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ORIGINAL ARTICLE

The Persian Exercise Addiction Inventory—Adult and Youth Versions: Psychometric Properties Based on Rasch Analysis Among Iranians

Mehdi Akbari[1] · Elahe Zamani[1] · Mohammad Seydavi[1] · Mark D. Griffiths[2] · Amir H. Pakpour[3]

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Abstract
Exercise addiction is a morbid-compulsive behavioral pattern characterized by a loss of control over exercise and which results in major detrimental consequences in the affected individual's life. Although the condition is not formally recognized in official psychiatric texts, exercise addiction can lead to clinical impairment of everyday activities just like other more traditional addictions. This has led to the development of many instruments to assess exercise addiction. One of the most widely used instruments is the Exercise Addiction Inventory (EAI) which has been translated into a number of languages and has separate versions of the scale for adults and adolescents (i.e., the EAI-Y for youth). However, there are currently no Persian versions. Therefore, the present study translated the EAI into Persian and assessed its psychometric properties using Rasch analysis among both Iranian adults ($n = 745$, age range = 19–30 years, 60.53% female) and Iranian adolescents ($n = 562$, age range = 13–18 years, 62.45% female). An online survey was used to collect data from September to November 2021. Confirmatory factor analyses and the Rasch analyses confirmed the unidimensional structure of the EAIs and good reliability using the Omega coefficient (.71 to .72). Also, separation reliability on item, scale, and person-level was established, along with supported measurement invariance, demonstrating that EAI can discriminate individuals on a high or low level of exercise addiction independent of their age and gender. Overall, the Persian EAI demonstrated sound psychometrics in screening for exercise addiction among Iranian adults and adolescents.

Keywords Exercise addiction · Problematic exercise · Exercise Addiction Inventory · Confirmatory factor analysis · Differential item functioning · Measurement invariance · Rasch analysis

1. Introduction

Exercise addiction has been defined as *"a morbid pattern of behavior in which the habitually exercising individual loses control over his or her exercise habits and acts compulsively exhibits dependence and experiences negative consequences to health as well as in his or her*

social and professional life" (Szabo et al., 2015). Exercise addiction is seen by most researchers as a psychological addiction although some early research claimed the general public viewed it more like a physiological addiction (i.e., Griffiths & Duff, 1993). According to Griffiths (1996), some addiction benefits including pleasure, relaxation, changing mood, helping to cope with threats, and having a meaningful life, all of which can make exercise a potentially addictive activity.

To date, exercise addiction as a disorder has not been formally recognized in official texts such as the *International Statistical Classification of Diseases* (ICD) or the *Diagnostic and Statistical Manual of Mental Disorders* (Berczik et al., 2011; Lichtenstein et al., 2012). However, many scholars such as Berczik et al. (2011) believe that problematic exercising is a hidden addiction that can act like substance or behavioral addictions, and can be equally detrimental among those individuals affected. Side-effects of EA at the physical level include joint damage, loss of muscle mass, sprained ligaments, strained or torn muscles or tendons, heart problems, extreme weight loss, and irregular periods with possible reproductive issues; Also, at the psychological level, it includes emotional distress, anxiety, and depression ("Exercise Addiction", 2021).

The prevalence of exercise addiction has been reported in many studies over the past 30 years although almost all of them have been small-scale convenience samples. However, in one of the few nationally representative studies, Mónok et al. (2012) reported 1.9-3.2% of exercisers and 0.3-0.5% of the general population were at risk of exercise addiction in Hungary. A recent comparative meta-analysis (Trott et al., 2019) estimated the prevalence of exercise addiction in populations with and without eating disorders. Nine studies with a total sample of 2140 participants (mean age = 25.06 years; 70.6% female) were included. Of these, 1732 participants did not have any eating disorders (mean age = 26.4 years; 63.0% female), with the remaining 408 having eating disorders (mean age = 23.46 years; 79.2% female). The odds ratio

(OR) for exercise addiction among populations with eating disorders versus those without was 3.71 times higher (95% CI 2.00–6.89; $I^2 = 81$; $p \leq 0.001$). However, the prevalence rates for the two populations were not reported. Based on a systematic review by Juwono et al. (2021), the prevalence rate of exercise addiction among athletes (runners) ranged between 2.7% to 42%. Another study showed that 7.6% were at risk of exercise addiction among elite athletes competing at a national level, exercising despite injuries, feeling guilty without doing exercise, and having substantial eating disorder symptoms (Lichtenstein et al., 2021).

