International Journal of Mental Health and Addiction
https://doi.org/10.1007/s11469-022-00936-5

ORIGINAL ARTICLE

Measurement Invariance of the Exercise Addiction Inventory According to Eating Disorder Risk Status

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Accepted: 5 October 2022

Abstract
The comparison of self-reported levels of risk of exercise addiction between individuals at-risk and not-at-risk of thinness-related eating disorders (EDs) has been an increasing topic of research. However, among these two population groups, there is a lack of evidence to support the invariant nature of the Exercise Addiction Inventory (EAI), one of the most utilized self-report instruments that assesses the risk of exercise addiction. The main aim of the present study was to provide evidence concerning the invariant nature of the EAI scores in terms of thinness-related EDs' risk status. Data from 1187 Spanish undergraduate regular exercisers aged from 18 to 30 years ($M_{age}=20.92$, $SD_{age}=2.48$) were analyzed employing multigroup confirmatory factor analysis (CFA) techniques. Results provided evidence of configural, metric, partial scalar (intercept of Item 1 freed up), and strict invariance of the EAI scores according to EDs' risk status. Findings of the present study support the employment of the EAI for the purpose of conducting reasonably unbiased comparisons in self-reported levels of exercise addiction between individuals at risk and not at risk for EDs.

Keywords Psychometrics · Behavioral addictions · Morbid exercise · Exercise dependence · Problematic exercise

There is much evidence supporting the health benefits of regular exercise (Thompson et al., 2020). However, there is also evidence to suggest that such activity can become addictive to a small minority (Juwono & Szabo, 2021). This mainly involves the loss of control over exercise, which can lead to a wide range of negative consequences for the individual (Downs et al., 2019; Szabo et al., 2018). Such consequences might be either physical (e.g., suffering from overuse injuries or persisting in exercise even in the presence of such injuries), psychological (e.g., experiencing withdrawal symptoms when unable to exercise) or social (e.g., the occurrence of relationship conflicts with others as a result of excessive exercise habits) (Lichtenstein & Jensen, 2016; Sicilia et al., 2022).

Despite the serious health consequences that may result from engaging in addictive patterns of exercise, the phenomenon has not been officially recognized as a psychiatric disorder in diagnostic manuals by international organizations (e.g., American Psychiatric Association, 2013; World Health Organization, 2019). One of the likely reasons for this lack of recognition is the controversy surrounding the precise nature of exercise addiction (Szabo et al., 2018). An example of this controversy is the ongoing discussion on (i) whether to consider this phenomenon as a specific nosological entity or, alternatively, as one compensatory behavior aimed at weight control and mood management in the context of thinness-related eating disorders (EDs) such as bulimia nervosa and the restricting subtype of anorexia nervosa (American Psychiatric Association, 2013; Godoy-Izquierdo et al., 2021; Starcevic & Khazaal, 2017); and (ii) the appropriateness of distinguishing between the secondary and primary nature of exercise addiction depending on whether it is respectively coupled or not with one of the aforementioned EDs (Szabo et al., 2018).

One issue that has attracted considerable research interest within the context of the aforementioned controversy is the degree of association between self-reported risk levels of exercise addiction and EDs, which according to the results of recent meta-analytical research has proved to be weak- to-moderately sized (Alcaraz-Ibáñez et al., 2020; Trott et al., 2021). Preliminary evidence has also been provided within this context that both the etiology and the potential outcomes of exercise addiction might differ between individuals at-risk and not-at-risk for EDs (Trott, Johnstone, et al., 2020; Trott, Yang, et al., 2020). However, the accuracy and validity of the evidence the present paper refers to may be called into question due to a major methodological limitation. Namely, there is a lack of evidence concerning the measurement invariance of the scores from one of the most frequently used instruments (Alcaraz-Ibáñez, Paterna, Sicilia, et al., 2022) to assess self-reported risk levels of exercise addiction (i.e., the Exercise Addiction Inventory, EAI; Terry et al., 2004). More specifically, it is unknown whether the scale's items are interpreted similarly (so that the resulting scores are therefore comparable) by individuals with different risk status (i.e., being at-risk or not at-risk) in terms of EDs. This issue is particularly relevant given that the lack of such evidence does not allow ruling out the possibility that conclusions derived from using the EAI scores in these two population groups (e.g., in comparing both these scores and their relationship with other variables across groups according to EDs risk status) could be significantly biased (van de Schoot et al., 2012).

