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Psychometric properties of the Expanded Exercise Addiction Inventory 3 (EAI-3) in a Danish sample

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Abstract
The risk of exercise addiction, characterized by an uncontrollable urge to engage in physical activity, poses significant health risks yet lacks clinical diagnostic criteria. The need for its assessment is increasing in research and applied settings. The present study evaluated the psychometric properties and reliability of the Expanded Exercise Addiction Inventory (EAI-3) within a Danish population. The present study involved 392 Danish adults who were all regular exercisers. Participants completed the EAI-3, the Exercise Dependence Scale-Revised (EDS-R), the SCOFF Questionnaire for eating disorders, the Obsessive–Compulsive Inventory-Revised (OCI-R), and the Ten-Item Personality Inventory (TIPI). Confirmatory factor analysis (CFA) and measurement invariance testing were performed to assess the factor structure and reliability of the EAI-3 across biological sex. The results indicated strong reliability and validity for the EAI-3, with good fit indices across models (CFI = .981, RMSEA = .054). The scale scores demonstrated configural, metric, and scalar invariance, indicating consistent performance across male and female exercisers. Reliability analyses yielded high internal consistency (α = .85, ω = .88), and ROC analysis established a cut-off score of 33.5 for potential exercise addiction risk, with high specificity (.856) and sensitivity (.889). Similar good results emerged from the bifactor model, but the original structure was still preferable. The present study supports the EAI-3 as a valid and reliable tool for screening the risk of exercise addiction among Danish adults, facilitating early identification and potential intervention. Further research should focus on longitudinal studies and clinical validations to enhance the understanding and management of exercise addiction.

Keywords Behavioral addiction · Compulsive exercise · Exercise addiction · Exercise Addiction Inventory · Exercise dependence · Psychometric evaluation

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Introduction

Regular physical activity should be part of a contemporary healthy lifestyle (Bull et al., 2020). However, planned exercise training can be abused to the point of self-harm (Szabo & Demetrovics, 2022). This behavior, known as exercise addiction, is studied within the field of behavioral addictions. Exercise addiction is characterized by a loss of control over exercise (Szabo, 2010). It may surface through therapeutic and mastery pathways (Dinardi et al., 2021). The therapeutic path is linked to escape behavior or coping with stress and trauma. In contrast, mastery involves ignoring one's physical limits, pushing training to the point of pain, injury, and reinjury, or even ending an individual's sports career (Dinardi et al., 2021).

Loneliness and social isolation are well-known risk factors for both mental and physical health throughout life, with stronger effects among aging individuals, including associations with cardiovascular disease, immune system problems, mental disorders, and more healthcare visits (Tragantzopoulou & Giannouli, 2021). Because individuals are fundamentally social, disruptions in social bonds may lead to behaviors aimed at finding meaning, connection, and a sense of ongoing self. In this light, physical exercise can serve not only as a health-related activity but also as a means of connecting with others, such that even intense exercise may be experienced as socially and existentially meaningful rather than primarily performance-oriented.

In the present paper, exercise addiction is framed using the components model of addictions (Griffiths, 2005), which posits six core features shared by behavioral and substance addictions: salience (exercise dominates thoughts and behavior), mood modification (exercise is used to regulate affect), tolerance (progressive increase in exercise volume/intensity), withdrawal (negative affect when prevented from exercising), conflict (intrapersonal/interpersonal impairments in daily functioning due to exercise), and relapse (reinstatement of exercise after attempts to cut down). Moreover, several clinical models of exercise addiction have been proposed (e.g., Dinardi et al., 2021), and numerous empirical studies have been published in this area.

However, diagnosed cases of exercise addiction are almost nonexistent due to the lack of clinical diagnostic criteria. The disorder was not included in the latest (fifth) edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5; American Psychiatric Association, 2013). This omission is mainly due to the lack of high-quality research (e.g., large-scale epidemiological studies using representative samples, lack of neurobiological studies), and lack of clinical data, as well as related factors such as inconsistent clinical cases, seen mainly by medical doctors (Juwono & Szabo, 2020) rather than clinical psychologists or psychiatrists who are experts in behavioral addiction. Additionally, most research assesses only a level of 'risk' of exercise addiction using psychometric scales, which may not translate into clinical morbidity (Szabo & Demetrovics, 2022).

