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Validation of the Expanded Exercise Addiction Inventory (EEAI) in Chinese College Students

Run Tian[1], Yihan Liao[2], Yuling Duan[3], Wang Zhang[4], Siqi Wang[5], Yunyan Xue[6], Yu Liu[7], Xing Zhang[8], Mingyue Yin[9], Hansen Li[10]*

[1] *School of Physical Education, Sichuan Agricultural University, Ya'an 625014, China*

[2] *School of Physical Education, Sichuan Agricultural University, Ya'an 625014, China*

[3] *School of Physical Education, Sichuan Agricultural University, Ya'an 625014, China*

[4] *School of Physical Education, Sichuan Agricultural University, Ya'an 625014, China*

[5] *School of Physical Education, Sichuan Agricultural University, Ya'an 625014, China*

[6] *School of Physical Education, Sichuan Agricultural University, Ya'an 625014, China*

[7] *School of Physical Education, Sichuan Agricultural University, Ya'an 625014, China*

[8] *Department of Physical Education and Sport, Faculty of Sport Sciences, University of Granada, Granada 18071, Spain*

[9] *School of Athletic Performance, Shanghai University of Sport, Shanghai 66315, China*

[10] *School of Physical Education, Sichuan Agricultural University, Ya'an 625014, China*

Abstract

The Expanded Exercise Addiction Inventory (EEAI) is a newly adapted instrument designed to comprehensively assess maladaptive tendencies toward excessive exercise. This study aimed to preliminarily validate the psychometric properties of the Chinese translation of the EEAI among university students, a population characterized by high levels of physical activity. A total of 440 undergraduate students were recruited from a university, and their levels of exercise addiction, physical activity, and mental well-being were assessed using the EEAI, the Revised Exercise Addiction Inventory (EAI-R), the WHO Mental Well-Being Index, and the Physical Activity Rating Scale (PARS). We examined the structural validity, convergent validity, and internal consistency of the EEAI. In addition, test-retest reliability over a two-week interval was assessed in a subsample. The results indicated that the revised structure of the EEAI demonstrated acceptable levels of structural, convergent, and internal consistency. However, neither the translated EEAI nor the previously validated EAI-R exhibited acceptable test-retest reliability. In conclusion, our findings support the use of the EEAI as a tool for investigating exercise addiction among university students in mainland China, while also highlighting the temporal instability of this construct.

Keywords: Exercise, Physical activity, Sport, Health, Addiction.

INTRODUCTION

With changes in modern lifestyles and growing health awareness, exercise has become an important part of daily life for many people [1]. Numerous studies have confirmed the broad health benefits of physical activity [2,3]. For instance, moderate exercise not only helps regulate body mass index and improve psychological well-being [4,5], but also plays a key role in slowing age-related functional decline [6,7]. Furthermore, regular physical activity benefits cardiovascular health by modulating lipid metabolism, reducing vascular inflammation, and improving hemodynamic factors such as blood pressure and endothelial function, thereby lowering the risk of atherosclerosis and related diseases (e.g., coronary heart disease) [8,9]. In the neurological field, evidence from animal models and observational studies suggests that exercise may delay cognitive decline and protect against the progression from mild cognitive impairment to dementia. This is thought to occur through the upregulation of brain-derived neurotrophic factor (BDNF) and the promotion of hippocampal neurogenesis [10-12]. Overall, these findings highlight the value of exercise as a multi-target, non-pharmacological strategy for promoting public health.

Beyond its well-known benefits, the "double-edged sword" effect of exercise is gaining increasing academic attention. Excessive exercise can lead to negative outcomes such as a higher risk of sports injuries, tendencies toward eating disorders, and various psychobehavioral issues [13,14]. Among these concerns, a growing mental health issue is exercise addiction [15]. Exercise addiction, recognized as a subtype of behavioral addiction, has drawn significant interest in recent years. Although research on this topic has accumulated over the past three decades, there remains considerable controversy regarding its core characteristics and the validity of existing assessment tools [16-20].

*Corresponding author:
Dr. Hansen Li
Xinkang Road No.46, School of Physical Education, Sichuan Agricultural University, Ya'an 625014, China
Email: hanson-swu@foxmail.com

According to the ICD-11 framework for behavioral addictions, exercise addiction has not yet been formally recognized as an independent diagnostic category. Most existing studies instead reference the definition of "compulsive persistent behavior" seen in other disorders, such as gambling disorder. Exercise addiction is generally conceptualized as a pathological dependence on regular physical activity, characterized by compulsive exercise behaviors and withdrawal symptoms when unable to exercise [21,22]. Current assessments of exercise addiction primarily rely on self-report scales, including the Exercise Addiction Inventory (EAI) and its updated version, such as the Exercise Addiction Inventory-Revised (EAI-R) and the Expanded Exercise Addiction Inventory (EEAI).

