Psychometric Properties and Measurements Invariance of the Behavioural Regulation in Exercise Questionnaire-2 (BREQ-2) among Chinese Mainland Adolescents

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Abstract

The objective of this study is to conduct a thorough assessment of the psychometric properties and measurement consistency of the Behavioural Regulation in Exercise Questionnaire-2 in a sample of adolescents from Mainland China. This research project involves recruiting 350 middle and high school students to conduct a thorough assessment of internal consistency and discriminant validity. The methods used include confirmatory factor analysis and multi-group confirmatory factor analysis. In addition, the study examines the consistency of these measures among various genders and educational backgrounds. The findings indicated that the students' motivation levels were moderately high, as evidenced by the internal consistency coefficients ranging from 0.818 to 0.903 for the subscales. The confirmatory factor analysis provided strong evidence for a 5-factor structure, as indicated by the satisfactory fit indices (CFI = 0.972, RMSEA = 0.046). Also, the measurement invariance tests demonstrated the stability of the factors across various genders and academic groups (ΔCFI < 0.01). The results of this study confirm the effectiveness of the Behavioural Regulation in Exercise Questionnaire-2 as a valuable tool for evaluating exercise motivation regulation among young individuals in Mainland China. This reinforces the tool's usefulness for future scholarly research as well as its practical application in educational and developmental settings.

Keywords: Behavioural Regulation, Psychometric Properties, Measurement Invariance, Chinese Mainland Adolescents.

Introduction

In today's fast-paced world, the rapid progress of technology and society has brought about a decrease in physical activity among young people. The prevalence of modern conveniences like cars, lifts, and smart devices, combined with sedentary leisure activities such as television and online gaming, has contributed to this decline (Dwivedi et al., 2021). Young individuals often lead sedentary lifestyles and make poor dietary choices, which are leading to various health concerns such as obesity and declining cardiovascular well-being (Wacks & Weinstein, 2021). China has conducted regular physical fitness surveys, which have revealed a concerning trend of diminishing physical fitness and rising obesity rates among adolescents over the past decades. This situation is urgent and requires attention. These findings highlight the importance of exercise motivation and healthy habits in addressing these adverse health effects.

Self-determination theory (SDT) is a humanistic theory of motivation developed by Deci and Ryan (1985). Self-determination theory posits that motivation varies not only in terms of quantity but also in terms of quality, which sets it apart from other existing theories of motivation (Ryan & Deci, 2000). The self-determination theory proposes three types of motivation: amotivation, external motivation, and internal motivation. Amotivation (AM) refers to a state characterised by a lack of purpose for engaging in behaviours. Extrinsic motivation (EM) is the drive that prompts individuals to engage in a behavior in order to obtain external rewards or benefits. The concept of external motivation encompasses three distinct types: external regulation (EX), introjected regulation (IJ), and identified regulation (ID) (Ryan et al., 2000).

External regulation refers to a situation where an individual's behaviour is influenced mainly by external factors or pressures. These factors may include the desire for rewards, the fear of punishment, or being compelled to act in a certain way. An individual's behaviour is primarily governed by internal pressure, such as the desire to avoid feelings of guilt or to increase feelings of competence and effectiveness. Identification regulation involves individuals recognising the

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significance of an action and feeling compelled to participate in it. An identified rule is when someone acknowledges the significance of a task and subsequently feels compelled to complete it. Internal motivation is the most self-driven form of motivation, where individuals engage in certain behaviours out of personal interest and enjoyment, with the main focus being on the behaviour itself (Ryan et al., 2000).

The various forms of motivation are spread across a spectrum of internalisation, with the level of internalisation indicating the level of self-determination. The self-determination theory suggests that there is a stronger relationship between motivations that are closer together on the continuum, compared to motivations that are further apart. One way to move from a motivation type with a low degree of self-determination to a motivation type with a higher degree of self-determination is through the process of internalisation (Ryan & Connell, 1989). Furthermore, external regulation and introjected regulation are mainly influenced by stress and are thus categorised as controlled motivation. Identified regulation and internal motivation are considered autonomous motivation due to their relative autonomy in self-determination.

There is a significant lack of research into the factors that influence exercise motivation among Chinese adolescents. There is a lack of research on the application of the Behavioural Regulation in Exercise Questionnaire-2 (BREQ-2) to middle and high school students in China, despite its extensive use in measuring motivational regulation in different contexts. In addition, there has been limited research on the variations in motivational factors based on gender and academic levels within this particular demographic. This study seeks to address these gaps by answering the following research questions:

1. How effectively can the BREQ-2 measure exercise motivation among Chinese adolescents?

2. Are there Invariance in BREQ-2 across gender and academic levels within this group?

The objective is to validate the use of the BREQ-2 for Chinese adolescents and to identify motivational factors that could guide targeted interventions aimed at enhancing their exercise levels.