Psychometric scales can be helpful in preliminary screening of the risk of exercise addiction. High-scoring individuals can be followed by clinicians to detect whether there is an issue regarding psychopathology. Szabo and Demetrovics (2022) proposed a collaboration model (the pyramid model) between researchers and clinicians to collect clinical evidence for including exercise addiction in medical/psychiatric reference manuals. A practical starting point for this model concerns the assessment of this construct. The first version of the Exercise Addiction Inventory (EAI) was developed in 2004 and has been used across countries and in different sport settings (Szabo, 2021; Szabo et al., 2019; Terry et al., 2004). The EAI is a brief, quick-to-administer screening tool for the risk of exercise addiction. The original English EAI (Terry et al., 2004) has been translated and validated in several languages, including Hungarian, Spanish, Danish, Polish, Brazilian Portuguese, Italian, Turkish, Mexican, and Persian (Aydın et al., 2023). The revised version, EAI-R (Szabo et al., 2019), used a six-point Likert scale rather than the original five-point scale, thereby eliminating the neutral point, which was thought to artificially inflate the total score. The EAI-R has been translated and validated in Hungarian (Szabo, 2021), Chinese (Wang et al., 2024), and Italian (Soraci et al., 2023). It can be administered by various health practitioners, such as orthopedists and other experts who encounter numerous exercise-related injuries, due to its straightforward nature. If a patient scores above the cut-off point on the EAI, they should probably be referred to health professionals to rule out psychiatric problems. The construct of exercise addiction can be different among populations in terms of the clinical manifestation of the symptoms or prevalence.

In Denmark (where the present study was carried out), exercise addiction has been investigated in different sports and exercise samples for over a decade using the EAI. Among Danish adults, the prevalence was 5.8% in a mixed sample of fitness attendees and football players (Lichtenstein et al., 2012), 7.1% among male football players, 9.7% among male fitness exercisers (Lichtenstein et al., 2014), 5.0% among CrossFit enthusiasts (Lichtenstein & Jensen, 2016), and 7.6% among elite athletes from different sports (Lichtenstein et al., 2021). Among Danish adolescents, the prevalence was 4.0% among school athletes and 8.7% among fitness attendees (Lichtenstein et al., 2018).

The Danish prevalence studies examining the psychometric properties of EAI scores found that the index scores for internal consistency and validity were satisfactory and supported the international literature, which indicates that the EAI is a valuable screening instrument across different

exercise populations. Because the EAI was developed based on six generic components of addiction, it has been noted that the EAI does not assess some specific symptoms of exercise addiction, such as guilt when missing a planned session and training despite injury (Lichtenstein & Jensen, 2016). Granziol et al. (2024) addressed this by expanding the EAI to include these two symptoms, creating the third version of the Exercise Addiction Inventory (EAI-3).

EAI-3 scores showed good psychometric properties and identified a cut-off score of 34 (out of 48), above which a person might be at risk of exercise addiction. An evaluation of the psychometric properties of the EAI-3 among Danish adults has not been conducted previously. Therefore, the present study tested the eight-item EAI-3 structure among adult Danish exercisers. In particular, the study tested whether the EAI-3 performs consistently independently of the biological sex of the individual through measurement invariance analyses. The study also investigated the association between exercise addiction and eating disorder symptoms, obsessive–compulsive symptoms, and personality traits.

Methods

Participants

Individuals practicing sport or engaged in physical activity consistent with the WHO 2020 guidelines (i.e., ≥150 min/week of moderate-intensity aerobic activity, or ≥75 min/week of vigorous-intensity activity, or an equivalent combination) were enrolled. Participants were recruited through online social networking platforms, including *X* (formerly *Twitter*), *Facebook,* and *Instagram*. Recruitment advertisements were posted in public and private groups dedicated to sports-related and physical activities, including different levels of athletic involvement and competitiveness. The advertisements briefly described the study and included a link to the online survey. In line with a snowball sampling strategy (Goodman, 1961), participants who agreed to take part in the study were encouraged to share the participation link with other like-minded individuals.

For screening purposes, activity on ≥3 days per week and ≥6 months of regular participation were added as inclusion criteria. These frequencies and maintenance thresholds are not part of the WHO definition but were used to operationalize regular exercisers in the sample. In relation to exclusion criteria, participants were excluded if they (i) were younger than 18 years; (ii) exercised fewer than three times per week; (iii) accumulated <150 min of exercise per week; (iv) had engaged in regular exercise for <6 months; and/or (v) provided incomplete responses on either of the two exercise addiction/dependence scales. Individuals were also excluded if they completed the entire survey in less than six minutes, because the authors, following a pilot study, took the view that completing the survey so quickly was indicative of not giving all of the questions due consideration.

The initially recruited sample comprised 425 individuals. However, 12 participants exercised less than three times per week or, overall, less than 150 min per week; one participant regularly exercised for less than six months; 16 participants did not report full answers to the problematic exercise measures; and seven participants completed the entire survey in less than six minutes. Therefore, after applying the aforementioned exclusion criteria, the final sample comprised 392 participants (49.75% female; mean age = 38.9 years; SD = ± 12.55; range = 18–76 years). Descriptive statistics of demographic variables and exercise-related characteristics are reported in Table 1.