The EAI-R was specifically modified to enhance measurement properties by improving scoring method. The EEAI, on the other hand, has been supplemented with extra items to enhance its content validity [23].

Research on exercise addiction remains limited in China [24]. While both the EEAI and EAI-R have been examined in Chinese-speaking contexts, the EEAI's initial development included only a small number of Chinese participants, primarily recruited through overseas social media. As a result, cultural and linguistic differences between these participants and those from mainland China may affect the tool's validity, and further testing is needed within the mainland population [23].

In this study, we focused on university students as our main research group. This demographic not only represents 7.8% of the country's 18-22-year-old population, but also shows a high exercise participation rate of 83.5%. Moreover, university students are particularly susceptible to excessive exercise behaviors due to strong socio-cultural influences [25-27].

METHODOLOGY

Participants

A sample of college students was recruited for this study, and the recruitment process took place in a public area of the university campus. The recruitment process began on November 1, 2024, and lasted for two weeks. Members of the research team proactively approached potential participants and guided them through the questionnaire in real time on their smartphones. Inclusion criteria included the need to be an enrolled college student with basic physical abilities (able to participate in a standard physical education program). Before completing the questionnaire, all participants were fully informed about the purpose of the study and how their data were expected to be used. Each participant provided written informed consent to ensure that participation was completely voluntary. A total of 440 students voluntarily completed the questionnaire. Of these participants, 36 completed the questionnaire again two weeks later to assess the reliability of the measurement instrument.

Measurement Tools

The Expanded Exercise Addiction Inventory

The Expanded Exercise Addiction Inventory (EEAI)it is a self-report scale for assessing exercise addiction [28], an expanded and revised version of the original Exercise Addiction Inventory (EAI) [20]. The EEAI contains eight entries designed to measure the presence or absence of behavioral and psychological characteristics that make individuals overly dependent on exercise.

The EEAI has two dimensions, Health Relevance (HR) and Addiction Tendency (AT). The HR dimension consists of entries 1,3,4, and 6, while the AT consists of entries 5,8,7, and 2. Each entry is scored according to the individual's level of agreement, usually calculated through total scores using a 6-point Likert scale (from 1 = "completely disagree" to 5= "completely agree"). calculated by totaling the scores, with higher scores indicating more severe levels of exercise addiction. Based on previous examples of cross-cultural translation [29], we translated the questionnaire using a team of 4 translators and obtained the final version using a committee approach (Table 1).

The Revised Exercise Addiction Inventory

The Revised Exercise Addiction Inventory (EAI-R) is a self-report scale used to assess exercise addiction and is an improved version of the original EAI [30]. It contains 6 entries that primarily measure the characteristics of an individual's addiction to exercise. The EAI-R uses a 6-point Likert scale (from 1 = "completely disagree" to 6 = "completely agree"). Higher scores indicate a more pronounced tendency toward exercise. The Chinese version of the EAI-R retained five items and was tested for reliability and found to be a one-dimensional structure [31].

The WHO-5 wellbeing index

The WHO-5 Well-Being Index (WHO-5) is a short self-report scale used to assess an individual's overall mental health and sense of well-being. It was developed by the World Health Organization (WHO) to measure an individual's emotional and psychological well-being over the past two weeks. The WHO-5 consists of five items covering emotional state, interest, energy for activity, and positive feelings in daily life. Each entry is scored using a 5-point Likert scale ranging from 0 (not at all) to 5 (completely), with scale scores ranging from 0 to 25. The Chinese version used in this study was pre-translated by other scholars [32].

Physical Activity Rating Scale

Physical activity (PA) was assessed using the Physical Activity Rating Scale (PARS) [33]. This scale comprises three items measuring physical activity intensity, duration, and frequency. Each item is rated on a 5-point Likert-type scale. For instance, the response options for PA frequency range from "less than 1 time/month (1 point)" to "every day (5 points)," with intermediate options such as "2 to 3 times/month (2 points)," "1 to 2 times/week (3 points)," and "3 to 5 times/week (4 points)." General physical activity levels were calculated by multiplying the intensity score, the duration score minus one, and the frequency score. This scale has been widely utilized in studies involving Chinese populations [34,35].

Demographic Variables

We collected demographic information through a questionnaire, including participants' gender, age, academic year, and family income. The categorization methods for these variables are presented in the Results section.