Measures assessing problematic exercise

Some instruments have been developed to assess different aspects of extreme behavior and emotion in exercise such as the Commitment to Running Scale (Carmack & Martens, 1979), Obligatory Exercise Questionnaire (OEQ; Pasman & Thompson, 1988), Running Addiction Scale (Chapman & Castro, 1990); the Exercise Dependence Questionnaire (EDQ; Ogden et al., 1997), Exercise Dependence Scale (EDS; Hausenblas & Downs, 2002) and its revised version (EDS-R; Symons-Downs et al., 2004). Although these instruments contributed to the expansion of exercise addiction research over recent years, they have some problems such as having many items, lack of ease in scoring, and unclear interpretation (Griffiths et al., 2005). Moreover, Terry et al. (2004) asserted that many of the instruments were not theoretically-based, and were not practical for easy use by physiotherapists or sports experts. For example, the EDS has some difficulties on calculating a score to detect individuals at-risk of exercise addiction, so it is hardly used in sport and medical settings (Sicilia et al., 2013), and the Commitment to Running Scale provides only a limited assessment of exercise addiction (Hausenblas & Symnons-Downs, 2002).

The Exercise Addiction Inventory

To overcome the aforementioned existing problems, Terry et al. (2004) developed the Exercise Addiction Inventory (EAI), a theory-based instrument for assessing the risk of

exercise addiction. This quick and easy screening six-item self-report instrument has a unifactorial structure. In the development of the EAI, items were developed based on components model of behavioral addiction (Brown, 1993, Griffiths, 1996, 2005), comprising salience, mood modification, tolerance, withdrawal, conflict, and relapse. The EAI is a psychometric instrument based on a reflective model (i.e., indicators of a construct are considered to be caused by that construct) designed for all adult population samples. The original validation study was conducted with British students who reported a regular exercise activity.

One strength of the EAI (scored out of 30) is its capacity to differentiate between individuals who are asymptomatic of exercise addiction (i.e., having a score between 0 to 12), individuals who have some symptoms (i.e., having a score between 13 to 23), and individuals who are at risk of exercise addiction (i.e., having a score of 24 or more). In another study, Mónok et al. (2012) tried to find the best cut-off score through Receiver Operating Characteristic curve analysis (ROC analysis). This analysis resulted in a slight difference from the original study resulted in the following criteria: asymptomatic individuals = 0-13, non-dependent symptomatic individuals = 14-23, and at-risk dependency = 24-30. The EAI showed good reliability and validity in the original psychometric studies (Griffiths et al., 2005; Terry et al., 2004).

Since then, a number of validation studies have confirmed the psychometric properties of the EAI in different cultures and sport settings. For example, the EAI has been found to be an adequate and reliable instrument in Mexico (Salazar et al., 2021), Spain (Alías-García et al., 2013), Hungary (Mónok et al., 2012), Italy (Gori et al., 2021). In a series of studies in the Danish context, Lichtenstein et al. (2012, 2014, 2016) found good reliability and construct validity for the EAI among samples of Danish elite athletes, football players, fitness exercisers, and cross-fitters (a mix of aerobic and anaerobic exercise).

Griffiths et al. (2015) re-analyzed the psychometric properties of the EAI using the existing datasets from five different countries. This process resulted in the re-confirmation of the one-factor structure of the EAI along with confirmed measurement invariance. Another Danish study validated the youth version of the EAI (i.e., the EAI-Y) for use among adolescents (Lichtenstein et al., 2018). Like the EAI, the EAI-Y also has a unifactorial structure and comprises six items. The developers used a cross-sectional survey for three high-risk samples (i.e., sport school students, fitness center attendees, and patients with eating disorder diagnoses) aged 11–20 years (M_{age} =16.3 years). The EAI-Y showed good reliability and construct validity.

