the majority of individuals understand the significance of exercise, and therefore, Item AM1 was removed from the C-BREQ-4. In addition, the FL of Item IAR1 was <0.5 , thus justifying its removal (Hair et al., 2010).

Therefore, the 26-item C-BREQ-4 may be a better solution for assessing SDT-based 7-factor motivational regulation in Chinese adolescents.

The study also provides evidence of the structural validity of BREQ-4, with the 7-factor C-BREQ-4 correlation results supporting the SDT hypothesis of a single model. This suggests that the 7-factor C-BREQ-4 represents seven different constructs (amotivation, external regulation, introjected avoidance regulation, introjected approach regulation, identified regulation, integrated regulation and intrinsic regulation). On the 7-factor self-determination continuum, positive correlations between neighbouring factors were higher than correlations between non-neighbouring factors. This correlation pattern is in line with previous findings in diverse fields of study (Assor et al., 2009; Teixeira et al., 2022). It is also supported by findings in the cultural contexts of Israel and Portugal (Assor et al., 2009; Teixeira et al., 2022). In addition, findings support the convergent validity, discriminant validity, and internal consistency reliability of the C-BREQ-4 in a Chinese adolescent population.

Analysis of model invariance showed that the FLs, factor variance, and covariance of the C-BREQ-4 measurement model were invariant among Chinese adolescents. This result suggests that the C-BREQ-4 measures the same constructs. It indicates that the model can explain the behaviours of Chinese adolescent males and females at secondary and high school levels.

Finally, the criterion validity of the C-BREQ-4 was supported by correlations with behavioural outcomes (PA), and the results of the study are compatible with those of previous studies (Ng et al., 2012; Rodrigues et al., 2018). The pattern of positive correlation between introjected approach regulation and behavioural outcome (PA) is consistent with the findings of Assor et al. (2009) and Teixeira et al. (2022). It suggests that the emergence of introjected approach regulation makes the transition from controlled motivation (introjected avoidance regulation) to autonomous motivation (identified regulation) clearer.

5. Strengths and limitations

The findings of this study denoted psychometric proof for the C-BREQ-4 and offered the potential for better insights into the association between distinct

types of motivational regulation and PA in a group of Chinese adolescents during PA. The present study makes several contributions to the generalisation of the BREQ-4. First, validating the C-BREQ-4 in the Chinese context expands the generalisability of the BREQ-4 across countries and cultures. In addition, the present study addresses the measurement invariance of the BREQ-4 across genders and grades in adolescent populations, providing evidence for its use in meaningfully comparing motivational processes in the domain of PA or exercise in adolescents.

While this study has some strengths, it also has inevitable limitations. First, all participants in this study were Chinese adolescents, resulting in findings that may not be generalisable to other Chinese populations. Therefore, future studies should examine the applicability of the C-BREQ-4 in different Chinese populations, such as children, adults, and the elderly. In addition, the present study only examined patterns of association between the C-BREQ-4 and behavioural outcomes, and future researchers are encouraged to examine patterns of association between the C-BREQ-4 and known antecedents of SDT (e.g. goal content or basic psychological needs, satisfaction, and frustration, etc.), thereby increasing the validity of the BREQ-4.

6. Conclusions

The C-BREQ-4 is a reliable and valid measure for assessing 7-factor motivational regulation in a Chinese adolescent population, adding evidence to the cross-cultural applicability of the BREQ-4. In addition, the C-BREQ-4 was invariant across adolescents' gender and grade, suggesting the BREQ-4 can be used to better understand different types of motivational regulation in adolescent populations.

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Publication ethical

Informed consent was obtained from all participants included in the study. All procedures in studies involving human participants were performed in accordance with the ethical standards of the institution's Human Research Ethics Committee (JKEUPM-2023-1166).

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