At present, there is evidence to support the invariant nature of the EAI according to gender (Sicilia et al., 2013, 2017) as well as several linguistic and cultural contexts (Griffiths et al., 2015). However, there is no such evidence in the literature as regards a variable frequently studied in conjunction with the EAI such as EDs risk status (Alcaraz-Ibáñez et al., 2020; Trott et al., 2021; Trott, Johnstone, et al., 2020; Trott, Yang, et al., 2020). Providing evidence that is supportive (or unsupportive) of the invariant character of EAI scores according to the level of

EDs risk status would allow recommendations concerning the appropriateness (or inappropriateness) of using the EAI to make reasonably unbiased comparisons between the two population groups (i.e., individuals with or without risk of EDs).

Therefore, the main aim of the present study was to obtain evidence concerning the invariant nature of the EAI scores in terms of EDs risk status. In the event that evidence was obtained to support such a measurement property, a secondary aim of the present study was to quantify differences in self-reported continuous scores of the EAI between individuals at-risk and not-at-risk for EDs. The lack of clinical validation for the cut-off points to be used in case of adopting a categorical approach for expressing the EAI scores (i.e., being or not being at high-risk) led to the expressing of these scores on a continuous basis (i.e., the higher the score, the higher the risk level) (Alcaraz-Ibáñez et al., 2020; Alcaraz-Ibáñez, Paterna, Griffiths, et al., 2022). Based on the results of previous meta-analytic research (Alcaraz-Ibáñez et al., 2020) it was hypothesized that the differences of interest would likely be small in magnitude.

Method

Participants

A total of 1,302 undergraduate students aged from 18 to 30 years enrolled in a public university located in Southern Spain were invited to participate in the study. The following inclusion criteria were applied: (i) being considered as physically active, which was judged on the basis of exercising at least once a week on a regular basis (Piercy et al., 2018); and (ii) providing informed consent to participate in the research. Adopting these criteria led to the exclusion of 115 individuals from the final analyzed sample. Participants reported as being engaged in endurance-oriented sports or exercise modalities such as running or cycling (25.7%), non-endurance-oriented team sports such as basketball (20.1%) or individual sports such as tennis (8.4%), fitness and health-oriented modalities such as yoga (10.8%), strength-oriented modalities such as cross-fit (10.4%), or multiple modalities (24.6%). The remaining characteristics of the participants whose data were analyzed (N = 1,187; 48.3% females) are presented in Table 1 (segmented according to the EDs risk status).

Instruments

Exercise Addiction

The Spanish version (Sicilia et al., 2013) of the Exercise Addiction Inventory (EAI; Terry et al., 2004) was used to assess the risk of exercise addiction. The items included in this unidimensional instrument cover the six following criteria proposed as inherent to behavioral addictions: *salience* (i.e., exercise becomes the most important behavior carried out by the individual, to the point of dominating their thinking, feelings, and behavior), *conflict* (i.e., conflict between the individual and those around them, other activities, or within the individual itself due to exercise), *mood modification* (e.g., engaging in exercise as a coping strategy to escape from distressing thoughts or feelings), *tolerance* (the process whereby increasing amounts of exercise are needed for the purpose of achieving the former mood modifying effects), *withdrawal* (i.e., experiencing unpleasant feelings and/or physical effects as a result of discontinuing or a sudden reduction in exercise), and *relapse* (the tendency for repeated reversions to earlier patterns of exercise after a period of abstinence or control) (Griffiths, 1996; Terry et al., 2004). Each item (e.g., *"If I have to miss an exercise session, I feel moody and irritable"*) is answered using a Likert scale ranging from 1 (*Strongly Disagree*) to 5 (*Strongly Agree*). Higher scores on the EAI suggest higher levels of risk of exercise addiction. In the present study, composite reliability ($\rho = .76$) and internal consistency ($\alpha = .76$) were good for the whole study sample.

Eating Disorders Risk Status

The Spanish version (Garcia-Campayo et al., 2005) of the SCOFF (Sick, Control, One, Fat, Food) Questionnaire (Morgan et al., 1999) was used to assess EDs risk status. The instrument includes five dichotomous items (e.g., *"Would you say that food dominates your life?"*) reflecting some of the main components involved in anorexia and bulimia nervosa. Two or more positive responses suggest that the individual may be at-risk of developing an ED (Morgan et al., 1999). This instrument has previously been used to identify individuals at-risk for EDs in the Spanish context (Alcaraz-Ibáñez et al., 2019; Alcaraz-Ibáñez & Sicilia, 2020). Sensitivity and specificity values of 80% and 93% have been respectively observed for the SCOFF in studies conducted in the Spanish context (e.g., Botella et al., 2013).