Aim of the present study

Only three studies have been conducted in Iran to date using the EDS (Hausenblas & Downs, 2002), which is comprised of twenty-one items pertaining to substance abuse. The authors discovered significant positive associations between exercise dependence and negative perfectionism (Aayadi et al., 2020), drive and attitude toward muscularity, and attitude toward performance-enhancing drug use (Besharat et al., 2017), as well as a negative association with sport mindfulness (Shahhosseni et al., 2018).

As previously stated, EAI possesses strengths that make it an excellent candidate for consideration in the Persian context, thus, since no previous study has evaluated the psychometric properties of the two versions of EAI among Iranians, the present research carried out a psychometric evaluation of the Persian EAI and the Persian EAI-Y in two independent studies and samples. Confirmatory factor analysis (CFA) was to assess the factor structure of these two scales. Furthermore, to expand the analysis on the structure of both scales, measurement invariance was also tested to ensure that all participants interpreted the items in the same way alongside a Rasch analysis to provide a comprehensive picture of the invariance of the scales across participants.

2. Method

The present study was a cross-sectional psychometric validation study carried out according to the **CO**nsensus-based **S**tandards for the selection of health status **M**easurement of **IN**struments (COSMIN; Gagnier et al., 2021). An online survey was used to collect the data.

2.1. Participants, procedure, and ethics

The present study comprises two samples for each of the validations. The sample size of at least 250 participants for factor analyses through each split-half sample (i.e., a minimum of 500 total participants) is deemed as acceptable (Schönbrodt, & Perugini, 2013). The first sample comprised 957 participants. Being 19-30 years, signing the consent form to participate, and being Persian speakers were the only inclusion criteria. The second sample comprised 723 Iranian adolescents aged 13 to 18 years. The only inclusion criteria were the 13-18 years of Persian speakers, and parental consent to participate. Since September 2 to November 2, 2021, an invitation link was shared on several groups in social media-related apps (WhatsApp & Telegram) and invited participants to participate in the study. Participants were volunteers, were not compensated, were not restricted for residency, and informed consent was obtained before completing the study (as well as parental consent for the adolescent participants). Two additional items were inserted as attention check items (e.g., *"Please select strongly agree"*) to detect careless responders. Among the adult participants who completed the survey, 212 were identified as careless responders and were removed from the sample. This left 745 adult participants for the EAI validation. Among the adolescent participants, 161 were identified as careless responders and were removed from the sample. This left 562 adolescent participants for the EAI-Y validation. The study was conducted following the Helsinki Declaration as revised 1989 and the study was approved by the first author's university ethics committee.

2.2. Translation process

The present research was conducted following Beaton et al.'s (2000) guidelines as the basis for the scale translation process. Initially, permission was obtained from original scale developers to validate the EAI. It should also be noted that Szabo et al. (2019) introduced a slight change in the item response of the EAI from a five-point to six-point (the EAI-R) to remove the neutral response (*neither agree nor disagree*), resulting changes in answers at three different levels (1 = *strongly disagree*, 2 = *disagree*, 3 = *slightly disagree*, 4 = *slightly agree*, 5 = *agree*, and 6 = *strongly agree*). The EAI-R demonstrated good psychometric properties and the developers suggested it would be better to use the revised version of EAI. Therefore, the present study tested both ratings through a pilot study. The original five-point rating had better internal consistency utilizing Cronbach's alpha. Therefore, in the present study, the original versions of EAI were validated.

The original version was translated by the Iranian authors, and minor inconsistencies were discussed and then were solved, and an independent bilingual person prepared the back-translation form. In the next step, this back-translation version was approved by one of the developers. For the EAI validation, a pilot study was conducted utilizing think-aloud cognitive interviews with 15 individuals aged 18-30 years old (45% males, M_{age} = 24.15 years [SD = 7.61]). For the EAI-Y validation, think-aloud cognitive interviews were performed with 15 individuals aged 13-18 years (53.3% females; M_{age} = 16.4 years [SD = 3.47]). This method provided an individuals' interpretation of the items and allowed the research team to make some changes in items to maximize fluency and keep the psychological meaning of the items. Following this, the content validity of the second translated version was evaluated by four clinical psychologists who were Persian speakers. This ensured the understanding and fluency of the EAI items and led the final Persian version of the EAI (see Appendix).