In the upcoming sections, we will delve into the methodology used to evaluate the psychometric properties of the BREQ-2. We will then present the findings from this assessment, analyse the implications of these findings, and suggest potential areas for future research based on the outcomes of this study.

Literature Review

Research on exercise indicates that the motivation of adolescents to engage in physical activity is shaped by various

factors, encompassing socio-cultural and psychological aspects (Atakan et al., 2021; Calcaterra et al., 2022). Recent studies have highlighted the significance of comprehending these factors in order to address the growing sedentary lifestyle that is being observed worldwide, particularly in societies heavily influenced by technology.

Research has demonstrated that there is a strong connection between intrinsic motivation and long-term exercise habits, as well as improved mental well-being (Standage et al., 2008). On the other hand, extrinsic motivation, specifically external regulation, has been linked to lower adherence to exercise regimens (Brötz, 2013). BREQ and its subsequent revision, BREQ-2, have been extensively utilised to assess motivational constructs in the realm of physical activity (Markland & Tobin, 2004).

Researchers have developed various versions of tools to measure motor motivation, such as the sport motivation scale (SMS; SMS-2) based on self-determination theory (Brière et al., 1995). Markland et al. (2004) developed the Behavioural Regulation Exercise Questionnaire. BREQ-2 is commonly utilised in the realm of exercise. The questionnaire includes 19 questions that address five dimensions. Participants will rate their level of compliance using a 5-point Likert scale, with 1 indicating total non-compliance and 5 indicating complete compliance. Multiple international studies have demonstrated the questionnaire's strong reliability and validity (D'Abundo et al., 2014; Kovács & Kovács, 2021; Mahony et al., 2019; Moustaka et al., 2010; Murcia et al., 2007) .

The Chinese version of BRSQ-2 has been utilised by researchers studying Chinese athletes and college students. Previous studies have reported a range of internal consistency reliability values (0.6 ~ 0.9) (LIU et al., 2015). Unfortunately, there is a lack of research on BREQ-2 among high school students in China, particularly middle and high school students. Chinese Mainland middle and high school students are becoming increasingly disengaged from physical activity due to the mounting academic demands they face. Further exploration by researchers is necessary to examine the psychometric properties of the Chinese version of the BREQ-2 for Chinese Mainland middle and high school students.

The BREQ-2, an extension of the original 15-item Behavioural Regulation in Exercise Questionnaire (BREQ), includes an additional sub-scale with four questions to measure amotivation, thus expanding its scope for a more comprehensive analysis of exercise behaviour. This version is widely used in academic research. The self-reported BREQ-2 scale assesses various types of motivation, including amotivation, external motivation, intrinsic motivation, identified motivation, and intrinsic motivation of regulation (Ryan et al., 1989).

The BREQ-2, a 19-item test with 5 associated factors, does

not distinguish between integrative regulation and intrinsic regulation like other behavioural regulation tools. While these two types of regulation are conceptually simple to identify, they are difficult to differentiate experimentally (Mullan et al., 1997). The validity and reliability of the scores produced by the BREQ and BREQ-2 have been supported by extensive empirical data from previous research (Ingledew & Markland, 2008; Markland et al., 2004; Moustaka et al., 2010; Mullan et al., 1997). The structural aspects of the instrument were not influenced by the gender or academic standing of the participants. All of these findings indicate that the instrument (BREQ/BREQ-2) is strong from a psychometric perspective and is appropriate for use in research conducted in the context of exercise (Mullan et al., 1997).

Translating measurement tools into different languages is considered an important strategy for expanding the use of theories and models across different cultures and countries (Moustaka et al., 2010). The BREQ-2 has been widely adapted into different languages such as Spanish, Greek, and Chinese. Several studies have been conducted to explore the measurement characteristics of the BREQ-2 in these language versions (Chung & Dong Liu, 2012; Moustaka et al., 2010; Murcia et al., 2007). The factor model that was initially predicted was successfully recreated, and it was also found that the subscales demonstrated satisfactory internal consistency. However, a specific regulation item that caused difficulties was identified and eventually removed (such as the Spanish, Greek, and Chinese versions). These findings provided support for the notion that the BREQ-2 could potentially be used in a range of different settings, involving a variety of cultures, if it is translated and applied correctly.

