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ORIGINAL ARTICLE

Psychometric Evaluation of the Revised Exercise Addiction Inventory (EAI-R) Among Chinese College Students

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Abstract
The present study tested the psychometric properties of the Chinese Revised Exercise Addiction Inventory (EAI-R). In Study 1, 800 non-sport and 357 sports science students completed the Chinese EAI-R, the Exercise Dependence Scale (EDS), the Compulsive Exercise Test (CET), and the Eating Disorder Inventory (EDI). They also reported their weekly exercise frequencies and exercise length per workout. An exploratory factor analysis (EFA) was conducted. Three weeks later, 94 students were re-administered the Chinese EAI-R to determine its test–retest reliability. In Study 2, 398 college students completed the Chinese EAI-R. A confirmatory factor analysis (CFA) was conducted and measurement invariance across gender was evaluated. In Study 1, the EFA yielded a one-factor structure after excluding one item (interpersonal conflict) from the Chinese EAI-R. The correlation between the Chinese EAI-R and EDS ($r=0.60$) reflected concurrent validity. The risk of exercise addiction was higher among males than females in both samples and among sports science students compared to non-sports science students. The Chinese EAI-R also correlated with the CET score ($r=0.26$) but not the EDI score ($r=0.01$). Therefore, the convergent and divergent validity of the Chinese EAI-R was supported. McDonald's omega was 0.79 for the Chinese EAI-R items among non-sports science students and 0.84 among sports science students. The scale's test–retest reliability was 0.75 over 3 weeks. Finally, Study 2 confirmed the unidimensional structure of the scale while also supporting its measurement invariance between males and females. The Chinese EAI-R appears to be a valid and reliable tool for assessing the risk of exercise addiction among Chinese college students.

Keywords Assessment · Exercise dependence · Measurement · Physical activity · Questionnaire · Validation

1. Introduction

Exercise has numerous beneficial effects. For example, it can prevent or delay the onset of about 40 chronic diseases (Ruegsegger & Booth, 2017); promote brain functions such as learning and memory (Cotman et al., 2007); prevent and treat depression (Gujral et al., 2017, Harvey et al., 2018); and improve quality of life for people suffering of chronic diseases (i.e., cancer; Mishra et al., 2012). A recent study showed that college students who participated in sports regularly before college had higher self-esteem and happiness than those who did not (Collins et al., 2018). However,

the dose of exercise seems to be a key variable when judging the potential benefits of exercise, just as stated by ancient physician Hippocrates: "*All parts of the body, if used in moderation and exercised in labors to which each is accustomed, become thereby healthy...*" On the one hand, the association between lack of exercise and chronic diseases has been well documented (Mokdad et al., 2004). On the other hand, many people exercise excessively (Juwono & Szabo, 2020), which leads to body injuries and social function impairments (Griffiths, 1997, Hausenblas & Downs, 2002). Compared to the broad benefits of exercise, the adverse effects of excessive exercise have been much less addressed, especially in China.

In some rare and extreme cases, excessive exercise manifests in the form of exercise addiction, characterized by addictive symptoms similar to substance abuse addiction and harm to the individual (Griffiths, 2005). Exercise addiction has not yet been listed as a diagnosis under the substance-related and addictive disorders category in the fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5), mainly due to a lack of sufficient peer-reviewed evidence and course descriptions (American Psychiatric Associations, 2013). Currently, only gambling disorder is listed as a diagnosis of non-substance-related disorders in DSM-5. However, almost all listed nine symptoms of gambling disorder, such as increasing amounts with time, withdrawal symptoms, loss of control, preoccupation with exercise, serving as a strategy for distress relief, compensation, and relationship jeopardization, can be observed among the reported case with exercise addiction (Griffiths, 1997). Due to its negative consequences, exercise addiction has been suggested to be a behavioral addiction (Szabo et al., 2015). The prevalence rate in a 12-months was speculated to be 3% among U.S. adults (Sussman et al., 2011, Szabo et al., 2015) and even higher among athletes and patients with eating disorders (Lukács et al., 2019).

To distinguish addictive exercise patterns from healthy committed exercise and identify individuals at high risk of exercise addiction, Terry, Szabo, and Griffiths (2004) developed the Exercise Addiction Inventory. This measure has six items, each assessing one of six components of behavioral addiction proposed by Griffiths (1996): salience, mood modification, tolerance, withdrawal symptoms, conflict, and relapse. As a theory-driven tool, EAI showed good psychometric properties. The unidimensional structure of EAI was supported by factor analyses (Terry et al., 2004). Usually, measures with fewer items exhibit smaller internal consistency. However, with only six items, a Cronbach's alpha of .84 was observed in the original scale (Terry et al., 2004), supporting the good internal consistency of this scale. The excellent concurrent validity of EAI was supported by its significant correlation with other problematic exercise measures (i.e., r = .80 with the Obligatory Exercise Questionnaire and r = -.81 with the Exercise Dependence Scale; Terry et al., 2004).