Sociodemographic Variables

Participants were asked to report their age, gender, typical weekly frequency of exercise, height, and weight. The values provided for height and weight were used to obtain the body mass index (BMI) according to the formula BMI = Weight in kg/(height in meters)^2.

Procedure

First, approval was obtained from the authors' university ethics committee. Individuals were then personally invited to participate in the study at the opening of a teaching session. The research was presented to potential participants as a study examining the exercise habits of students. After being informed of (i) the voluntary and anonymous nature of their participation in the study and (ii) their right to leave the study at any time, those individuals who met the inclusion criteria provided their informed consent to participate. Upon completion of the 'paper-and-pencil' survey (that took place in collective classroom settings and lasted approximately five minutes), participants were thanked for their cooperation and then informed about the precise nature of the study. Participants were not rewarded for their participation in the study (either financially or in the form of academic credits).

Statistical Analyses

Examination of the measurement invariance of EAI scores according to EDs risk status was carried out according to the procedure described in detail elsewhere (Milfont & Fischer, 2010). This involved conducting confirmatory factor analyses (CFAs) in which the following four progressively constrained multigroup models were tested: Model 1 (configural invariance), which examined the equivalence of the factor structure based on the simultaneous free estimation of the parameters in the different subgroups of interest; Model 2 (metric invariance), which additionally examined the equivalence of the factor loadings (i.e., the level of correlation between each item and the underlying global factor); Model 3 (scalar invariance), in which the equivalence of the intercepts (i.e., the starting points of the measurement scale for each item) were additionally examined; and Model 4 (strict invariance), in which the equivalence of the error terms (i.e., the error variance of each item) was additionally examined. In the absence of evidence supporting full invariance, the existence of partial invariance was examined by sequentially freeing specific constrained parameters according to the values of the modification indices (MIs). The goodness-of-fit of the models under examination were judged using the following combination of indices: chi-square ratio to degrees of freedom (χ^2/df), Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). CFI values above or slightly below .95, and RMSEA and SRMR values below or slightly above .06 and .08, respectively, were deemed satisfactory (Hair et al., 2010). Decreases of more than .010 in the incremental values of CFI (Δ) arising from the comparison of successive constrained models were considered as indicative of lack of invariance (Cheung & Rensvold, 2002). All CFAs were conducted in *IBM Amos 22* (Arbuckle, 2013).

In the presence of evidence supporting the invariant nature of scores from the EAI according to EDs risk status, differences in the self-reported levels of exercise addiction between the two population groups of interest (i.e., at-risk or not-at-risk of EDs) were computed. This difference was expressed in terms of its effect size (Cohen's *d*; Cohen, 1988), which was accompanied by its 95% confidence interval (CI). This value was calculated using the pooled standard deviation, which was obtained by weighting the specific sample size of the two groups involved in the comparison (Hedges & Olkin, 1985). The effect sizes of interest were interpreted as trivial (*d* = 0.00 to 0.10; *r* = .00 to .10), small (*d* = 0.10 to 0.40; *r* = .10 to .30), moderate (*d* = 0.40 to 0.70; *r* = .30 to .50), and large (*d* > 0.70; *r* > .50).

Results

The goodness-of-fit indices of the different models are shown in Table 2. The values of the specific parameters segmented by EDs risk status are shown in Table 3. Acceptable goodness-of-fit indices were observed for the two population groups of interest established according to EDs risk status, as well as for the baseline Model 1 (configural invariance). In particular, factor loadings ranging from .46 (Item 2, *conflict* component) to .70 (Item 5, *withdrawal* component) were obtained for the group of individuals at-risk for EDs. These values ranged from .47 (Item 2, *conflict* component) to .70 (Item 5, *withdrawal* component) for the group of individuals not-at-risk for EDs. Composite reliability and internal consistency values were respectively $\rho = .78$ and $\alpha = .78$ in the group of individuals at-risk for EDs and .76 and .75 in the group of individuals not-at-risk for ED. No significant differences were observed between the goodness-of-fit indices of Model 1 (configural invariance) and Model 2 (metric invariance). Significant differences (ΔCFI = .014) were observed between the goodness-of-fit indices of Model 2 (metric invariance) and Model 3 (scalar invariance), which suggested that there may be non-invariant intercepts across groups. Further inspection of M. I. pointed to the intercept of Item 1 (*salience* component; MI = 7.81) as the most likely cause of the lack of equivalence. Once the equality constraint on the intercept for Item 1 was freed, no significant differences were observed between the goodness-of-fit indices of Model 2 (metric invariance) and Model 3 (scalar invariance). Additionally, no significant differences were observed between the goodness-of-fit indices of Model 3 (scalar invariance) and Model 4 (strict invariance). Finally, the result of the analysis of differences in exercise addiction scores (see Table 1) showed differences of small magnitude favoring the group of individuals at-risk for EDs. Given the marked differences in BMI values between groups (see Table 1), a univariate analysis of covariance (ANCOVA) was conducted in order to examine if BMI was a potential confounding variable in the context of examining differences in EAI scores according to EDs risk status. The results of this analysis suggested that between-group differences in EAI scores were not dependent on BMI ($F = 0.334$, $p = .563$, $\eta^2 = .000$).