Although the BREQ-2's psychometric properties have been confirmed among college students and athletes in Mainland China and Hong Kong, it is important to note that the cognitive abilities and psychological maturity of middle and high school students vary significantly from those of college students. There is a clear lack of research in Mainland China that utilises psychometric tools like the BREQ-2, which highlights this gap even more. This research aims to investigate the psychometric characteristics of BREQ-2 among middle and high school students in mainland China. Therefore, study proposed five research objectives:

(1) to assess the factorial validity of BREQ-2 among Chinese Mainland middle and high school student.

(2) to assess the discriminant validity of BREQ-2 among Chinese Mainland middle and high school student.

(3) to assess the reliability of consistency for BREQ-2 among Chinese Mainland middle and high school student.

(4) to assess the measurement invariance between male and female students.

Methods

Participants and procedure

The study was conducted in Binzhou City, Shandong Province, and focused on two middle schools and two high schools as research sites. Binzhou and the four schools were selected due to their representation of the educational atmosphere and the varied youth population in China's eastern coastal regions. The region's unique blend of urban and rural characteristics, along with its diverse economic and social development, offers a rich sample base encompassing a wide range of social backgrounds for academic study.

A total of 350 middle and high school students from mainland China were recruited to participate in this study by completing a questionnaire. A total of 350 questionnaires were submitted by students, resulting in a response rate of 100%. A total of 25 questionnaires that did not meet the qualifications were excluded, leaving us with 325 valid questionnaires. The average age of the participants from the Chinese middle and high school was 13.50 (range 12-14; SD=0.52, 174 females and 151 males). A total of 152 students are enrolled in two middle schools, while 173 students are attending two high schools.

Ethical approval was obtained from the JKEUPM, the Ethic Committee for Research Involving Human Subjects at University Putra Malaysia. Prior to approaching students in the classroom about participating in the research, it was determined that it would be necessary to contact the educators of the middle and high school to obtain their approval. All participants in the research voluntarily chose to participate. Prior to commencing the courses, all participants were given the chance to complete questionnaires. The completion of the questions took approximately ten minutes.

Measures

The BREQ-2 (Markland et al., 2004) was used to evaluate behavioural regulations associated with exercise. The identified regulation item "I get restless if I don't exercise regularly" in a previous study showed associations with multiple factors and significant deviations in standardised residuals. Removing the element from the analysis would significantly improve the model's fit. The 18-item questionnaire was assessed using a Likert 7-point scale, ranging from 1 (representing complete disagreement) to 7 (representing complete agreement). The measurement of exercise motivation was conducted using five dimensions, as shown in Table 1. The study employed the Chinese version of the Behavioural Regulation in Exercise Questionnaire-2 (BREQ-2), which was translated and evaluated by LIU et al. (2015).

Date Analysis

The data were analysed using SPSS 27.0 and AMOS 24. The statistical analyses involved conducting a confirmatory factor analysis (CFA) using AMOS 24.0 to examine the proposed 5-component structure of the BREQ-2 in the second step of the research. Furthermore, this study aims to assess the internal consistency reliability of the BREQ-2 subscales using composite reliability and Cronbach's alpha, in light of the observed limitations of Cronbach's alpha. In order to evaluate the discriminant validity, we calculated the correlations between the subscales of the BREQ-2 and the relevant variables. A multiple-group confirmatory factor analysis (CFA) was conducted to examine the measurement invariance of the BREQ-2 among gender and academic level of middle and high school students residing in mainland China. The analysis focused on unconstrained parameters, including measured weights, structural covariances, and measurement residuals.

The fit indices for the full model were evaluated using several key metrics: the chi-square value ($\chi2$), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardised Root Mean Square Residual (SRMR). Acceptable fitted models are characterised by CFI values greater than 0.90, TLI values greater than 0.90, SRMR values less than 0.08 (Browne & Cudeck, 1992), and RMSEA values less than 0.08. The study employed confirmatory factor analysis with Amos 28 to determine the optimal factor structure of the active behaviour scale. Additionally, multiple confirmatory factor analysis was conducted to assess the measurement equivalence of the scale among male and female middle school students. In order to assess the equivalence of a measurement, it is essential to

evaluate the nested models of configuration equivalence, measured weights, structural covariances, and measurement residuals. The change in the absolute fitting index is used as the criterion for the equivalence test. A commonly accepted criterion is that a △ CFI value of less than 0.01 indicates a good fit for the nested model and validates the test of equivalence. A CFI value between 0.01 and 0.02 suggests that the fit of the nested model is poorer, but it does not provide information about the significance of the change in the nested model. A CFI value greater than 0.02 suggests that the nested model exhibits differences across different samples (Browne et al., 1992; D'Abundo et al., 2014; Kovács et al., 2021; Williams, 2011).