Measures

Expanded Exercise Addiction Inventory, Third Version (EAI-3)

The new version of the EAI/EAI-R (Szabo et al., 2019; Terry et al., 2004) validated by Granziol et al. (2024) was used to assess the risk of exercise addiction. Each of the eight items in the EAI-3 is scored on a six-point Likert scale, from 1 (*strongly disagree*) to 6 (*strongly agree*), like the EAI-R (Szabo et al., 2019). The EAI-3 has two subscales: 'healthy relevance' (HR; assessing aspects related to the passion and healthy relevance of exercise) and 'addiction tendency' (AT; assessing pathological aspects of exercise). Consequently, three scores can be obtained by summing specific sets of items: a total score, HR score (summing Items 1, 3, 4, and 6), and AT score (summing Items 2, 5, 7, and 8) (see Granziol et al., 2024). The lowest score that can be obtained from the total scale is 8 (or 4 for each subscale), and the highest

Table 1 Descriptive statistics of the participants (N = 392)

Variable	n (%)/M (SD)
Age (in years)	38.9 (12.6)
Female	195 (49.7%)
Male	197 (50.3%)
Exercise purpose	
Health/mental benefits	290 (74.0%)
Skill/mastery	84 (21.4%)
Social reasons	18 (4.6%)
Type of sport	
Aerobic	98 (25.0%)
Anaerobic	71 (18.1%)
Both	223 (56.9%)
Format of sport	
Individual	267 (68.1%)
Team	37 (9.4%)
Both	88 (22.5%)

score is 48 (or 24 for each subscale). A higher score indicates a greater risk of EA symptomatology.

The original EAI, comprising six items, was two-way translated and validated in Danish in 2012 (Lichtenstein et al., 2012). The additional two items were translated into Danish by a native Danish speaker with English proficiency. Subsequently, each item was back-translated from Danish to English (by a different person) using the same level of language skills and approved by the research group (Granziol et al., 2024). Both the English and Danish versions of the items are available in the Appendix.

Exercise Dependence Scale-Revised (EDS-R)

The 21-item EDS-R (Hausenblas & Symons Downs, 2002) comprises seven subdimensions (withdrawal effects, continuity, tolerance, lack of control, reduction in other activities, time, and intentions effects), each of which consists of three items. Items are evaluated on a six-point Likert scale from 1 (*never*) to 6 (*always*). The lowest score that can be obtained from the scale is 21, while the highest score is 126. The scores of all items are added together to determine the overall score for each dimension. A higher score indicates a greater risk of exercise dependence. For each subdimension, an individual is classified as being at-risk if the score is higher than 14, is non-dependent but symptomatic if it is between 7 and 14 and is not dependent but non-symptomatic if it is lower than 7. According to the EDS-R manual (Hausenblas and Symons Downs, 2002), to create an exercise-dependent profile, it is necessary to evaluate the 'risk' score of at least three subdimensions of the scale. If an independent asymptomatic score is obtained from at least four subdimensions, the individual is classified as independent asymptomatic. In all other cases, the individual has a non-dependent profile without symptomatic characteristics. Because numerous studies have demonstrated the stability of this scale in assessing problematic exercise, it was used as a 'gold standard' to test the validity of the EAI-3 criteria (Di Lodovico et al., 2019). Additionally, it should be noted that EAI and EDS are the two scales most frequently used internationally to assess problematic exercise (Szabo & Demetrovics, 2022). Because the EDS-R has not been validated in a Danish population, it was translated and back-translated following the aforementioned procedure.

SCOFF Questionnaire

The SCOFF Questionnaire (Morgan et al., 1999; Danish version: Lichtenstein et al., 2021) is a five-item screening instrument developed to detect anorexia and bulimia (e.g., *"Would you say that food dominates your life?"*). The SCOFF's total scores range from 0 to 5, which are obtained by summing the scores of each item (1 = "yes" and 0 = "no"). A score of 2 or more indicates the risk of eating disorders. According to Hill et al. (2010), the SCOFF shows good sensitivity and specificity when used among individuals with clinically confirmed food disorders.

Obsessive–Compulsive Inventory Revised (OCI-R)

The 18-item revised version of the Obsessive–Compulsive Inventory (Abramowitz & Deacon, 2006) assesses an individual's inclination toward obsessions and compulsive actions. OCI-R assesses six facets of obsessive–compulsive symptoms: washing, obsessing, hoarding, ordering, checking, and mental neutralizing. Each item is rated on a five-point scale, ranging from 0 (*not present*) to 4 (*extremely severe*), with total scores ranging from 0 to 70. Higher scores indicate the overall severity of obsessive and compulsive tendencies. The present study utilized the OCI-R based on previous research linking emotional awareness to obsessions and compulsions (Naylor et al., 2011). Because the OCI-R has not been validated in a Danish population, it was translated and back-translated following the aforementioned procedure.

Ten-Item Personality Inventory (TIPI)

The TIPI (Gosling et al., 2003) evaluates the Big Five personality traits (extroversion, agreeableness, openness to experience, conscientiousness, and emotional stability), which are assessed using two items that are rated on a seven-point Likert scale from 1 (*disagree strongly*) to 7 (*agree strongly*). The scores for each domain range from 2 to 14. This instrument was selected because EA has been associated with various Big Five personality traits (Miller & Mesagno, 2014). Because the TIPI has not been validated in a Danish population, it was translated and back-translated following the aforementioned procedure.