2.3. Measures

The Persian forms of the following self-report measures were used in the present study.

2.3.1. Socio-demographic Features

Participants were asked to state their age, gender, and educational level. This information is presented in Table 1.

2.3.2. Exercise Addiction Inventory (EAI; Terry et al., 2004)

The six-item EAI was used to assess the risk of exercise addiction. Items are rated on a five-point Likert scale from 1 (*Strongly disagree*) to 5 (*Strongly agree*). The EAI has a total score ranging from 6-30, and higher scores indicating higher levels of addictive and problematic exercise. A cut-off point of 24 or above (as in the EAI) is considered to indicate being at risk of exercise addiction. The original validation studies of the EAI (Griffiths et al., 2005; Terry et al., 2004) reported excellent internal consistency, construct validity, content validity, and concurrent validity.

2.3.3. Exercise Addiction Inventory (EAI-Y; Lichtenstein et al., 2018)

The six-item EAI-Y was used to assess the risk of exercise addiction. Items are rated on a five-point scale from 1 (*Strongly disagree*) to 5 (*Strongly agree*). The EAI-Y has a total score ranging from 6-30, and higher scores indicating higher levels of addictive and problematic exercise. A cut-off point of 24 or above (as in the EAI) is considered to indicate being at risk of exercise addiction. Lichtenstein et al. (2018) reported good reliability ($\alpha = 0.70$) and construct validity for the EAI-Y.

2.4. Data analysis

The reliability of the EAI was examined using Cronbach's alpha, McDonald's omega, and item-total correlation. Acceptable reliability was determined as Cronbach's > 0.7, McDonald's omega > 0.7 and corrected item-total correlation > 0.3. The one-dimensionality of the EAI scale was examined using CFA and Rasch analysis. Due to the ordinal nature of the data, the diagonally weighted least squares (DWLS) method was chosen to estimate the CFA model. The model fit was evaluated using several goodness-of-fit indices, including χ^2, Tucker-

Lewis's index (TLI), comparative fit index (CFI), root mean square residual of approximation (RMSEA), and standardized root mean square residual (SRMR). Acceptable model fit was indicated by CFI and TLI >0.90, RMSEA and SRMR< 0.08. Rasch analysis with a partial credit model was chosen to evaluate the functioning of the EAI scale. Item fit was evaluated by infit MnSq and outfit MnSq (acceptable value range are between 0.5 and 1.5), and person and item separation reliability > 0.7 (Linacre, 2020).

Measurement invariance of the EAI items across different subgroups including gender (male vs. female) and age (i.e., <22 years vs. ≥22 years) using CFA and Rasch analyses were conducted. Multigroup confirmatory factor analysis (MGCFA) was conducted to test measurement invariance across age and gender subgroups of the participants. For MGCFA, three models were specified for testing measurement invariance: configural invariance, metric invariance, and scalar invariance. The measurement invariance is evident if $\Delta CFI > -0.01$, $\Delta SRMR < 0.01$, and $\Delta RMSEA < 0.015$ (Chen, 2007). Differential item functioning (DIF) was conducted across age and gender subgroups to explore measurement invariance further. Significant DIF is defined as a DIF contrast >0.5.

3. Results

The EAI's internal consistency is shown in Table 2. Cronbach's alpha and McDonald's omega for the six-item EAI were 0.71 and 0.72, respectively. The corrected item-total correlations were > 0.3 for all items. The results of the CFA are reported in Table 2. The unidimensional model provided an acceptable fit to the data: CFI=0.998; TLI= 0.997; RMSEA=0.019; and SRMR=0.026. All factor loadings were significant and ranged from 0.41 to 0.71.

The results of Rasch analysis are shown in Table 3. None of the items showed infit or outfit mean squares > 1.5 or < 0.5 as suggested by Bond and Fox (2007). The reliability index was 0.72 and 1.0 for individuals and items, respectively. The separation index for individuals

and the items were 2.52 and 18.81, respectively. DIF was conducted on age and gender subgroups to examine how well the data fitted. None of the items showed substantial DIF across age and gender.