Results

Descriptive statistics

The results of the descriptive statistical analysis for the BREQ-2 items are displayed in Table 1. The results show that the mean, standard deviation, and absolute skewness of BREQ-2 ranged from 3.659 to 4.748, 1.193 to 1.624, and 0.030 to 0.652, respectively. The absolute value of kurtosis ranged from 0.072 to 1.025. The skewness and kurtosis coefficients of each item on the active behaviour scale indicated a non-normal distribution (Mardia, 1970). Confirmatory factor analysis and multiple sets of CFAs were conducted using the maximum likelihood method in this study. The mean values of intrinsic regulation and identified regulation dimensions were above the median, while the mean values of external regulation and amotivation dimensions were below the median (Table 1).

Descriptive Statistics

Descriptive Statistics				
	Mean	Std. Deviation	Skewness	Kurtosis
Amotivation1	3.692	1.221	0.524	-0.191
Amotivation2	3.717	1.245	0.521	-0.210
Amotivation3	3.720	1.242	0.408	-0.496
Amotivation4	3.659	1.208	0.491	-0.297
External1	3.680	1.263	0.538	-0.161
External2	3.699	1.243	0.530	-0.179
External3	3.674	1.232	0.652	0.072
External4	3.723	1.193	0.384	-0.363
Introjected1	4.191	1.624	0.355	-1.006
Introjected2	4.194	1.588	0.414	-0.872
Introjected3	4.148	1.534	0.431	-0.693
Identified1	4.619	1.560	-0.148	-0.623
Identified2	4.695	1.510	0.030	-0.946
Identified3	4.720	1.505	-0.209	-0.526
Intrinsic1	4.631	1.529	0.040	-0.936
Intrinsic2	4.634	1.507	-0.134	-0.720
Intrinsic3	4.594	1.578	0.073	-1.025
Intrinsic4	4.748	1.533	-0.076	-1.009

Structural Validity and Internal Consistency

All subsequent CFAs were conducted following Byrne's guidelines, using maximum likelihood estimates and a bootstrap strategy. This technique is advantageous for dealing with non-multivariate normal data. In this study, 5000 bootstrap replication samples were generated by resampling from the dataset, following the recommendations of Preacher and Hayes. The goodness-of-fit indexes for the BREQ-2 with 18-item model responses were: $\chi^2 = 211.462$, df = 125, p < .001, CFI=.972, GFI=.932, NFI = .934, TLI = .965, RMSEA = .046, IFI=.972, RMSEA 90% CI (.035-.057) (See Fig.1). Loadings for the whole scale varied from 0.713 to 0.886. No additional items with factorial complexity were identified through the examination of the solution's modification indices and standardised residuals.

To gain a deeper understanding of the reliability of the five-factor structure of the active behaviour scale, an internal consistency test was conducted on both the scale itself and its sub-dimensions. In this study, the internal consistency of the scale was measured using Cronbach's α coefficient. The reliability coefficient test results for internal consistency of this study are displayed in Table 2. The results indicate that the Cronbach's coefficients for each sub-dimension of the scale fall within the range of 0.818 to 0.903, all of which satisfy the minimum measurement requirements. A validation factor analysis was conducted to assess the reliability and validity of the scales. Reliability was assessed using combined reliability (CR), Cronbach's α, and the values of C.R. and Cronbach's coefficients for all dimensions exceeded 0.7.

The study found that the internal consistency reliability of the scale was strong. Convergent validity was assessed through factor loadings and the average squared extracted quantity (AVE). All of the standardised loading's coefficients exceeded 0.6. All indicators in the daily model had significant factor loadings at a level of 0.01. Additionally, the AVE values for each dimension of the measurement model were all greater than 0.5, suggesting strong convergent validity (Table 2). Discriminant validity is established when there is a minimal correlation or a clear distinction between the trait measured by one latent variable and the traits measured by other latent variables. It is evident that the square root of the Average Variance Extracted (AVE) for each latent variable surpasses the correlation coefficients between that latent variable and all other latent variables, which demonstrates robust discriminant validity (Table 3).