Procedure and ethics

Data collection started in February 2022 and finished in November 2022. A snowball sampling method was used to recruit participants via social media from groups interested in sports. This method involves identifying individuals who can provide valuable data and leveraging their connections to reach additional participants. The study utilized the *Qualtrics* survey platform, which adheres to the General Data Protection Regulation (GDPR) in the European Union. Initially, participants were presented with a consent form outlining the study's purpose, significance, example content, and the principal investigator's information. This form served as the first page of the online survey. To maintain anonymity, participants generated random codes instead of providing their names. They were assured of their right to withdraw from the survey

at any point, and their data would be processed anonymously. Participants were not compensated for their involvement. The study was approved by the first author's university Ethical Board (code: 18F7D86802A124B1E783A3074ED80641).

Data analyses

All analyses were conducted using the *R* statistical environment (R Core Team, 2020). An a priori sample size determination analysis was conducted by using the *semPower* package (Moshagen and Bader, 2023). The analysis was based on the factorial model tested in the present study. Assuming a target root mean square error of approximation (RMSEA) of.05, a statistical power of.80, and following the approach adopted by Granziol et al. (2024), the minimum required sample size was estimated to be 358 participants. The final sample size met this requirement (n = 392), ensuring adequate power for the tested model. Moreover, because the original developers established the factorial structure of EAI-3, a confirmatory factor analysis (CFA) was performed, followed by testing of measurement invariance in biological sex, as well as the reliability, and validity analyses of EAI-3 scores. All testing of the CFA models were performed by using the *lavaan* package (Rosseel, 2012).

Confirmatory factor analysis and measurement invariance

Normality of each item's distribution was tested through descriptive analysis of skewness and kurtosis indices and a Shapiro–Wilk normality test. This preliminary check was necessary to select an adequate estimator for the CFA models. In case of normality violations, CFA models were tested employing a diagonally weighted least squares estimator (DWLS; Li, 2016), also considering robust standard errors and a test statistic adjusted for mean and variance via a scale-shifted approach, aligning with previous recommendations (WLSMVS; Schermelleh-Engel et al., 2003). Otherwise, a Maximum Likelihood one was used. The first international validation study of the EAI-3 (Granziol et al., 2024), as well as other studies validating it in other languages (e.g., Ozer et al., 2025; Szabo et al., 2024) suggested two subscales factor solutions (i.e., HR and AT); nonetheless, the corresponding scores were often highly correlated. In the present study, a bifactor model[1] including a general factor investigating all the items was included and compared with the original one through goodness-of-fit indices: Comparative Fit Index (CFI; values lower than 0.90 indicate a non-acceptable fit; values between 0.90 and 0.95 indicate adequate fit; values higher than 0.95 indicate a good fit; Hu & Bentler, 1999) and the Root Mean Square Error of Approximation (RMSEA; values lower/equal≤0.05 indicate a good fit; values between 0.05 and 0.10 suggest adequate fit, while values higher than 0.10 indicate a non-acceptable fit; Steiger, 1990). As noted by Zhao (2015), CFI and RMSEA are regarded as the most robust indices when using the DWLS estimator, especially in its robust variants. The implementation of a bifactor model was included for two reasons: (i) exploring the potential existence of a general factor that can account for potential relations (common variance) among factors and items; and (ii) re-examining the structure of EAI-3, considering the new sample, in line with some methodological recommendations (e.g., Brown, 2015; Morin et al., 2016; Reise, 2012).

Measurement invariance (MI) across biological sex was tested, considering the configural, metric, and scalar levels (Byrne, 2010; Chen, 2007; Meredith, 1993). Configural invariance was first evaluated to determine whether the overall factorial structure of the EAI-3 was equivalent across male and female participants. Establishing configural invariance implies that the same number of factors and the same pattern of factor-item relations are held across groups, therefore providing a baseline for subsequent tests. Metric invariance was then assessed by constraining factor loadings to be equal across groups. This step evaluates whether participants interpret the latent construct in a comparable way, enabling meaningful comparisons of factor covariances across groups. Finally, scalar invariance was examined by additionally constraining item intercepts, which tests whether group differences in observed scores reflect true differences in the latent construct rather than measurement bias. To evaluate invariance, two complementary criteria were taken into account: (i) the change in model fit indices, intended as the difference between two invariance models fit indices (ΔCFI>.01 and ΔRMSEA>.015 indicating potential violations; Cheung & Rensvold, 2002), and (ii) the absolute fit of each model (an inadequate fit suggests potential violations). Partial invariance was considered when a specific item caused misfit, in which case only the parameters associated with that item were freed while retaining constraints for all others (Byrne et al., 1989). Any potential source of misfit was addressed using modification indices (i.e., a modification index beyond 3 and a related Expected Parameter Change index not close to zero were used as suggestions for potential changes to consider).