Discussion

The main objective of the present was to examine evidence concerning the invariant nature of EAI scores (Terry et al., 2004) according to individual's risk status in terms of EDs. The findings support the invariance of the scores under consideration between the groups of interest, which makes it possible to recommend the use of the EAI in order to compare the levels of the risk of exercise addiction between individuals at-risk and not-at-risk for EDs.

The first noteworthy finding of the present study concerned the fact that the magnitude of the factor loadings of the items in the EAI were found to be similar in the two population groups under consideration. This suggests that the items included in the EAI are similarly contributing to representing the underlying latent construct in the instrument, which would support its use in both population groups (Sass, 2011). However, the emerging evidence suggests the possibly non-invariant nature of the intercept of Item 1 (the *salience* of exercise), which suggests that the starting point of its measurement scale may not be equivalent between the two groups of interest (Milfont & Fischer, 2010). A common explanation for this type of finding is the existence of a social desirability effect (i.e., the tendency to assign higher scores to items whose content might be particularly desirable from a social point of view) (Sass, 2011). This possibility is particularly likely in the present case in view of evidence suggesting that, among individuals who are not at risk of developing an ED, placing undue emphasis on exercise is seen as a socially accepted practice (Lichtenstein et al., 2017). In the light of these results, it seems pertinent to suggest that future studies aimed either at refining the EAI or proposing others instruments covering the exercise salience component should examine the eventual presence of response biases depending on social desirability (Kyriazos & Stalikas, 2018).

A second noteworthy finding of the present study concerned the differences favoring the group of participants at-risk for EDs in exercise addiction levels. Here, it is worth noting that the magnitude of such differences reported (i.e., d = 0.22; r = .11) is consistent with that reported in previous meta-analysis study (i.e., d = 0.30; r = .15) (Alcaraz-Ibáñez et al., 2020). These findings suggest that addictive exercise patterns tend to be more prevalent among individuals at-risk of developing an ED. This may due to the potential of exercise as a means of controlling body weight (Wright et al., 2006). More specifically, since perceiving that exercising may contribute to achieving a goal present in the context of EDs (e.g., managing body weight) may trigger the mechanisms operating in the maintenance of addictive patterns of exercise behavior (Szabo et al., 2018). Two kinds of reinforcement are relevant here. Firstly, those of a positive nature linked to obtaining a reward (e.g., the one derived from perceiving that exercising contributes to the goal of controlling body weight). Secondly, those of a negative nature linked to the avoidance of an undesirable consequence (e.g., gaining weight as a result of not being able to exercise) (Alcaraz-Ibáñez et al., 2021).

Limitations

Three main limitations of the present study should be noted. First, the present study tested only one (i.e., Spanish version) of the many available translations of the EAI (Persian; Akbari et al., 2022; Italian; Gori et al., 2022; Cantonese Chinese; Li et al., 2016; Danish; Lichtenstein et al., 2014; Hungarian; Mónok et al., 2012; Brazilian Portuguese; Sicilia et al., 2017). This is an important limitation because variations in the psychometric properties of a given instrument according to the socio-demographic characteristics of the respondents might differ across its translated versions (Sicilia et al., 2020). Future studies are therefore needed to examine whether the results presented here are replicable across the wide range of linguistic versions of the EAI. Secondly, a self-report screening tool (rather than a clinical interview) was used for the purpose of identifying participants at-risk for EDs (Garcia-Campayo et al., 2005; Morgan et al., 1999). Therefore, the present study was unable to establish the clinical nature of this sub-sample and could not overcome possible response biases (such as the aforementioned social desirability). This limitation is relevant because individuals with a clinical diagnosis of EDs have been found to be particularly prone to showing maladaptive patterns of exercise (Alcaraz-Ibáñez et al., 2020). In view of this limitation, further research is needed that includes participants with a clinical diagnosis of EDs as well as using other methodologies to collect data. Thirdly, the sample exclusively comprised emerging adults, which prevents the generalizing the results to other populations. Future studies should therefore provide evidence on the invariant nature of scores from the EAI by considering other relevant populations in terms of their high prevalence rates of EDs (e.g., adolescents; Von Soest & Wichstrøm, 2014).