In this study, the BREQ-2 underwent Confirmatory Factor Analysis (CFA) to establish its five-factor structure. The results of the analysis indicated that the model fit was good, as suggested by the fit indices. This indicates that the tool is a dependable measure for evaluating exercise motivation among Chinese adolescents.
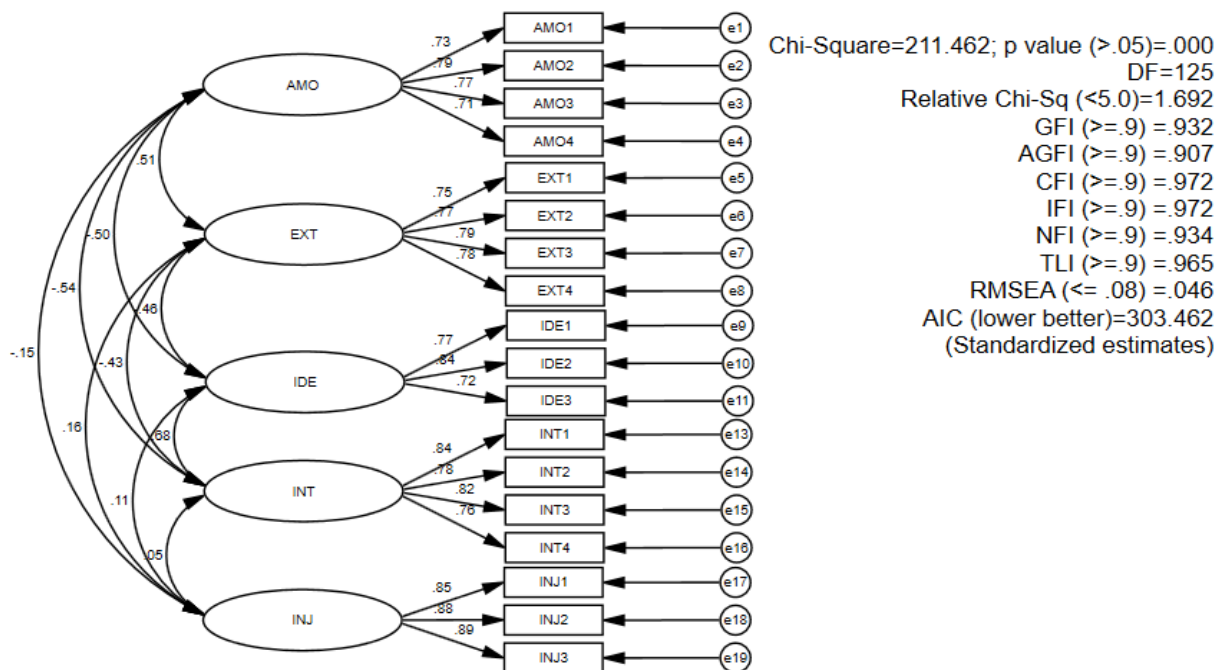

Figure 1: Confirmatory Factor Analysis for BREQ-2.

Notes: AMO: Amotivation, EXT: external regulation, IDE: identified regulation, INT: intrinsic regulation, INJ: introjected regulation

Table 2

Structural Validity and Internal Consistency test

Dimension	item	Unstd.	S. E	Z	P	Std	AVE	CR	Cronbach α
Amotivation	Amotivation1	1.000				0.728	0.565	0.838	0.837
	Amotivation2	1.108	0.086	12.875	***	0.791			
	Amotivation3	1.076	0.085	12.594	***	0.770			
	Amotivation4	0.969	0.083	11.741	***	0.713			
External regulation	External1	1.000				0.747	0.595	0.854	0.854
	External2	1.008	0.077	13.065	***	0.765			
	External3	1.035	0.077	13.503	***	0.793			
	External4	0.987	0.074	13.313	***	0.780			
Identified regulation	Identified1	1.000				0.844	0.606	0.821	0.818
	Identified2	1.059	0.075	14.045	***	0.777			
	Identified3	0.898	0.073	12.381	***	0.816			
Intrinsic motivation	Intrinsic1	1.000			***	0.761	0.641	0.877	0.876
	Intrinsic2	0.906	0.058	15.746		0.846			
	Intrinsic3	0.998	0.059	16.838	***	0.878			
	Intrinsic4	0.903	0.059	15.314	***	0.886			
Introjected regulation	Introjected1	1.000				0.770	0.756	0.903	0.903
	Introjected2	1.015	0.053	19.196	***	0.843			
	Introjected3	0.989	0.051	19.353	***	0.717			

Table 3

Discrimination validity test of potential variables

	INJ	INT	IDE	EXT	AMO
INJ	**0.869**				
INT	0.053	**0.801**			
IDE	0.114	0.682	**0.778**		
EXT	0.160	-0.431	-0.462	**0.771**	
AMO	-0.154	-0.542	-0.495	0.506	**0.752**

Noted: AMO: Amotivation, EXT: external regulation, IDE: identified regulation, INT: intrinsic regulation, INJ: introjected regulation

The diagonal bold text is the AVE open root value, and the diagonal lower triangle is the Pearson correlation for each dimension.