MGCFA further confirmed measurement invariance across age and gender. All configural, metric, and scalar models fitted well to the data. Moreover, there were no significant differences in model fit among configural, metric, and scalar models across age and gender subgroups (Table 4).

The internal consistency results for the EIA-Y were acceptable because Cronbach's α= 0.72 and McDonald's omega 0.72. All inter-item correlations and corrected item-total correlations were within the recommended range, confirming good internal consistency (Table 5). The results of the CFA are shown in Table 5. As Table 6 shows, the one-factor structure of the EIA-Y was confirmed, and the model showed a good fit: CFI=0.978; TLI= 0.963; RMSEA=0.072; and SRMR=0.052. All factor loadings were significant and higher than 0.40.

The results of the Rasch analysis (i.e., the estimated item difficulty parameters and fit measures) are reported in Table 5. The reliability index was 0.71 and 0.99 for individuals and items, respectively. The separation index for individuals and the items were 2.55 and 12.65, respectively. As Table 5 shows, the item difficulty estimates ranged from -0.71 for Item 1 (the easiest item for respondents) to 0.78 for Item 2 (the most difficult item for respondents). Moreover, both infit and outfit MnSq statistics ranged between 0.5 and 1.5. Also, the measurement invariance across age and gender subgroups was explored using DIF. There was no DIF by age or gender, and all values were below the threshold value of 0.5. The results of the MGCFA of the EAI-Y single-factor model across age and gender subgroups are shown in Table 7. All three configural, metric, and scalar invariance models fitted the data well and fully supported age and gender subgroups.

4. Discussion

The present study evaluated the psychometric properties of the Persian versions of the Exercise Addiction Inventories for both adults and adolescents (EAI and EAI-Y). Comparable to the English versions, the one-dimensionality of the Persian EAI and the Persian EAI-Y, their reliability at the item, scale, and person-level were confirmed. Moreover, the Persian EAI and the Persian EAI-Y both demonstrated robust psychometrics that can discriminate high or low levels of the risk of exercise addiction among adults and adolescents, respectively. The study used two traditional psychometric procedures, classic test theory (CTT), and Rasch analysis among Iranian adults and adolescents. Two psychometric approaches were utilized because CTT is a commonly used to make comparisons of the item-correlations-loadings with previous studies and the Rasch analysis provides additional helpful data to extend the understanding of a psychometric instrument. In particular, CTT employs observed scores, derived by adding up participants' item responses and predicting a particular outcome's accuracy value. Consequently, CTT has the benefit of being straightforward to understand. However, Rasch analysis focuses on the distinction between scales and individuals. That is, Rasch analysis has the benefit of sample-free features. More specifically, results from CTT depend on the tested sample's characteristics. Moreover, the results of Rasch analysis do not have such problems because they generate item difficulty (i.e., whether the item makes the participant report low or high scores irrespective of the item difficulty) and individual ability (i.e., whether the item makes the participant report low or high scores irrespective of their ability). With the separation of item and individual, the Rasch analysis is independent of the tested sample's characteristics (Bond et al., 2020).

The outcomes of the present study showed that the Persian versions of EAI and EAI-Y both had unidimensional structure and good internal consistency when analyzed using both the CTT and Rasch techniques. The unidimensional structure was comparable to the proposed structure in the original English version (Terry et al., 2004) as well as other translated versions

in non-English countries such as Mexico (Salazar et al., 2021), Italy (Gori et al., 2021), Denmark (Lichtenstein et al., 2012), and Hungary (Mónok et al., 2012). Additionally, the invariance of items in the Persian version across gender and age is consistent with cross-cultural studies conducted in the United States, the United Kingdom, Spain, Denmark, and Hungary (Griffiths et al., 2015).

In addition, the Persian versions of the EAI and EAI-Y both had adequate reliabilities (internal consistency and separation reliability). Although item difficulty was varied (i.e., some items were easier or harder to respond to), invariance measurement indicated that irrespective of age and gender, all participants understood and responded to the items in the same pattern. The DIF analysis confirmed that each item assessed what it was intended to and not more or less. Furthermore, the results indicate that both the EAI and the EAI-Y are robust instruments that can discriminate individuals at risk of developing exercise addiction.