Reliability

Reliability was assessed using Cronbach's alpha and McDonald's Omega. Composite reliability (CR) was also computed because it accounts for the standardized factor loadings and error variances of the items within each latent construct. Unlike Cronbach's alpha, CR does not assume tau-equivalence and is therefore considered a more accurate

[1] In the present study, a second order model could not be tested. In fact, with only two first-order factors, the model cannot be identified (Kline, 2011).

measure of internal consistency in the context of structural equation modeling. Values≥.60 are generally regarded as acceptable (Bagozzi & Yi, 1988). A value≥.70 for both alpha and omega, and≥.60 for composite reliability, indicates adequate reliability (Dunn et al., 2014; Hair et al., 2019; Kline, 2016; Nunnally & Bernstein, 1994).

EAI-3 cut-offs

Receiver Operating Characteristic (ROC) curve analysis was conducted to establish the optimal cutoff score for the EAI-3. To determine the best cutoff, the categorization provided by the EDS-R manual was used as the external criterion. More specifically, participants classified as "at-risk" according to the EDS-R were considered the "at-risk" group, whereas all others were assigned to the "not-at-risk" group. Analyses were performed with the *pROC* package (Robin et al., 2011). The area under the curve (AUC) was computed to assess the discriminative ability of the scale. The optimal cutoff was identified using the Youden index, which maximizes the sum of sensitivity and specificity. For each potential cutoff point, sensitivity, specificity, and overall accuracy were examined.

Correlations

Convergent validity was evaluated using Spearman correlation coefficients between total scale and subscale scores of the EAI-3 with scales and subscale scores of the EDS-R. Moreover, associations with other clinical and personality measures (i.e., OCI-R, SCOFF, and TIPI) were tested, with *p*-values adjusted using False Discovery Rate correction due to multiple tests. Discriminant validity was assessed using the Heterotrait-Monotrait (HTMT) ratio of correlations (Henseler et al., 2015) to evaluate the factorial structure of the EAI-3. A value below 0.90 suggests appropriate discriminant validity (Henseler et al., 2015). The *semTools* package (Jorgensen et al., 2022) was used to estimate the HTMT coefficient.

Results

Confirmatory factor analysis and measurement invariance

The preliminary check on items' distribution suggested normality violation and an ordinal nature of the data. Therefore, a robust version of the DWLS estimator was applied. All the CFA models' results are shown in Table 2. Considering the model proposed by Granziol et al., (2024; named as the original one), the structure of the EAI-3 was corroborated, as suggested by the fit indices (CFI=.981; RMSEA=.054, 90% CI=0-.087, see Table 2). On the Healthy Relevance subscale, all the items' loadings values were above .55 (range:.55-.70, Fig. 1, left panel). On the Addiction Tendency subscale, all the items' loadings values were above .66 (range:.66-.81). Both subscales were highly correlated (r=.91). The same applied to the models tested separately on both females (CFI=.964; RMSEA=.089, 90% CI=.044-.135) and males (CFI=.986; RMSEA=.042, 90% CI=0-.093).

The model presented configural invariance (CFI=.974; RMSEA=.068, 90% CI=.033-.101), metric invariance (CFI=.977; RMSEA=.065, 90% CI=.036-.093; ΔCFI=.003; ΔRMSEA=.003), and scalar invariance (CFI=.979; RMSEA=.051; 90% CI=.023-.074; ΔCFI=.002; ΔRMSEA=.014), with excellent fit indices. No violations occurred. Nonetheless, the analysis on the modification indices suggested considering including Item 6 (mi=4.49, |epc|=.827) in the AT subscale and include the correlation between Items 5 and 7 (mi=4.96, |epc|=.102). The CFA models, shown in Table 2, obtained worse fit and metric violations, suggesting that the original solution was preferable. Considering the bifactor model, the fit indices were good and slightly better compared to the original structure, considering the overall model (CFI=.995; RMSEA=.035, 90% CI=0-.083), as well as the single models for female (CFI=.984; RMSEA=.07, 90% CI=0-.135) and male (CFI=1; RMSEA=0, 90% CI=0-.072) participants. Even in this case, no violations occurred comparing configural and metric (ΔCFI=.001; ΔRMSEA=.008), as well as metric and scalar models (ΔCFI=.004; ΔRMSEA=.005). In this model, it is important to note that several items had loadings with their latent subscales; moreover, Item 6 had a negative association with the HR subscale (i.e., −0.13, Fig. 1, right panel). However, testing a model with this item shift produced convergence problems, suggesting misfit issues.

Reliability

The overall score (composite reliability=.84; α=.85; ω=.88), as well as both the HR subscale scores (composite reliability=.66; α=.71; ω=.73) and AT subscale scores (composite reliability=.77; α=.81; ω=.82) on the EAI-3 obtained adequate to very good internal consistency indices.