Speaking for this tool's construct validity, those with higher exercise frequency scored significantly higher on EAI than those with lower exercise frequency (Terry et al., 2004). Additionally, those screened out as high-risk by EAI were largely superposed by those identified by other lengthy measures, making it an ideal tool to assess problem exercise when the time for measurement is limited. More recently, the psychometric properties of EAI have been further improved by changing the 5-point rating scale (1 = "Strongly disagree" , 2 = "Disagree", 3 = "Neither agree nor Disagree", 4 = "Agree", 5 = "Strongly Agree") to a 6-point rating system (1 = "strongly disagree", 2 = "disagree", 3 = "slightly disagree", 4 = "slightly agree", 5 = "agree", and 6 = "strongly agree"; Szabo et al., 2019), since the adoption of the midpoint answer in the original EAI can artificially increase the total score.

The EAI has been validated in Italy, Spain, Denmark, and Hungary and exhibited good psychometric properties. Cronbach's alphas of .66 or larger have been reported together with a unidimensional structure (Sicilia et al., 2013, Lichtenstein et al., 2014a, Monok et al., 2012). Each item loaded reasonably to the sole factor. Convergent validity was obtained by correlating self-reported exercise intensity and total EAI score (Sicilia et al., 2013). Additionally, the temporal reliability of the Spanish version of EAI was supported by an intra-class correlation coefficient of .92 over a 4-week interval (Sicilia et al., 2013). Males and females also responded similarly to the Spanish version of EAI since gender invariance has been obtained at construct, measurement weight, structural covariance, and residual levels (Sicilia et al., 2013). A large-scale study with data collected in five countries suggested that EAI is a proper tool assessing the risk of exercise addiction in different cultures (Griffiths et al., 2015).

As far as the present authors are aware, the only measure that can be used to assess exercise dependence on the Chinese mainland is the Chinese Exercise Dependence Scale (Li et al., 2012). This tool was developed based on the features of exercise dependence described by Hausenblas and Downs (2002), which reflects the diagnostic criteria of substance use disorder in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; American Psychiatric Associations, 1994)). Although dependence and addiction describe similar behavior patterns functionally (Cook et al., 2014), exercise dependence tended to screen a much higher proportion of participants as having risk compared to measures of exercise addiction (Cook et al., 2014). As much as 45.9% of college students could be identified as having a risk of exercise dependence (Zmijewski & Howard, 2003). This large number reminds us of the potential existence of false positives. Further, it has been argued that while dependence is part of addiction, it is not the same concept because addiction, also involves compulsion (Szabo &

Demetrovics, 2022). Furthermore, the Chinese Exercise Dependence Scale has 20 items. Although it is not lengthy for a standard self-report scale, it can be time-consuming for special populations of interest, such as elite athletes, and when used for screening purposes in clinical settings. Therefore, the validation of a brief and easy-to-interpret scale that assesses the risk of exercise addiction in Chinese exercisers is warranted.

2. Study 1

Study 1 aimed to validate the revised version of the Exercise Addiction Inventory (EAI-R; Szabo et al., 2019) in Chinese settings. Given the robust psychometric properties of EAI in different cultures and populations, it was hypothesized that the Chinese EAI-R would demonstrate good internal consistency, temporal stability, convergent and divergent validity, and concurrent validity. Furthermore, the convergent and divergent validity would be established by its association patterns with Chinese EDS (Li et al., 2012), Compulsive Exercise Test (CET; Taranis et al., 2011), and Eating Disorder Inventory (EDI; Garner et al., 1983).

De Coverley Veale (1987) distinguished two types of problem exercise, namely primary exercise dependence and secondary exercise dependence. The difference has mainly been made by whether exercise is taken as an end or a means. The end of primary exercise dependence is the exercise itself. In contrast, secondary exercise dependence happens when the person exercises to reach other goals (i.e., to lose weight or compensate for consumed calories, as frequently observed among those with eating disorders). The EAI was designed to assess primary exercise dependence (Terry et al., 2004, Griffiths et al., 2005), while the CET was intended to assess problematic exercise in an eating disorder context. Accordingly, we firstly expected that participants' responses on EAI-R would be strongly associated with those to Chinese EDS. This

finding would support the concurrent validity of this tool. Second, we hypothesized that sports science students would score higher than non-sports science students and that prevalence rates among sports science students would be higher, given the higher risk of exercise addiction among sports populations (Cook et al., 2014). Findings as such would support the convergent validity of this scale. Third, we hypothesized that participants' response to EAI-R would be slightly correlated with their response to CET and EDI. The associations would be much smaller than the association between EAI-R and EDS. The findings related to CET and EDI would support the divergent validity of Chinese EAI-R.