Given the rigorous psychometric testing of the Persian versions of the EAI and EAI-Y, they are robust and reliable scales for assessing exercise addiction among habitual exercisers. By identifying those at risk of developing exercise addiction, it is possible to help develop prevention and intervention programs. Additionally, the scales can be utilized as outcome measures in randomized controlled trials or as instruments for monitoring therapeutic progress in treatment.

4.1 Strengths, limitations and conclusion

The findings of the present study were enhanced by evaluating the psychometric features of two scales assessing exercise addiction using two distinct psychometric approaches among two independent Iranian samples, including CTT and Rasch analysis. CTT analysis simplifies the interpretation of data for healthcare practitioners (Chang et al., 2015). However, the advantages of Rasch analysis include the capacity to calculate reliability on an item-by-item and participant-by-participant basis, to eliminate reliability dependencies within the

sample, and to examine item measurement invariance (Chang et al., 2014) As a consequence, the findings of these two methodologies significantly corroborate the psychometric validity of the Persian versions of both the EAI and EAI-Y. However, the present study has some limitations. Both scales evaluated are self-report questionnaires. Therefore, methodological concerns about social desirability and recall biases may occur. Second, while various measures of reliability were investigated, test-retest reliability was not, leaving the temporal reliability of the findings to be determined in future research. Further, convenience sampling may led in an unrepresentative sample.

Overall, based on the findings of the present study, the Persian versions of the EAI and EAI-Y have satisfactory validity and reliability for use in Persian-speaking countries. Early detection of individuals at risk of developing exercise addiction are beneficial in order to provide preventive interventions.

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Table 1. Demographic features and additional data of the two samples

EAI sample (Mean 22.36, SD=3.06)			
Variable	Category	N	%
Gender	Female	451	60.53
	Male	294	39.46
	Total	745	100
Educational level	First High School	0	0

	Second High School	27	3.62
	Advanced Diploma	34	4.56
	Bachelor	495	66.44
	Master	143	19.19
	PhD	46	6.17

EAI-Y sample (Age mean =14.95, SD= 1.7)			
Variable	Category	N	%
Gender	Female	351	62.45
	Male	211	37.54
	Total	562	100
Educational level	First High School	362	64.41
	Second High School	198	35.23
	Advanced Diploma	2	0.35
	Bachelor	0	0
	Master	0	0
	PhD	0	0

Table 2. Psychometric properties of the Exercise Addiction Inventory at item level

Item #	Classical test theory analysis		Rasch analysis						
	Factor loading[a]	Item-total correlation	Infit MnSq	Outfit MnSq	Difficulty	Model SE	Item discrimination	DIF contrast across gender[bc]	DIF contrast across time on age[bd]
EAI1	0.640	0.506	0.80	0.87	-0.51	0.04	1.14	-0.25	-0.11
EAI2	0.406	0.315	1.35	1.31	1.32	0.05	0.77	0.30	0.25
EAI3	0.501	0.381	1.13	1.13	-1.07	0.05	0.79	0.03	0.03
EAI4	0.617	0.483	0.87	0.90	-0.25	0.04	1.13	-0.20	-0.11
EAI5	0.706	0.537	0.98	0.98	-0.01	0.04	1.11	0.00	0.03
EAI6	0.602	0.460	0.91	0.92	0.53	0.04	1.16	0.24	0.00

[a] Based on confirmatory factor analysis.
[b] DIF contrast > 0.5 indicates substantial DIF.
[c] DIF contrast across gender=Difficulty for females-Difficulty for males.
[d] DIF contrast across age= Difficulty for participants with younger age (i.e., < 22.36)-Difficulty for participants with older age (i.e., ≥ 22.36)
MnSq=mean square error; DIF=differential item functioning.