Conclusion

The findings of the present study support the employment of the EAI for the purpose of conducting reasonably unbiased comparisons in self-reported levels of exercise addiction between individuals at-risk and not-at-risk for EDs. The findings also suggest that individuals at-risk for EDs are slightly more susceptible than those not-at-risk for EDs to report increased levels of exercise addiction. Consequently, this population should be a priority target for prevention efforts aimed at promoting healthy exercise habits. Further research should be conducted in order to corroborate the findings presented here by considering populations of special interest (e.g., adolescents) and the different translations of the EAI.

Ethical approval

Approval was obtained from the ethics committee of University of (omitted). The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

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Table 1

Participants' characteristics and analysis of differences

Variables	Risk of eating disorders				Differences	
	Not-at-risk (n = 957)		At-risk (n = 230)		d_{Cohen} (95% CI)	$r_{Pearson}$ (95% CI)
	M	*SD*	*M*	*SD*		
Age	20.94	2.49	20.85	2.45	-0.04 (-0.18 to 0.11)	-.02 (-.09 to .05)
Body mass index	22.31	2.58	24.29	3.29	0.73 (0.58 to 0.87)	.35 (.28 to .40)
Weekly exercise frequency	4.11	1.57	3.91	1.54	-0.13 (-0.27 to 0.02)	-.06 (-.13 to -.01)
Exercise addiction	15.43	4.71	16.49	4.97	0.22 (0.08 to 0.37)	.11 (.04 to .18)

Note. CI = Confidence interval.

Table 2

Goodness-of-fit indexes for tested invariance models across risk of eating disorders

Model/Group	χ^2	*df*	χ^2/df	Comparison models	CFI	ΔCFI	RMSEA (90% CI)	SRMR
Not at-risk of EDs (*n* = 957)	69.77	9	6.75	-	.954		.078 (.060 to .097)	.036
At-risk of EDs (*n* = 230)	10.29	9	1.14	-	.996		.025 (.000 to .081)	.029
M1: Configural invariance	71.04	18	3.95	-	.963		.050 (.038 to .062)	.037
M2: Metric invariance	75.74	23	3.29	M2 vs. M1	.963	.000	.044 (.033 to .055)	.037
M3: Scalar invariance	102.40	29	3.53	M3 vs. M2	.949	.014	.046 (.037 to .056)	.037
M3P: Partial scalar invariance	92.62	28	3.31	M3P vs. M2	.955	.008	.044 (.034 to .054)	.036
M4: Strict invariance	98.92	34	2.91	M4 vs. M3P	.954	.001	.400 (.031 to .049)	.036

Note. CFI = Comparative Fit Index, TLI = Tucker-Lewis Index, RMSEA = Root Mean Square Error of Approximation, CI = Confidence interval, *df* = degrees of freedom, EDs = Eating Disorders, M1 = Baseline model, M2 = Invariant factor loadings, M3 = Invariant factor loadings + invariant items' intercepts, M3P = Invariant factor loadings + partially invariant items' intercepts (intercept of Item 1 freed), M4 = Invariant factor loadings + partially invariant items' intercepts (intercept of Item 1 freed) + invariant error terms.

Table 3

Means, standard deviations, factor loadings, and error terms of EAI items across risk of eating disorders

Item	Possible range	Risk of eating disorders									
		Not-at-risk (n = 957)					At-risk (n = 230)				
		M	*SD*	λ	ν	ε	*M*	*SD*	λ	ν	ε
1	1-5	2.67	1.11	.62	2.67	.61	2.60	1.12	.57	2.60	.67
2	1-5	1.67	1.04	.45	1.67	.80	1.85	1.17	.54	1.85	.71
3	1-5	3.12	1.21	.61	3.12	.63	3.29	1.22	.62	3.29	.62
4	1-5	3.09	1.23	.62	3.09	.62	3.27	1.20	.67	3.27	.55
5	1-5	2.12	1.15	.69	2.12	.52	2.36	1.26	.72	2.36	.47
6	1-5	2.76	1.29	.51	2.76	.74	3.11	1.27	.52	3.11	.73

Note. λ = Factor loadings, ν = Intercepts, ε = error terms (residual variances).