2.1 Method

2.1.1 Participants

Efforts were made to recruit two groups of college students, one group of non-sports science students and the second group of sports science students. The first group included 838 students. Part of them responded to questionnaires online (n = 611). The other 227 college students from Xi'an and Beijing responded to the questionnaire in a paper and pencil style.

Among all the 838 data collected, 38 were removed during the quality check process (i.e., regular response) and incomplete response. The remaining participants were 466 men (58.25%) and 334 women (41.75%). Their ages ranged between 17 and 31 years (M = 20.41, SD = 1.85).

The second group included 448 sports science students. All of them responded to the questionnaires online. Ninety-one responses were removed due to regular (identical ratings) or incomplete responses of more than 10% of the items. The remaining 357

valid data included 261 men (73.11%) and 96 women (26.89%). Their ages ranged between 19 and 40 years (M = 21.39, SD = 2.29).

2.1.2 Measures

All participants completed items regarding their age, gender, height, weight, years of formal education, ethnicity, weekly exercise frequency, and exercise length per workout (for computing individual weekly exercise time).

Revised Exercise Addiction Inventory, EAI-R

The EAI-R was developed by Szabo et al. (2019). It contains six items, each capturing one of the six components of addictive behaviors according to the component model of addiction (Griffiths, 2005): salience, mood modification, tolerance, withdrawal symptoms, conflict, and relapse. Participants respond to each of the six items in the EAI-R on a six-point rating scale (1 = strongly disagree, 2 = disagree, 3 = slightly disagree, 4 = slightly agree, 5 = agree, and 6 = strongly agree). Summing the scores of all items generates an exercise addiction risk score, with higher scores indicating a greater risk of exercise addiction. The Chinese and English versions of the EAI-R are presented in the Appendix.

In the present study, the English version of the EAI-R was initially translated into Chinese by a native Chinese who was also fluent in English. Three associate professors then reviewed this translated version. Minor changes in wording were made based on their comments. The revised Chinese version was then back-translated to English by a student who did not know about exercise addiction. The translated version was then sent back to one of the original developers of the EAI-R (Prof. Attila Szabo) for comments. The wording of one item was changed based on the feedback from the

original author. According to Szabo et al. (2019), a total score equal to or beyond 80% of the maximum score (≥ 29) was considered a risk to exercise addiction.

Chinese version of the Exercise Dependence Scale (EDS)

The Chinese EDS includes 20 items to assess the extent of exercise dependence (Li et al., 2012). This scale has five dimensions, withdrawal symptoms (six items), over-exercise (three items), tolerance (three items), loss of control (five items), and reduction of other activity (three items). Participants respond to each item on a five-point Likert scale, ranging from 1=strongly disagree to 5=strongly agree. In a previous study among Chinese adults who persisted in exercise, the Cronbach's α of .74 and the test-retest reliability of .78 over a three-week interval were obtained (Li et al., 2012). A cut-off score of 53 was suggested to screen out those at high risk of exercise dependence (Li et al., 2012). Only non-sports science students completed the scale, and McDonald's omega was .88 for the Chinese EDS items in the present study.

Compulsive Exercise Test (CET)

The Compulsive Exercise Test (CET) was developed by Taranis et al. (2011) to assess the core cognitive, behavioral, and emotional features of compulsive exercise in eating disorders. It has 24 items grouped into five subscales: avoidance and rule-driven behavior, weight control exercise, mood improvement, lack of exercise enjoyment, and exercise rigidity. Participants responded to each item with a 6-point Likert scale (0 = never true; 5 = always true). CET has been widely used in both clinical and research settings. Cronbach's α varied between .85~.88 in different samples (Taranis & Meyer, 2011, Taranis et al., 2011, Meyer et al., 2016, Goodwin et al., 2011). The original author granted permission before it was translated into Chinese for research purposes. McDonald's omega was .85 for the CET items in the present study.

Eating Disorder Inventory (EDI)

Disordered eating was evaluated by using the Eating Disorder Inventory (Garner et al., 1983). The EDI consists of 64 items to assess eating disorder symptoms, such as a drive for thinness, bulimia, body dissatisfaction, ineffectiveness, perfectionism, interpersonal distrust, interoceptive awareness, and maturity fears. The Chinese version of EDI demonstrated good psychometric properties (e.g., Cronbach's α = .95), and patients with anorexia nervosa scored significantly higher than healthy controls on total scale and subscale scores (except for maturity fears; Zhang & Kong, 2004). McDonald's omega was .94 among non-sports science students and .93 among sports science students in the present study.