Statistical Analysis

Validity

We employed Confirmatory Factor Analysis (CFA) to assess the structural validity of the measurement tools. The analysis was conducted using Structural Equation Modeling (SEM) with Maximum Likelihood (ML) estimation. To detect potential multicollinearity issues among the variables in the model, we calculated the Variance Inflation Factor (VIF). We ensured that the VIF values for all variables were below 5.0 [36], thereby mitigating the risk of multicollinearity.

According to the guidelines of the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN), the sample size should be at least seven times the number of items in the scale when validating structural validity [37,38]. Additionally, based on previous experiences with SEM, a sample-to-parameter ratio of 10:1 is

considered ideal [39]. Therefore, our sample size meets the analytical requirements.

Concerning structural validity, we referred to the following fit indices and their acceptable thresholds: Standardized Root Mean Square Residual (SRMR) < 0.08; Adjusted Goodness-of-Fit Index (AGFI) > 0.9; Normed Fit Index (NFI) > 0.90; Tucker-Lewis Index (TLI) > 0.90; Comparative Fit Index (CFI) > 0.90; and Root Mean Square Error of Approximation (RMSEA) < 0.10 [40]. Furthermore, we required the standardized factor loadings to be greater than 0.5, the Average Variance Extracted (AVE) to exceed 0.5, and the Construct Reliability (CR) to be higher than 0.6 to ensure the measurement quality of the model [41,42].

Convergent validity refers to the requirement that tools measuring the same or similar concepts should exhibit at least a moderate level of correlation [43]. In this study, we explored the relationship between the DMAQ and several similar psychological measurement tools, as well as exercise levels, through Spearman correlation analysis to provide evidence for convergent validity.

We interpreted the correlation coefficients based on the following intervals: 0–0.10: no significant correlation; 0.11–0.39: weak correlation; 0.40–0.69: moderate correlation; 0.70–0.89: strong correlation; 0.90–1.00: very strong correlation [44].

Reliability

We used Cronbach's alpha and McDonald's omega to assess internal consistency. The acceptable minimal reliabilities of Cronbach's alpha and McDonald's omega are 0.7 [45].

Test-retest reliability refers to the consistency of responses when repeated assessments are made within a stable population [46]. To assess the test-retest reliability of the scale, we used a two-way mixed effects model based on absolute agreement to calculate the Intraclass Correlation Coefficient (ICC) [47]. The interpretation of ICC values is as follows: ICC ≥ 0.75 indicates excellent/high reproducibility; ICC between 0.4 and 0.75 indicates moderate to good reproducibility; and ICC < 0.4 indicates poor or low reproducibility [48].

Results

Participants' characteristics

Our participants were slightly more male, with an average age of 19.41 years. Nearly one-third of the participants were sophomores. Their monthly household incomes were mainly in the range of 5001-10000 RMB (approximately 0.138 USD per RMB as of December 5, 2024).

Validity

The initial model did not have an acceptable model fit. Entry 2 had a factor loading of less than 0.5 and was therefore removed. However, the model fit remained unacceptable. Based on the hints of the model modification index, we found that entry 6 had a higher correlation with factor 2 (i.e., propensity to addiction), and we therefore loaded it on factor 2 (Figure 1). Subsequently, the model exhibited acceptable fit parameters (SRMR = 0.051; AGFI = 0.909; NFI = 0.928; TLI = 0.904; CFI = 0.941; RMSEA = 0.096). The CR coefficients for Factor 1 (health-relatedness) and Factor 2 (propensity to addiction) were 0.733 and 0.753, respectively. their AVEs were 0.481 and 0.435, respectively. although the AVEs were slightly below the criterion of 0.5, they were within a marginally acceptable range (AVEs higher than 0.4 are acceptable when the CR is > 0.6 [49]. This structure was therefore used in subsequent analyses.
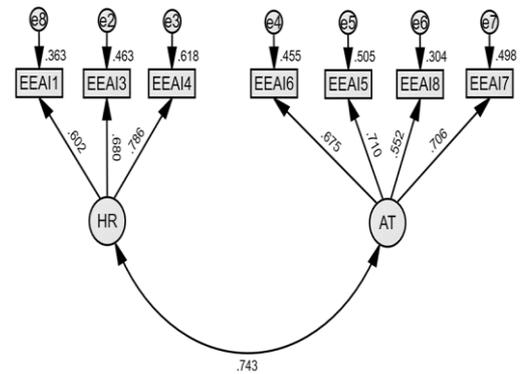

Figure 1: Model structure and factor loading

Both EEAI dimension scores were correlated with the EAI-R. Notably, the total EEAI score had a strong positive correlation with the EAI-R (Spearman rho = 0.759). At the same time, there was a positive correlation between the EEAI and the PARS (measuring physical activity) and a negative correlation with the WHO-5 (measuring mental health), although those correlations were relatively weak (Table 3).