EAI-R-3 cut-offs

Applying the EDS-R cutoff, 18 participants (13 F, 5 M) were classified as at risk of developing exercise dependence, while 374 participants (182 F, 192 M) were not at risk. Based on this dichotomy, the ROC analysis suggested that a cutoff of 33.5 for the total score of EAI-3 was sufficient to suggest a potential risk of exercise addiction. The specificity was .856, the sensitivity was .889, and the area

Table 2 Results of the measurement invariance analysis on the CFA models

Original Model						
Model	**CFI**	**RMSEA**	**90% CI Lower**	**90% CI Upper**	**ΔCFI**	**ΔRMSEA**
Overall	0.981	0.054	0.020	0.087	-	-
Female	0.964	0.089	0.044	0.135	-	-
Male	0.986	0.042	0.000	0.093	-	-
Configural	0.974	0.068	0.033	0.101	-	-
Metric	0.977	0.065	0.036	0.093	0.003	0.003
Scalar	0.979	0.051	0.023	0.074	0.002	0.014
Model with Item 6 assessing AT subscale						
Model	**CFI**	**RMSEA**	**90% CI Lower**	**90% CI Upper**	**ΔCFI**	**ΔRMSEA**
Overall	0.994	0.031	0.000	0.070	-	-
Female	0.968	0.085	0.037	0.133	-	-
Male	1.000	0.000	0.000	0.057	-	-
Configural	0.987	0.050	0.000	0.087	-	-
Metric	0.996	0.029	0.000	0.066	0.009	0.021
Scalar	0.990	0.036	0.000	0.063	0.006	0.007
Bifactor Model						
Model	**CFI**	**RMSEA**	**90% CI Lower**	**90% CI Upper**	**ΔCFI**	**ΔRMSEA**
Overall	0.995	0.035	0.000	0.083	-	-
Female	0.984	0.070	0.000	0.135	-	-
Male	1.000	0.000	0.000	0.072	-	-
Configural	0.995	0.036	0.000	0.088	-	-
Metric	0.996	0.028	0.000	0.067	0.001	0.008
Scalar	0.992	0.033	0.000	0.062	0.004	0.005

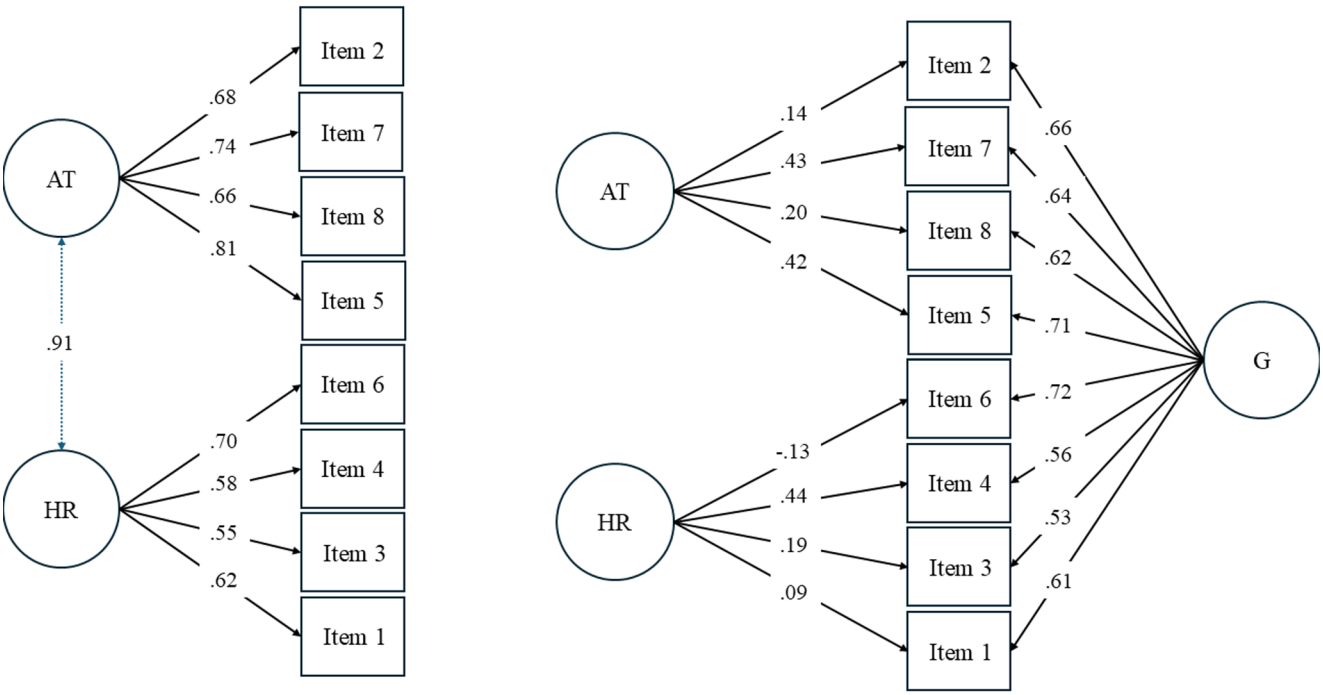

Fig. 1 Assessment models of EAI-3, Danish version. Left panel refers to the original model. Right panel refers to bifactor model. AT = Addiction Tendency. HR = Healthy Relevance. G = General Factor including all the items

under the curve (AUC) was equal to .933. Focusing only on the AT subscale, a cutoff of 17.5 was sufficient to suggest a potential risk of exercise addiction. The specificity was .906, the sensitivity was .777, and the area under the curve (AUC) was equal to .915. Based on these new cut-off points, 70 participants (total score, 44 F) and 49 (AT score, 36 F) were

classified as at risk. The kappa coefficients between the new cutoff and the one Hausenblas and Symons Downs (2002) suggested were .31 and .38, suggesting minimal agreement.