2.1.3 Procedure

The Ethics Committee of the Institute of Psychology, Chinese Academy of Sciences approved this study (protocol number: H18020). The online participants were recruited via advertisements posted on various social media utilizing the snowball method (n = 611; Goodman, 1961). The confidential online survey was advertised as a study on exercise habits among Chinese adults and was posted to *Questionnaire Star web (https:// www.wjx.cn/)*, an online survey creation platform. Each participant filled in the questionnaire in return for 10 RMB (about 1.5 US dollars). The consent form was presented at the first screen of the survey, and survey items appeared only after the participant had clicked the *"Confirm"* button relating to informed consent.

The offline participants (n = 227) were tested in the classroom and received course credit for participating. All provided informed consent to participate in the study. Ninety-four of them were re-administered the Chinese EAI-R three weeks after the first test to assess the test-retest reliability of Chinese EAI-R

2.1.4 Data analyses

Individual weekly exercise time was quantified by the product of exercise frequency per week by the length of time per workout. Exploratory factor analyses (EFA) were used to explore the structural validity of the Chinese EAI-R in both samples. The concurrent and divergent validity of Chinese EAI-R was assessed with its correlational pattern with Chinese EDS, CET, and EDI. To examine the convergent validity, one-way analyses of variances (ANOVA) were performed for the total Chinese EAI-R score between sports science and non-sports science students and between male and female students. Gender and sample differences in the prevalence rate of exercise addiction were investigated with a *Z*-test. The *Z*-test (Meng, Rosenthal & Rubin, 1992) was used whenever correlation coefficients were compared. All statistical analyses were performed using SPSS 23, with a significance level of .05 (two-tailed).

2.2 Results

2.2.1 Structural validity

Results of Kaiser-Meyer-Olkin measure of sampling adequacy (KMO = .75 for the sample in the non-sports science and KMO = .80 for the sample in the sports science) and the Bartlett's test of sphericity ($\chi^2(15) = 582.32$, $p < .001$ for the sample in the non-sports science; and $\chi^2(15) = 443.25$, $p < .001$ for the sample in sports science) showed that the Chinese EAI-R was suitable for EFA in both samples. Among the non-sports science students, a one-factor structure was extracted by principal component analysis, as suggested by both eigenvalue (2.24) and Scree-plot, which accounted for 37.33% of the total variance. The factor loadings varied from .39 to .72 (Table 1). Clark and Watson (1995) suggested that factor loadings less than .40 for a principal component analysis should be removed. Based on this criterion, the second item was deleted.

The EFA generated two factors instead of a general factor among sports science students, which explained 44.77% and 16.78% of the total variance, respectively. The factor structures and loadings are also shown in Table 1. Again, Item 2 *"Conflicts have arisen between me and my family and/or my partner about the amount of exercise I do"* was the only item not loaded into the primary factor and was deleted accordingly.

Insert Table 1 here

2.2.2 Concurrent and divergent validity

The individual total score of Chinese EAI-R was then computed by adding up the responses to the remaining five items. As expected, the Chinese EAI-R correlated significantly to the Chinese EDS, $r = .60$, $p < .01$ and the CET, $r = .26$, $p < .01$ among the participants in non-sports science. The method outlined by Meng et al. (1992) was used to compare the three correlated correlation coefficients. The results showed that the correlation between EAI-R and the Chinese EDS was significantly larger than the correlation between EAI-R and the CET ($Z = 9.75$, $p < .01$, $r_{CET\text{-}EDS} = .34$). The correlation between EAI-R and EDI was also insignificant ($r = .01$, $p > .05$).

2.2.3 Convergent validity

Sample difference in EAI-R. As expected, sports science students (762.71±653.78 minutes) exercised significantly more than non-sports science students (176.55±164.89 minutes) each week, F (1, 1155) = 563.33, $p < .001$, $\eta^2 = .33$. There was a significant difference in EAI-R total scores between sports science students (19.57±4.74) and non-sports science students (17.46±4.26), F (1, 1155) = 56.49, $p < .001$, $\eta^2 = .05$.

Prevalence rates of exercise addiction. The prevalence rate of exercise addiction among sports science students (18.21%) was higher than that among non-sports science

students (5.88%), $Z = 6.55$, $p < .01$. When screened using the EDS, 42.13% of non-sports science students were at high risk for exercise dependence.

2.2.4 Reliability and item analyses

McDonald's omega for the five-item Chinese EAI-R was .79 among the non-sports science students and .84 among the sports science students. As shown in Table 2, the item scores were significantly correlated with EAI-R total score, and each item varied between .56 and .77, with p-values < .01 in both samples.

Insert Table 2 here

The test-retest reliability of Chinese EAI-R over a three-week interval was .75 ($p < .01$). The test-retest correlation coefficient for each item also reached a significant level (r-values ≥ .42, p-values < .01).