Table 3 Psychometric properties of the Exercise Addiction Inventory at scale level

Psychometric testing	Value	Suggested cutoff
Internal consistency (Cronbach's α)	0.714	>0.7
McDonald's omega	0.721	>0.7
Confirmatory factor analysis		
χ^2 (*df*)	11.530 (9)*	Nonsignificant
Comparative fit index	0.998	>0.9
Tucker-Lewis index	0.997	>0.9
Root-mean square error of approximation	0.019	<0.08
Standardized root mean square residual	0.026	<0.08
Item separation reliability from Rasch	1.00	>0.7
Item separation index from Rasch	18.81	>2
Person separation reliability from Rasch	0.72	>0.7
Person separation index from Rasch	2.52	>2

*p<0.001

Table 4. Measurement invariance across age and gender on Exercise Addiction Inventory through confirmatory factor analysis

Model and comparisons	Fit statistics							
	χ^2 (df)	$\Delta\chi^2$ (Δdf)	CFI	ΔCFI	SRMR	ΔSRMR	RMSEA	ΔRMSEA
Age[a]								
M1: Configural	65.578 (24)*		0.972		0.063		0.068	
M2: Plus all loadings constrained	51.195 (23)*		0.981		0.056		0.057	
M3: Plus all intercepts constrained	68.159 (40)*		0.981		0.056		0.044	
M2−M1		59.84 (8)*		-0.002		0.004		0.001
M3−M2		35.73 (8)*		-0.002		0.003		-0.002
Gender								
M1: Configural	46.280 (24)*		0.985		0.051		0.050	
M2: Plus all loadings constrained	46.269 (23)*		0.984		0.051		0.052	
M3: Plus all intercepts constrained[b]	92.643 (40)*		0.975		0.050		0.060	
M2−M1		497.66 (8)*		-0.032		0.027		0.035
M3−M2		134.29 (8)*		-0.009		0.009		0.005

*p<0.05

[a] Median weekly hours = 19 hours.

[b] Factor loadings of Items 4 and 9 were relaxed across two groups.

M1 = Model 1, a configural model; M2 = Model 2, a model based on M1 with all factor loadings constrained being equal across groups; M2P = Model 2 with partial invariance, a model based on M2 with some factor loadings relaxed across groups; M3 = Mode 3, a model based on M2 or M2P with all item intercepts constrained being equal across groups.

CFI = comparative fit index; SRMR = standardized root mean square residual; RMSEA = root mean square error of approximation

Table 5. Psychometric properties of the Exercise Addiction Inventory for youth (EAI-Y) at item level

Item #	Classical test theory analysis		Rasch analysis						
	Factor loading[a]	Item-total correlation	Infit MnSq	Outfit MnSq	Difficulty	Model SE	Item discrimination	DIF contrast across gender[bc]	DIF contrast across time on age[bd]
EAI-Y1	0.778	0.628	0.58	0.60	-0.71	0.05	1.46	-0.12	-0.28
EAI-Y2	0.597	0.441	1.18	1.14	0.78	0.05	0.85	-0.22	-0.15
EAI-Y3	0.410	0.327	1.13	1.21	-0.65	0.05	0.80	-0.21	0.46
EAI-Y4	0.548	0.424	1.05	1.06	-0.43	0.05	0.93	0.22	-0.11
EAI-Y5	0.672	0.526	0.95	0.95	0.32	0.05	1.11	0.25	0.13
EAI-Y6	0.489	0.388	1.06	1.03	0.69	0.05	0.89	0.03	-0.06

[a] Based on confirmatory factor analysis.
[b] DIF contrast > 0.5 indicates substantial DIF.
[c] DIF contrast across gender=Difficulty for females-Difficulty for males.
[d] DIF contrast across age= Difficulty for participants with younger age (i.e., <14, 95) - Difficulty for participants with older age (i.e., ≥14,95)
MnSq=mean square error; DIF=differential item functioning.