Correlations

Table 3 reports the correlations of the EAI-3 total score and its two subscales with scales and subscale scores of the EDS-R, OCI-R, SCOFF, and TIPI. Concerning convergent validity, the total and subscale scores of the EAI-3 showed strong positive correlations with the EDS-R (HR: ρ=.653, AT: ρ=.669, Total: ρ=.731, all *p*-values<.001). On the other associations, moderate correlations were also observed with clinical variables, including the OCI-R (HR: ρ=.258, AT: ρ=.419, Total: ρ=.374, all *p*-values<.001) and the SCOFF (HR: ρ=.288, AT: ρ=.339, Total: ρ=.341, all *p*-values<.001). In terms of personality traits, small-to-moderate negative correlations emerged with Extraversion (HR: ρ=–.155, AT: ρ=–.152, Total: ρ=–.166, all *p*-values<.01), Neuroticism (HR: ρ=–.223, AT: ρ=–.304, Total: ρ=–.286, all *p*-values<.001), and Openness (HR: ρ=–.180, AT: ρ=–.300, Total: ρ=–.265, all *p*-values<.001). No meaningful associations were found with Agreeableness (HR: ρ=.15, AT: ρ=–.078, Total: ρ=–.039; all *p*-values>.05) or Conscientiousness (HR: ρ=.074, AT: ρ=.024, Total: ρ=.054; all *p*-values>.05). The HTMT coefficient for EAI-3 scores was equal to .906, suggesting that the level of discriminant validity was slightly above the recommended threshold (i.e.,.90), and therefore the discriminant validity of the scores was not fully satisfied.

Discussion

Symptoms of exercise addiction reflect a presumed clinical condition whose conceptualization and definition as a disorder have not yet been consensually agreed. As a consequence, its assessment is still evolving. Some instruments, such as the Exercise Dependence Scale-Revised (EDS-R; Hausenblas & Symons Downs, 2002), the Compulsive Exercise Test (CET; Taranis et al., 2011), and the Exercise Addiction Inventory in its various versions (Szabo et al., 2019; Terry et al., 2004), are more widely used than others. The present study focused on the latest version of the EAI and tested its psychometric structure among Danish exercisers. The EAI-3 has several advantages over the EAI. It provides a more specific assessment of the risk of exercise addiction, including symptoms such as guilt when not exercising and continued training despite injury. It also has a calculated cut-off point and differentiates health-related and addiction-related factors, which helps in better determining the risk of exercise addiction. The results of the present study confirmed these advantages among Danish exercisers.

In particular, a general confirmatory factor analysis solution comprising two related subscales was identified, with excellent fit indices, corroborating the original validation study (Granziol et al., 2024). This suggests that the EAI-3 assesses two aspects of exercise addiction. The first factor assesses the healthy and passionate aspects of exercise (i.e., the 'healthy relevance' subscale), whereas the second factor assesses the pathology and risk of exercise addiction (i.e., the 'addiction tendency' subscale). The presence of two related but different subscales aligns with issues raised in scientific literature. For instance, Colledge et al. (2019) observed that when developing or using an instrument assessing the risk of exercise addiction, both (extremely) passionate and (potentially) addicted exercisers could use the same scale. However, such a scale should be able to distinguish between the two states. The EAI-3 structure appears to be capable of doing this. Moreover, the slightly better fit of the bifactor structure should also be considered, given the high correlation between subscales. This model could give a sense of the presence of both total and subscales scores. From a psychological point of view, the bifactor structure seems to suggest the existence of a general factor including all eight components of exercise addiction. Nonetheless, the low factor (or even negative) loadings with some items with the corresponding latent subscale suggests that the original solution is still preferable. Future studies with other populations could address the introduction of this bifactor model and its comparison with the original one.

Another noteworthy result was the absence of violations in measurement invariance, which suggests that the measurement model for EAI-3 scores works similarly well for both female and male exercisers. This result is an improvement compared to the original validation study (Granziol et al., 2024), where differences in Item 1 ("*Exercise is the most important thing in my life*"), Item 2 ("*Concerns have arisen between me and my family and/or my partner about*

Table 3 The correlations between the EAI-R-3 scores and scores on the other scales (i.e., EDS-R, OCI-R, SCOFF, and TIPI)

Variable	HR	AT	EAI-3 Total
EDS-R21	.653***	.669***	.731***
OCI-R	.258***	.419***	.374***
SCOFF	.288***	.339***	.341***
Extraversion	–.155**	–.152**	–.166**
Agreeableness	.015	–.078	–.039
Conscientiousness	.074	.024	.054
Neuroticism	–.223***	–.304***	–.286***
Openness	–.180***	–.300***	–.265***