3. Study 2

Study 2 was conducted to confirm the unidimensional structure of Chinese EAI-R observed in Study 1 in another independent sample. For this purpose, confirmatory factor analysis (CFA) was carried out. Additionally, Study 2 also examined the measurement invariance of Chinese EAI-R across gender since it was also important to ensure that the Chinese EAI-R assesses the same construct for males and females. Previously, measurement invariance by gender was reported using the Spanish EAI (Sicilia et al., 2013). It was hypothesized that all items of Chinese EAI-R would load on one factor, and the structure of the scale would be invariant across gender.

3.1 Method

3.1.1 Participants and procedure

A total of 427 college students were recruited. They responded to the survey via the *Questionnaire Star Web (https://www.wjx.cn/).* Like in Study 1, they also provided the consent online. This study was approved by the Ethics Committee of the Institute of Psychology, Chinese Academy of Sciences (protocol number: H18020).

Data from 29 participants did not pass the validity check item inserted into the survey (i.e., *"Please do not respond to this question so that we know you are carefully reading each item."*) and were excluded from further analyses. Among the remaining 398 participants, 181 were males (45.48%), and 217 were females (54.52%). Their ages ranged between 18 and 32 years (M = 21.93 years, SD = 2.62 years).

3.1.2 Measures

Participants reported their demographic information, height, and weight before completing Chinese EAI-R (see Section 2.1.2).

3.1.3 Data analyses

Amos 26 was used to conduct CFA and test for measurement invariance. The analysis first compared whether the original six-item Chinese EAI-R or the five-item Chinese EAI-R explored in Study 1 fitted the data better. The selected model was then tested for measurement invariance. Following this, a series of multigroup confirmatory factor analyses at different levels with increasing constraints were conducted to test measurement invariance across gender. Invariance was tested at three levels, namely (i) configural invariance, (ii) factor loading invariance, and (iii) intercept invariance. Three indices, the Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR), were used to evaluate the models, as recommended by Hu and Bentler (1999). The chi-square and

its changes were also provided, but they are largely influenced by the sample size, which makes it less favorable to evaluate the model fit.

3.2 Results

3.2.1 Confirmatory factor analysis results

Result of CFA indicated the original six-item scale fitted the data well: $\chi^2 = 12.07$, df = 9, CFI = .990, RMSEA = .029, 90% CI = [.001, .068]， SRMR = .028 based on the criteria suggested by Hu and Bentler (1999; CFI ≥ .95, SRMR ≤ .08, and RMSEA ≤ .06). However, the factorial loadings for Item 2 (interpersonal conflict) was only .18, which was below the suggested value of .40 (Clark & Watson, 1995), and was therefore excluded. Deletion of the item related to personal conflict resulted in a five-item scale which was the same as the scale in Study 1. The remaining factor loadings were all above .44.

A separate CFA for the five-item scale fitted the data well: $\chi^2 = 3.91$, df = 5, CFI = 1.000, RMSEA = .001, 90% CI = [.001, .062]， SRMR = .017. As shown in Fig. 1, all factor loadings were greater than .40. Therefore, the results of the CFA confirmed the five-item scale found in Study 1. The measurement invariance across gender was tested with the five-item scale.

Insert Figure 1 here

3.2.2 Tests for measurement invariance

The CFI, RMSEA, and SRMR results indicated that the configural invariance model tested fit the data well (Table 3). Therefore, the Chinese EAI-R items formed a similar exercise addiction latent factor for both males and females. When testing for

factor loading invariance, all factor loadings were constrained equally across males and females. The model provided a good fit to the data and did not differ significantly from the configural model based on the criteria recommended by Chen (2007; ΔCFI ≥ -.010, supplemented by ΔRMSEA ≥ .015 or ΔSRMR ≥ .030). All item-factor intercepts were constrained equally across gender when testing for intercept invariance. The intercept invariant model fitted the data well and was not significantly different from the corresponding factor loading model based on the criteria recommended by Chen (2007; ΔCFI ≥ -.010, supplemented by ΔRMSEA ≥ .015 or ΔSRMR ≥ .010). In summary, the Chinese EAI-R demonstrated measurement invariance across gender at all levels tested. Therefore, EAI-R scores can be meaningfully compared between males and females.

Insert Table 3 here

3.2.3 Comparison between males and females in Chinese EAI-R

Since measurement invariance between males and females was demonstrated, comparisons between males and females were practicable. As shown in Table 4, males scored significantly higher than females on the EAI-R in the Study 1 sample after removing the second item of the scale. In the Study 2 sample, the result was replicated with males scoring (17.01±4.90) significantly higher than females (15.53±4.36): F (1, 396) = 10.03, $p < .01$, $\eta^2 = .03$. Males in both non-sports science and sports science samples also had higher prevalence rates than females (Table 5).