Reliability

The instruments used in this study to measure abstract mental constructs all showed acceptable reliability (Cronbach's α and McDonald's ω > 0.7) (Table 4). However, the reproducibility of either the four-item EEAI scale we obtained or the EAI-R scale, which has been validated, was poor. In contrast, the PARS and WHO-5 had better reproducibility (Table 5).

DISCUSSION

General Discussion

This study evaluated the reliability and validity of the Expanded Exercise Addiction Inventory (EEAI) among a sample of Chinese university students. The original structure of the EEAI did not demonstrate ideal structural validity. However, after the removal of Item 2, the structural validity of the scale improved, showing acceptable levels of convergent validity and internal consistency. Nevertheless, the test-retest reliability remained suboptimal. These findings offer methodological support and new insights for future research on exercise addiction within the Chinese population, particularly among university students.

Structural Validity

This study revealed that the Chinese version of the Expanded Exercise Addiction Inventory (EEAI) demonstrated significant improvements in structural validity among college students, with fit indices of CFI = 0.941 and TLI = 0.904 after adjusting item attribution (e.g., reassigning Item 6 to the Addictive Tendencies dimension). The Chinese EEAI also showed a strong positive correlation with the Revised Exercise Addiction Inventory (EAI-R) (ρ = 0.759), aligning with general patterns observed in cross-cultural scale adaptations, which often enhance a tool's applicability and accuracy across different cultures or populations [30].

For instance, Szabo et al. (2019) [30] successfully improved the reliability and validity of the EAI-R (α = 0.87) by optimizing item response patterns, while Granziol et al. (2023) [28] emphasized that item deletion is often necessary to enhance cultural sensitivity. In this study, the removal of Item 2 ("My exercise causes my family to worry") may reflect cultural differences: Chinese college students tend to view

Table 1: The Items of EEAI in English and Chinese

Item	Original version (in English)	Translated version (in Chinese)
1	Exercise is the most important thing in my life	锻炼是我生命中最重要的事情
2	*Concerns* have arisen between me and my family and/or my partner about the amount of exercise I do	我的锻炼量引起我的家人和/或伴侣的担忧
3	I use exercise as a way of changing my mood (e.g., to get a buzz, to escape, etc.)	我将锻炼作为改变我的情绪的一个方式（例如，获取快感、逃避等）
4	Over time I have increased the amount of exercise I do in a day	随着时间的推移，我增加了我每一天内的锻炼量
5	If I have to miss an exercise session, I feel moody and irritable	如果我不得不错过一次锻炼，我会感到情绪低落和易怒
6	If I cut down the amount of exercise I do and then start again, I always end up exercising as often as I did before	如果我减少锻炼量后再重新开始，我总是会恢复到以前的锻炼频率
7	I feel guilty if I miss planned training or if my training does not go as well as planned	如果我错过了计划中的训练或者我的训练没有按计划进行，我会感到内疚
8	I am inclined to train when (or before completely recovered from) illness or injury	我倾向于在生病或受伤期间（或者未完全恢复前）进行训练

Table 2: Participants' characteristics

Variable	Category	N (%)	Mean (SD)
Sex	Male	239 (54.32%)	-
	Female	201 (45.68%)	-
Age	-	-	19.41 (1.24)
Grade	First year	180 (40.91%)	-
	Second year	134 (30.45%)	-
	Third year	101 (22.95%)	-
	Fourth year	22 (5%)	-
	Master student	3 (0.68%)	-
Family income	0-5000 RMB	176 (40%)	-
	5001-10000	141 (32.05%)	-
	10001-15000	56 (12.73%)	-
	15001-20000	32 (7.27%)	-
	20001-25000	20 (4.55%)	-
	25001-30000	1 (0.23%)	-
	>30000 RMB	14 (3.18%)	-

Table 3: The correlations of EEAI and other relevant scales

Variable	EEAI-HR	EEAI-AT	EEAI-Total	EAI-R	PARS
EEAI-HR	1.000	-	-	-	-
EEAI-AT	0.510**	1.000	-	-	-
EEAI-Total	0.832**	0.891**	1.000	-	-
EAI-R	0.639**	0.681**	0.759**	1.000	-
PARS	0.360**	0.173**	0.286**	0.327**	1.000
WHO-5	-0.210**	-0.109*	-0.170**	-0.197**	-0.065

Note: *, $p < 0.05$; **, $p < 0.01$.