Measurement invariance analysis

The study utilised the multiple-group CFA to examine the consistency of the measurement model among middle and high school students of different genders and academic levels. Specifically, the researchers investigated the Chinese revision of BREQ-2 for this purpose. A multicluster validated factor analysis was employed to examine the measurement equivalence of the Chinese version of BREQ-2 among the male and female groups. The measurement equivalence involved four aspects of equivalence. The first aspect, unconstrained (M1), examined whether the factor structures were consistent across clusters. The second aspect, measured weights (M2), assessed whether the factor loadings were identical across clusters. The third aspect, structural covariances (M3), evaluated whether the intercepts of the observed variables were equal among different groups. Lastly, the measurement residuals (M4) (Mardia, 1970) were examined to determine if the residuals of each observed variable were equal across different groups.

In this study, the procedure for measuring equivalence test (Vandenberg & Lance, 2000) was followed. The first step involved setting up an unconstrained model using multiple confirmatory factor analysis. The purpose was to determine whether the BREQ-2 scale is equivalent in different samples. During the model setting process, the configuration model incorporates a baseline model of two sub-samples. The factor load and item intercept are freely estimated on the population sample. However, the two sub-sample models do not undergo any equivalent setting. All

the fitting indexes of morphological model reach the minimum judging standard for gender (χ^2=434.779, DF=250, χ^2/df=1.739, TLI=0.925, CFI=0.960, SRMR=0.052, RMSEA=0.046) (Table 4) and academic level(χ^2=397.273, DF=250, χ^2/df=1.589, TLI=0.934, CFI=0.953, SRMR=0.043, RMSEA=0.046)(Table 5). The configuration of BREQ-2 remains consistent across both sub-samples. Additionally, the weights of the measured model were established using the morphological model as the baseline. This was done to assess the equivalence of factor loadings between two sub-samples, specifically by setting the factor loads to be equivalent based on the unconstrained model.

The results showed that $\triangle$ CFI = 0.001 < 0.010, $\triangle$ TLI = 0.005 < 0.010 (gender) and $\triangle$ CFI = 0.003 < 0.010, $\triangle$ TLI = 0.003 < 0.010(academic level) for the measured weights model versus the unconstrained model, the measured weights test held, and the relationship between the BREQ-2 questionnaire items and the latent variables they represented was unchanged on both subsamples. Thirdly, based on measured weights model, the intercept equivalence of measured items is further defined to form structural covariances model (test of the intercept equivalence of measured items), the results show that $\triangle$

CFI = 0.001 < 0.001, $\triangle$ TLI = 0.005 < 0.010 (gender) and $\triangle$ CFI = 0.001 < 0.010, $\triangle$ TLI = 0.005 < 0.010(academic level) of the structural covariances model and measured weights model is valid and the structural covariances test is valid, that is, the pattern equivalence of the BREQ-2 questionnaire item response values on two sub-samples.

In addition, the structural covariances model is used to assess the error variance of the measurement item across different samples. This leads to the formation of a measurement residuals model, which tests the reliability equivalence of BREQ-2 items in different samples, the results showed that $\triangle$ CFI = 0.003 < 0.010, $\triangle$ TLI = 0.007 < 0.010 (gender) and $\triangle$ CFI = 0.010 = 0.010, $\triangle$ TLI = 0.009 < 0.010(academic level) for the measurement residuals model and the structural covariances model, that is, the reliability of BREQ-2 items remained unchanged in different samples. Based on the findings of the measurement equivalence test, it can be concluded that the five-factor model of active behaviour is valid across different levels of measurement equivalence. The BREQ2 questionnaire's five-factor model is deemed suitable for junior middle school students in our country. Additionally, it exhibits better cross-group stability when considering different gender and academic levels.

Table 4

Measurement invariance analysis (Gender)

Model	CMIN	DF	CMIN/DF	TLI	CFI	RMSEA	SRMR	Model comparison	Δχ²	ΔDF	ΔTLI	ΔCFI
M1	434.779	250	1.739	0.925	0.939	0.046	0.052					
M2	444.487	263	1.69	0.93	0.940	0.045	0.054	M2 VS M1	9.708	13	0.005	0.001
M3	456.822	278	1.643	0.935	0.941	0.043	0.064	M3 VS M2	12.335	15	0.005	0.001
M4	464.839	296	1.57	0.942	0.944	0.041	0.064	M4 VS M3	8.017	18	0.007	0.003

Noted: M1: Unconstrained, M2: Measured weights, M3: Structural covariances, M4: Measurement residuals

Table 5

Measurement invariance analysis (Academic level)

Model	CMIN	DF	CMIN/DF	TLI	CFI	RMSEA	SRMR	Model comparison	Δχ²	ΔDF	ΔTLI	ΔCFI
M1	397.273	250	1.589	0.943	0.953	0.043	0.043					
M2	403.098	263	1.533	0.948	0.956	0.041	0.043	M2 VS M1	5.825	13	0.003	0.003
M3	437.512	296	1.478	0.954	0.955	0.038	0.065	M3 VS M2	34.414	33	0.006	0.001
M4	490.265	314	1.561	0.945	0.945	0.042	0.070	M4 VS M3	52.753	18	0.009	0.010

Noted: M1: Unconstrained, M2: Measured weights, M3: Structural covariances, M4: Measurement residuals

Discussion

This study focused on examining the suitability of BREQ-2 for young students in middle and high schools in China. To achieve this, a group of students from a middle and high school in Shandong province, China, was carefully chosen. The BREQ-2 scale adapted by LIU et al. (2015) underwent testing through CFA to assess its reliability, validity, and

equivalence.