Insert Tables 4 and 5 here

4. Discussion

The main aim of Study 1 was to test the psychometric properties of the Chinese version of EAI-R using exploratory factor analysis (EFA) and reliability testing among two samples of Chinese college students, one in the non-sports science and the other in the sports science. The main aim of Study 2 was to confirm the findings of Study 1 using confirmatory factor analysis (CFA) and test measurement invariance of gender in the Chinese EAI-R. Supporting the reliability of this tool, Study 1 obtained McDonald's omega was .79 for the Chinese EAI-R items among the non-sports science students and .84 among the sports science students. With only five items, the internal consistency of Chinese EAI-R is acceptable. The obtained level of internal consistency was comparable to the Spanish (Cronbach's α =.70), Danish (Cronbach's α =.66), and Hungarian (Cronbach's α =.72) versions of EAI (Sicilia et al., 2013, Lichtenstein et al., 2014a, Monok et al., 2012).

Further supporting the reliability of this tool, the test-retest reliability of .75 was obtained. Previously test-retest reliability of .85 over a two-week interval was reported (Griffiths et al., 2005). The present study demonstrated that the construct of exercise addiction has good temporal reliability in a period of as long as three weeks.

As for the structural validity, a general factor was obtained for the Chinese EAI-R in both Study 1 and 2, and a unidimensional structure was observed in both the EFA and CFA, which was consistent with findings for the EAI in English, Danish, Hungarian, and Spanish (Szabo et al., 2019, Sicilia et al., 2013, Lichtenstein et al., 2014a, Monok et al., 2012). However, compared to the EAI-R in other languages, Item 2 (*Conflicts have arisen between me and my family and/or my partner about the amount of exercise I do*) was removed based on the EFA and CFA results. There might be at least three reasons for 'conflict' not fitting in the model. First, exercise is generally viewed positively in China (Mao et al., 2004, Yang, 2011). People think that exercise is healthy

and the present study was an exception in that it examined the potential negative consequences of exercise. As a result, family members may appreciate excessive exercise rather than have doubts about it. Secondly, the exclusion of Item 2 may be related to the features of participants who were college students. In China, these individuals live far from their families in shared rooms with 4-6 other same-gender students. Therefore, their problematic exercise pattern may go unnoticed by family members. Third, sports science students have to exercise as part of their curriculum without conflict and non-sports science students only exercised a little more than three hours per week, which is unlikely to lead to conflict with others.

Further studies in older age groups may clarify whether there is a cultural difference in the construct of exercise addiction. However, we believe the lack of "conflict" component in the present study does not mean that exercise addiction on the Chinese mainland is less severe than in other cultures. Instead, it suggests that this problematic exercise pattern will go unnoticed by significant others. As a result, an individual with exercise addiction may likely develop a more serious problem without outer interference. This premise also calls for more focused attention to exercise addiction in China.

The Chinese EAI-R demonstrated measurement invariance at the configural, factorial, and intercept levels, indicating that the latent exercise addiction construct represented by the Chinese EAI-R items is the same for both males and females. Items of EAI-R are similarly interpreted by males and females. Therefore, the direct comparison of the items or mean scores between these groups is possible and meaningful. Supporting the convergent validity, we found men scored higher than women on the Chinese version of EAI-R. A similar pattern has been previously revealed (Dumitru et al., 2018, Costa et al., 2013). Further supporting the convergent

validity, a higher prevalence rate was observed among participants in the sports science than those in the non-sports science and among men than among women. Results as such have been well-documented in boys than girls (Villella et al., 2011), in men than in women (Szabo et al., 2013), and among those with larger exercise volume (Szabo et al., 2013, Monok et al., 2012, Lichtenstein & Jensen, 2016, Szabo & Griffiths, 2007) than those with less.

Notably, The Chinese EAI-R has the potential to serve as a better screening tool for exercise addiction in the Chinese context than the Chinese EDS. The prevalence rate screened out by the Chinese EDS reached 42.13% among participants in the non-sports science. The high prevalence rates pointed to the high false-positive rates. While only 5.88% in the non-sports sample and 18.21% in the sports-related samples were screened if the current Chinese EAI-R was used. This prevalence rate seemed more reasonable if compared with other studies. Previously, the prevalence rate of 11.30% (Li, 2018) and 8.42% (Li & Ma, 2011) among Chinese college students who engaged in exercise regularly, 8.7% among fitness attendees (Lichtenstein et al., 2014a), and 11.5% among those with regular exercise of at least three times per week for at least 30 min each time (Szabo et al., 2019) were reported.