Table 4: The internal consistency of the used scales

Scale	Cronbach α	McDonald's ω
EEAI-HR	0.737	0.739
EEAI-AT	0.757	0.759
EAI-R	0.839	0.840
WHO-5	0.909	0.910

Table 5: The test-retest reliability of the used scales

Scale	ICC (95%CI)	*p*
EEAI-HR	0.364 (0.058, 0.612)	0.011
EEAI-AT	0.350 (0.026, 0.607)	0.018
EEAI-Total	0.349 (0.022, 0.607)	0.019
EAI-R	0.286 (-0.043, 0.559)	0.044
PARS	0.724 (0.523, 0.849)	<0.001
WHO-5	0.489 (0.192, 0.703)	0.001

exercise as a positive behavior rather than a source of family conflict [50]. Similar item adjustments have been reported in other cross-cultural adaptations, such as Cheung et al. (2020) [29], who deleted items due to semantic inconsistencies when translating the "Connectedness to Nature" scale [29].

However, it is worth noting that the adjusted average variance extracted (AVE) value for the Health-Relatedness dimension was 0.481, slightly below the recommended threshold, indicating that further validation is needed to confirm the stability of the theoretical framework.

The temporal stability of EEAI

The low test-retest reliability of the EEAI (ICC = 0.349–0.364) may be attributed to two factors. First, the two-week interval between assessments may have been too long, given that exercise addiction is a dynamic psychological trait that can fluctuate over short periods in response to environmental factors such as academic stress [51]. This may explain why EAI-R also showed poor test-retest reliability in our study. Second, the instrument may lack sufficient sensitivity to capture the core psychological mechanisms of addiction, such as the emotional complexity associated with withdrawal symptoms. Future research could consider shortening the retest interval to 3–7 days and incorporating behavioral log tracking or ecological momentary assessment (EMA) methods to enhance data reliability [47,52,53].

Contributions

The contributions of this study are twofold:

(1) Chinese university students exhibit some of the highest levels of physical activity and exercise participation, while also being highly susceptible to the influences of social media and popular culture. Consequently, this population may be particularly vulnerable to exercise addiction. The validated measurement tool developed in this study provides a valuable resource for future research targeting this group.

(2) This study also identified a revised structural model for the Exercise Addiction Scale, highlighting that the original structure may vary across culturally diverse populations.4.5 Limitations and future directions of the study

Limitations and future directions

The limitations of this study include the following: the retest sample size (n = 36) was insufficient to meet recommended standards for stability assessment [54]; the ecological validity was limited, as the sample consisted solely of university students; and multidimensional data (e.g., physiological indicators or clinical interview data) were lacking [55].

Future studies should expand to include professional athletes and broader community populations, employ longitudinal designs to track the progression of exercise addiction over time, and integrate machine learning techniques to enhance predictive accuracy [56]. While our measurement tool provided scores indicative of the severity of exercise addiction, it cannot definitively diagnose high-risk cases; therefore, further research is needed to establish validated cutoff values [57]. In addition, future work should investigate the mechanisms underlying the co-occurrence of exercise addiction with anxiety and depression [58], in order to refine theoretical models and develop more effective intervention strategies.

CONCLUSION

We used a systematic approach to translate the extended version of the Exercise Addiction Index (EEAI) into Chinese and preliminarily validated the reliability of the instrument in a sample of college students from mainland China. Findings suggest that the structurally adjusted Chinese version of the EEAI exhibits acceptable structural and convergent validity as well as internal consistency. However, neither our translated EEAI nor the EAI-R, which has been validated by other studies, meets the desired standard in terms of retest reliability. This finding highlights the potential uncertainty regarding the temporal stability of the psychological construct of exercise addiction. Given that current research is still limited, we are unable to clarify whether this limitation stems from the construct's inherent instability or is limited by the sample characteristics used in this study. Therefore, we call for future research to further validate this study's findings in larger and more diverse Chinese samples, especially to systematically assess the instrument's construct validity.

ORCID ID

Yihan Liao: https://orcid.org/0009-0007-9860-3254

Yuling Duan: https://orcid.org/0009-0003-1461-8493

Wang Zhang: https://orcid.org/0009-0001-9732-7047

Siqi Wang: https://orcid.org/0009-0006-3914-8960

Yunyan Xue: https://orcid.org/0009-0004-6515-7209

Yu Liu: https://orcid.org/0009-0001-6447-5318

Xing Zhang: https://orcid.org/0009-0005-9506-174X

Mingyue Yin: https://orcid.org/0000-0002-6105-8797

Hansen Li: https://orcid.org/0000-0002-6147-1362

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