In the descriptive analysis, the findings suggest that the respondents generally found the survey questions to be valuable, as indicated by the consistently high and moderate average values. This supports the theoretical significance of the motivational continuum in the Self-determination theory. These findings align with previous confirmations conducted in different languages or

population groups (Chung et al., 2012; LIU et al., 2015; Markland et al., 2004; Moustaka et al., 2010).

The findings presented the initial hypothesised latent structure of the scale responses, providing the first supportive evidence. Based on the analysis results from the CFA, it was found that the translated BREQ-2 was validated by high item loadings in the five-correlated factor model. However, a particular item from the identified regulatory factor was excluded because previous studies involved samples of college students from Britain, Spain, and China. Previous studies have indicated that the factor loading was not satisfactory (Ingledew et al., 2008; LIU et al., 2015; Murcia et al., 2007). In order to ensure structural validity, the five dimensions of BREQ-2 underwent testing through traditional confirmatory factor analysis (CFA). The results indicate that the BREQ-2 measurement model demonstrates strong structural validity. This research has successfully demonstrated the discriminant validity of the BREQ-2 and the consistent reliability of the instrument.

The analysis of measurement invariance revealed that all forms of the BREQ-2 measurement model, including the unconstrained model, measured weights model, structural covariances model, and measurement residuals model, remained consistent across gender and academic level. Several confirmatory factor analyses demonstrated that the BREQ-2 was indeed equivalent in both groups. The observation scores of BREQ-2 in both male and female groups were found to be the same. Firstly, in the measurement equivalence test of BREQ-2, the initial step involves assessing form equivalence. This step determines whether BREQ-2 exhibits the same underlying variable structure in both male and female students, thus allowing for further equivalence testing. The second step revealed that both male and female students had the same factor load of BREQ-2. This means that a one-unit change in the latent variable would result in a consistent change in the observed variable across different groups.

In the third step, the cue scale's intercept was consistent across all groups, indicating a shared reference point among the different groups. In the study, the BREQ-2 scale was used to assess the validity of different models: the morphological equivalent model, the weak equivalent model, and the strong equivalent model. The data validated all three models, demonstrating the equal validity of the BREQ-2 scale for both male and female students. These findings suggest that the BREQ-2 measures a similar structure across different genders and academic levels among middle and high school students in mainland China. Overall, the participants believed that the questions on the scale were evaluating five distinct yet interconnected facets of motivation. The results validated the expected robustness of the BREQ-2's underlying framework, based on data collected from individuals engaged in physical activity in Mainland China. This was further supported by the strong internal consistency coefficients observed across each of the localised BREQ-2 subscales.

The Chinese version of BREQ-2 used in this study was specifically tailored for middle school students aged 13-17, who were comparatively younger than the other groups in the study. The Greek version of BREQ-2 included adults aged 18 and older (Moustaka et al., 2010). The participants in the Spanish version of BREQ-2 had an average age of 30 ± 11 years (Murcia et al., 2007). The Romanian version involved adolescents with an average age of 17 (Crăciun & Rus, 2012). The Iranian study by Farmanbar et al. (2011) used participants aged 18 to 30 for the BREQ-2. The Italian study by Costa et al. (2013) selected adult participants with an average age of 37±13 years for the BREQ-2. LIU et al. (2015) conducted cross-cultural tests of the BREQ-2 scale on Chinese mainland and Hong Kong University students in alternative Chinese versions of the scale. The 18-item BREQ-2 exhibited comparable reliability and validity, with similar scale fit indicators to those found in this study. These findings suggest that the motivational characteristics of Chinese Mainland students remain consistent, despite variations in academic periods.