Consistent with previous studies (Szabo et al., 2019, Monok et al., 2012, Terry et al., 2004), we found that Chinese EAI-R correlated substantially with Chinese EDS (r = .60). Thus, the concurrent validity of Chinese EAI-R was supported. Two facts supported the divergent validity of Chinese EAI-R. First, the association between EAI-R and EDS was significantly larger than its association with CET, a measure of problematic exercise observed in patients with eating disorders (Taranis et al., 2011). Second, the Chinese EAI-R was not significantly correlated with the severity of eating disorder symptoms. Exercise addiction has been conceptually framed to be

distinguished from the abnormal exercise pattern in eating disorders (i.e., to take exercise as a means to lose weight or compensate for consumed calories; Veale, 1987). These results suggest that the Chinese EAI-R is an ideal tool for primary exercise addiction rather than secondary exercise addiction or eating disorder pathology, which may include problematic exercise patterns. However, the correlation between exercise addiction and eating disorder symptoms has been documented previously in Israel and Danish samples (Levit et al., 2018, Lichtenstein et al., 2014b). The boundary between the primary and second exercise dependence seems clearer in this Chinese sample.

Limitations and future directions

Several limitations should be noted in the present study. First, the two studies did not consider the type of physical exercise individuals participate in when computing the weekly excise volume. Types of physical exercise could also be a relevant factor in exercise addiction (Kovacsik et al., 2018). Second, only college students were selected for the data collection in both studies, limiting the findings' generalization to other age groups. Third, item-response theory (IRT) was not used in the present study to analyze item characteristics. Future studies should carry out such analyses on the individual items that comprise Chinese EAI-R. Fourth, the EAI-R item related to partner or family conflicts was removed from the Chinese EAI-R, which may be because partner conflict or family conflicts are not salient among Chinese college students. The factor loading of Item 2 (conflict) is likely higher among participants in stable relationships or living with family members. Finally, only self-reported data were collected, which may be biased.

Future studies can include groups of different ages and educational levels and in a stable partnership to investigate the applicability of the scale in different groups and

establish multidimensional norms for exercise addiction in the Chinese context. Furthermore, because previous studies have found that exercise addiction and muscle dysmorphia are significantly associated (Olave et al., 2021), future studies could explore the association between exercise addiction and muscle dysmorphia (as well as other behavioral addictions) among the Chinese population.

Conclusion

The studies conducted here show that a five-item version of the Chinese EAI-R has acceptable psychometric properties. However, the need to exclude interpersonal conflict from the Chinese EAI-R needs further research attention among non-college students, especially those in stable relationships. Consequently, while the Chinese EAI-R is valid for sports science and non-sports science college students, its psychometric properties should be evaluated further with a more heterogeneous exercising sample.

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195 **Table 1.** Results of exploratory factor analysis of the EAI-R

	Non-sports science students (*n*=800)	Sports science students (*n*=357)	
	Factor 1	Factor 1	Factor 2
Item 1	.71	.71	-.42
Item 2	.39	.40	.79
Item 3	.56	.66	-.31
Item 4	.72	.78	-.13
Item 5	.72	.71	.27
Item 6	.49	.70	.13

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198 **Table 2.** Descriptive statistics and correlations of items of the EAI-R in non-sport
199 (*n*=800) and sports science (*n*=357) students

	M	*SD*	EAI-R total	Item 1	Item 3	Item 4	Item 5
Item 1	3.83/4.61	1.37/1.22	.71/.72				
Item 3	3.95/4.22	1.36/1.38	.62/.69	.26/.45			
Item 4	3.41/3.76	1.27/1.31	.69/.77	.46/.50	.23/.40		
Item 5	2.58/3.13	1.27/1.39	.69/.71	.37/.33	.27/.29	.37/.45	
Item 6	3.70/3.85	1.26/1.31	.56/.70	.19/.35	.23/.32	.19/.42	.24/.43