Table 6. Psychometric properties of the Exercise Addiction Inventory for youth (EAI-Y) at scale level

Psychometric testing	Value	Suggested cutoff
Internal consistency (Cronbach's α)	0.718	>0.7
McDonald's omega	0.723	>0.7
Confirmatory factor analysis		
χ^2 (*df*)	35.059 (9)*	Nonsignificant
Comparative fit index	0.978	>0.9
Tucker-Lewis index	0.963	>0.9
Root-mean square error of approximation	0.072	<0.08
Standardized root mean square residual	0.052	<0.08
Item separation reliability from Rasch	0.99	>0.7
Item separation index from Rasch	12.65	>2
Person separation reliability from Rasch	0.71	>0.7
Person separation index from Rasch	2.55	>2

*p<0.001

Table 7. Measurement invariance across age and gender on exercise addiction through confirmatory factor analysis

Model and comparisons	Fit statistics							
	χ^2 (df)	$\Delta\chi^2$ (Δdf)	CFI	ΔCFI	SRMR	ΔSRMR	RMSEA	ΔRMSEA
Age[a]								
M1: Configural	50.563 (24)*		0.977		0.062		0.063	
M2: Plus all loadings constrained	49.375 (23)*		0.978		0.060		0.064	
M3: Plus all intercepts constrained	81.783 (38)*		0.969		0.057		0.064	
M2−M1		1.188 (1)		0.001		-0.002		0.001
M3−M2		32.408 (15)*		-0.009		-0.003		0
Gender								
M1: Configural	50.426 (24)*		0.978		0.062		0.063	
M2: Plus all loadings constrained	41.795 (23)*		0.984		0.057		0.056	
M3: Plus all intercepts constrained[b]	70.092 (38)*		0.975		0.054		0.055	
M2−M1		8.631 (1)*		0.006		-0.005		-0.007
M3−M2		28.297 (15)*		-0.009		-0.003		-0.001

*p<0.05

[a] Median weekly hours = 19 hours.

[b] Factor loadings of Items 4 and 9 were relaxed across two groups.

M1 = Model 1, a configural model; M2 = Model 2, a model based on M1 with all factor loadings constrained being equal across groups; M2P = Model 2 with partial invariance, a model based on M2 with some factor loadings relaxed across groups; M3 = Mode 3, a model based on M2 or M2P with all item intercepts constrained being equal across groups.

CFI = comparative fit index; SRMR = standardized root mean square residual; RMSEA = root mean square error of approximation

Appendix 1: EAI-Persian Version

لطفا میزان موافقت یا مخالفت خود را با هر عبارت مشخص کنید.

پرسشنامه اعتیاد به ورزش-نسخه بزرگسالان	کاملا مخالفم	مخالفم	نه موافقم و نه مخالفم	موافقم	بسیار موافقم
1. ورزش مهمترین موضوع در زندگی من است.					
2. بخاطر مدت زمانی که صرف ورزش میکنم با پارتنر یا خانواده ام درگیرم.					
3. من از ورزش به عنوان راهی برای تغییر روحیه ام (مثلا برای ایجاد تنوع یا فرار از مشکلات و غیره) استفاده میکنم.					
4. به تدریج مدت زمان ورزش روزانه ام را افزایش داده ام.					
5. وقتی مجبورم یک جلسه از تمرین ورزشی ام را از دست بدهم بدخلق و کلافه می شوم.					
6. هرچقدر سعی میکنم مدت زمان ورزشم را کاهش دهم، خود به خود به وضعیت قبل برمیگردد.					

Appendix 2: EAI-Youth Persian Version

لطفا میزان موافقت یا مخالفت خود را با هر عبارت مشخص کنید.

پرسشنامه اعتیاد به ورزش-نسخه نوجوانان	کاملا مخالفم	مخالفم	نه موافقم و نه مخالفم	موافقم	بسیار موافقم
1. ورزش مهمترین موضوع در زندگی من است.					
2. بخاطر مدت زمانی که صرف ورزش میکنم با خانواده یا دوستانم درگیرم.					
3. من از ورزش برای تغییر روحیه ام (مثلا برای شادتر شدن یا فراموش کردن مشکلات) استفاده میکنم.					
4. در طول سال گذشته، مدت زمان ورزش روزانه ام را افزایش داده ام.					
5. وقتی مجبورم یک روز ورزش نکنم، بی قرار، ناراحت یا غمگین میشوم.					
6. من سعی کرده ام مدت زمان ورزشم را کاهش دهم، اما خود به خود به وضعیت قبل برمیگردد.					