The validation of this instrument is essential as it verifies its applicability across different cultures, contributing to our knowledge of exercise motivation dynamics among Chinese adolescents. The findings emphasise the significance of utilising culturally validated tools such as the BREQ-2 to develop targeted interventions, in light of the growing concern regarding sedentary lifestyles and their effects on adolescent health in China. The analysis focusses on identifying motivational factors that can be utilised to promote increased physical activity among Chinese youth. The significance of these findings extends beyond academic discussions, providing practical insights for educators, policymakers, and health practitioners. By comprehending the motivational factors that appeal to Chinese adolescents, stakeholders can develop more efficient programs that address their specific motivational requirements, potentially mitigating the decline in exercise motivation.

Conclusion

This study systematically examined the psychometric properties of the Chinese Version of BREQ-2 in Chinese adolescents. The results of our study provide strong evidence for the reliability and structural integrity of the questionnaire when used with this specific population. The BREQ-2 exhibited strong internal consistency, as indicated

by Cronbach's alpha coefficients ranging from 0.818 to 0.903 for its subscales. The confirmatory factor analysis supported a five-factor structure that is consistent with the theoretical framework of self-determination theory. The model fit indices (CFI=0.972, RMSEA=0.046) fell within an acceptable range, indicating that the construct validity of the questionnaire is maintained in this cultural context. The analysis of measurement invariance across genders and academic levels demonstrated the stability of the BREQ-2 scale. This is important for ensuring that comparisons between these groups are meaningful and not influenced by measurement artefacts. The ΔCFI values were all below 0.01, indicating the questionnaire's robustness across these demographic variables.

The practical implications of these findings are substantial. Given the increasing concerns regarding the decrease in physical activity among adolescents, it is crucial to have a valid and reliable measure for evaluating motivational regulation in exercise. The BREQ-2 can be effectively utilised by educators, psychologists, and researchers to identify motivational profiles, customise interventions, and ultimately promote a more active and healthier lifestyle among youth in Mainland China. This study also paves the way for future research to further investigate exercise motivation dynamics in this age group. Potential exists to analyse longitudinal changes in motivation, the influence of educational and cultural factors, and the relationship between motivation and physical activity levels. Furthermore, researchers should examine the correlation between these motivational constructs and broader health and academic outcomes.

This study emphasises the importance of psychological measurement tools in cross-cultural research and the need to consider cultural differences when designing health promotion programs. Future research should investigate variations in motivation across different cultural backgrounds, monitor changes in motivation through longitudinal studies, and evaluate the long-term effects of specific interventions. The study highlights the importance of considering cultural factors in assessing and improving exercise motivation. This study offers a theoretical and practical basis for developing physical education and health promotion initiatives that are customised to meet the unique requirements of Chinese adolescents. By comprehensively grasping and implementing these culturally significant insights, we can enhance the efficacy of motivating adolescents to engage in physical activities, thus fostering their physical and mental health development.

In conclusion, the BREQ-2 (Chinese) is a reliable tool for assessing the various aspects of motivational regulation in exercise among Chinese Mainland adolescents. The tool offers a dependable and culturally sensitive means to contribute to the global endeavour of comprehending and enhancing youth involvement in physical activity. This study contributes to the existing literature and provides a strong basis for future research in the field of cross-cultural applicability in psychological instruments.

Limitation and Further Directions

The analysis results confirm the consistency of the findings with previous research efforts, including the original version of the BREQ-2 and the Chinese college student's version (LIU et al., 2015). The exclusion of a specific item did not affect the validity estimates. However, it is important to note that this is only the initial stage of the test procedure, and there are several more steps to be completed. Furthermore, the analysis did not reveal any notable differences based on gender or academic level. This aligns with previous research findings on the subject, although more in-depth investigation is needed to fully explore this topic. In future studies, it is important to assess the discriminant validity and test-retest reliability of the measures. It is important to consider using more diverse samples in future research in order to broaden the scope of use for the device.

To summarize, the five-factor model of the BREQ-2 scale, adapted for Chinese Mainland adolescents, effectively evaluated their motivational attitudes towards exercise, specifically the characteristics of motivation of middle and high school students, and the research results also show the psychometric properties of Chinese Mainland middle and high school students. Therefore, additional investigation into the psychometric characteristics of the BREQ-2 within high school populations or primary school students is strongly recommended. Furthermore, this finding provides cross-cultural validation for BREQ-2 and additional psychometric evidence for the scale. This makes self-determination motivation in our youth groups in the exercise motivation research further application, and research provides a strong support.

Data Availability Statement

The original contributions presented in this study are detailed within the article and its Supplementary Material. For further information, interested parties are encouraged to contact the corresponding authors.

Author Contributions

XL: Designed, collected, analyzed data, wrote, and drafted this article. SS: Data interpretation, NJ and KGS: Revised and approved the article. Both authors contributed to the

article and approved the submitted version.

Conflict of Interest

The authors state that no commercial or financial ties that might be considered as a possible conflict of interest existed during the conduct of the study.

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