200 Note：all *p*-values < .01

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202

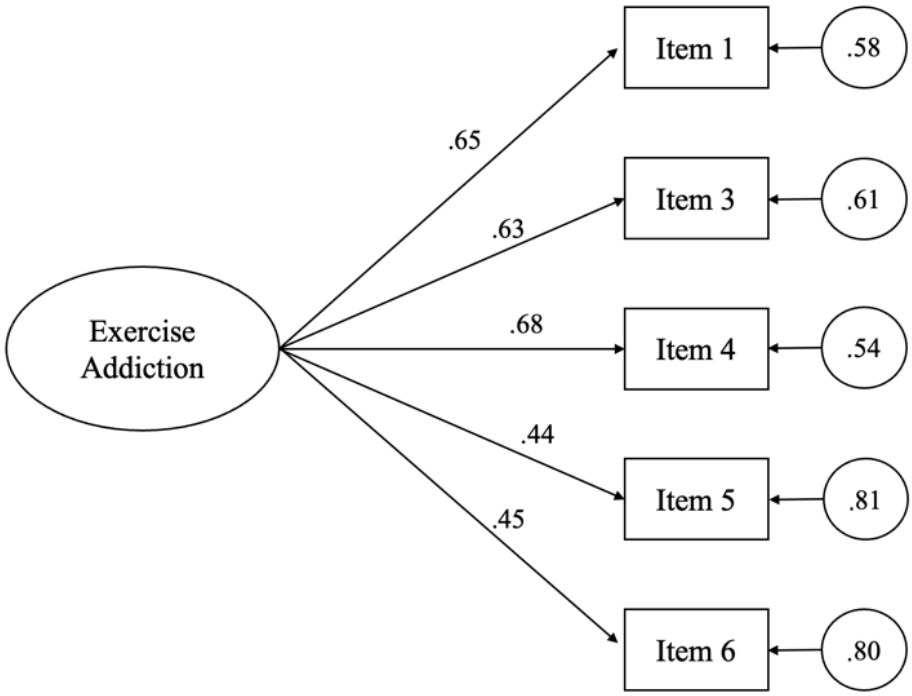

Fig 1. CFA of the Chinese EAI-R with standardized regression weights and residual variances.

Table 3 Tests of measurement invariance of the EAI-R items

Model	χ^2	df	CFI	RMSEA	SRMR	$\Delta\chi^2$	Δdf	*p*-value	ΔRMSEA	ΔCFI	ΔSRMR
Males vs. Females											
Configural invariance	13.03	10	.990	.028	.059						
Factor loading invariance	24.69	14	.965	.044	.063						
Configural vs. factor loading invariance						11.66	4	.02	.016	.025	.004
Intercept invariance	44.03	20	.920	.055	.050						
Factor loading vs. intercept invariance						19.34	6	.004	.011	.045	.013

Note: CFI = Comparative Fit Index, RMSEA = Root Mean Square Error of Approximation, SRMR = Standardized Root Mean Square Residual.

Table 4. Gender comparison in EAI-R, CET, and EDI scores in non-sports science (*n*=800) and sports science (*n*=357) samples.

	Females (*M*±*SD*)	Males (*M*±*SD*)	*F*	*p*	$\eta^2_{partial}$
Non-sports science students	(*n*=334)	(*n*=466)			
EAI-R	16.37±3.77	18.24±4.42	39.35	<.001	.05
CET	11.71±2.58	11.27±2.71	5.26	.022	.01
EDI	212.81±39.49	188.27±39.67	74.78	<.001	.09
weekly exercise time	122.25±122.80	215.47±179.67	67.36	<.001	.08
Sports science students	(*n*=96)	(*n*=261)			
EAI-R	18.34±4.59	20.03±4.72	9.05	.003	.03
weekly exercise time	480.16±350.74	866.63±707.09	26.27	<.001	.07

Table 5. Prevalence and gender difference in non-sports science (*n*=800) and sports science (*n*=357) samples.

	Total	Females	Males	*Z*
Non-sports science students		**(*n*=334)**	**(*n*=466)**	
EAI-R	47(5.88%)	4(1.20%)	43(9.23%)	4.76**
EDS	337(42.13%)	98(29.34%)	239(51.29%)	6.20**
Sports science students		**(*n*=96)**	**(*n*=261)**	
EAI-R	65 (18.21%)	8 (8.33%)	57 (21.84%)	2.93**

Note. ** refers to $p < .01$

Appendix: EAI-R in Chinese

		完全不同意	不同意	有点不同意	有点同意	同意	完全同意
1）	锻炼是我生活中最重要的事	1	2	3	4	5	6
2）	我把锻炼用作是改变感受的一种方式（例如，让自己兴奋起来、逃避，等等）	1	2	3	4	5	6
3）	随着时间的推移，我在增加每天的运动量	1	2	3	4	5	6
4）	如果不得不错过一次锻炼，我会感到难过和易怒	1	2	3	4	5	6
5）	如果我有意控制/减少运动量，试图重新开始锻炼计划，结果在执行的过程中却发现只能坚持一小段时间，之后还保持着和以前一样的运动量	1	2	3	4	5	6

EAI-R in English

		Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
1）	Exercise is the most important thing in my life	1	2	3	4	5	6
2）	I use exercise as a way of changing my mood (e.g., to get a buzz, to escape, etc.)	1	2	3	4	5	6
3）	Over time I have increased the amount of exercise I do in a day	1	2	3	4	5	6
4）	If I have to miss an exercise session, I feel moody and irritable	1	2	3	4	5	6
5）	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	1	2	3	4	5	6