HR = Healthy Relevance; AT = Addiction Tendency; EAI = Exercise Addiction Inventory; EDS-R21 = Exercise Dependence Scale-Revised (21 items); OCI-R = Obsessive–Compulsive Inventory-Revised; SCOFF = Eating Disorder screening. The False Discovery Rate adjustment on the *p*-values was used

*p<.05, **p<.01, ***p<.001

the amount of exercise I do"), and Item 7 ("*I feel guilty if I miss planned training or if my training does not go as well as planned*") were observed in specific populations. Therefore, among Danish exercisers, the risk (or absence) of exercise addiction is not a biological sex-related factor, at least based on EAI-3 items. This finding may be associated with the fact that exercise and its related characteristics are biological sex-independent in that both healthy and pathological aspects are perceived and experienced similarly by Danish individuals.

The strong association between the EDS-R and EAI-3 scores provided evidence of convergent validity for the scores. In addition, the correlations observed with the OCI-R, SCOFF, and TIPI, were consistent with theoretical expectations but did not constitute convergent validity because these measures capture related yet distinct constructs, and in the case of OCI-R and TIPI, have not been formally validated in Danish. Nonetheless, such results were in line with previous Danish studies examining exercise addiction and EAI (Lichtenstein et al., 2012, 2014, Lichtenstein et al., 2018, Lichtenstein et al., 2021; Lichtenstein & Jensen, 2016). First, both subscales and total EAI-3 scores were moderately to strongly correlated with all the clinical scales, suggesting a strong relationship between the risk of exercise addiction and the presence of compulsive behavior and obsessions. As indicated in prior studies, the desire to perform best in a sport may be perceived as comorbid (primary or secondary) with obsessive traits; or more generally, the desire to be the best in a specific sport may reflect an obsession, and the behavior undertaken to achieve such a goal may surface as a compulsive tendency (Naylor et al., 2011).

Correlations between exercise addiction and eating disorder symptoms have emerged, even in the present study. It may be explained considering that an extreme focus on body performance and appearance may be a typical underlying pattern, verifying the construct validity of the EAI-3. However, it is important to stress that eating disorders differ from exercise addiction, because exercise is a tool for weight control or serves as a compensatory behavior. In contrast, the primary goal of exercise addiction is the exercise itself (Uriegas et al., 2023). Moreover, a meta-analysis confirmed that exercise addiction can exist independently from eating disorders (Trott et al., 2020).

Moreover, the correlation between EAI-3 scores and personality traits suggests that the risk of exercise addiction is associated with higher levels of extroversion, emotional stability, and openness to experience. Considering these findings, future research should investigate these relationships, possibly trying to delineate the direction of such correlations. Finally, it is worth noting that the cutoff point indicating a potential risk of exercise addiction (i.e., 34) was consistent with that reported in previous studies. In particular, a recent cross-cultural validation of the EAI-3 (Granziol et al., 2024) reported the same threshold. Moreover, the validation of EAI-3 with a Hungarian sample used the same cutoff (Szabo et al., 2024). This convergence across different populations provides preliminary support for the robustness of the cutoff value internationally. Nonetheless, the available evidence is still limited to a small number of validation studies, all of which were conducted with non-clinical samples. Therefore, while the consistency of findings is encouraging, further research is needed to confirm the 34-point cutoff among clinical populations and to evaluate its diagnostic accuracy in applied contexts.

Limitations

The present study has a number of limitations. There was an absence of control over exercise history and reported exercise frequency, due to the self-report nature of the assessment measures. Moreover, because Danish validation studies for OCI-R and TIPI were not available (and the scales were translated specifically for the present study), their correlations with EAI-3 scores should not be interpreted as a proof of convergent validity, but as a result in line with previous findings. This constraint limits the strength of construct-validation inferences based on these measures. The discriminant validity analysis suggested that, at this stage, the evidence for the discriminant validity of EAI scores is not yet fully satisfied. More studies are necessary to create more evidence on this psychometric aspect.

Another limitation was that data collection was conducted exclusively using online surveys accessed through social media. Consequently, participation was limited to individuals with internet access and sufficient digital literacy to complete the survey. This recruitment and data collection strategy may have resulted in the underrepresentation of individuals without regular internet access or those less familiar with online platforms. Future research may benefit from adopting mixed recruitment and data collection methods, including offline data collection, to ensure broader inclusivity. It should also be noted that measurement invariance was only examined using a single categorical variable (i.e., biological sex). In future studies, measurement invariance should be established across different types of sports (i.e., individual or team, professional or recreational) and various age groups. Therefore, more studies with larger samples should test invariance based on other characteristics, such as those aforementioned, as well as the exercise motive of the individual, such as health or mastery, as based on the interactional model of exercise addiction (Dinardi et al., 2021). Finally, the self-report nature of the data is open to well-known methodological biases (e.g., social desirability), especially when examining sensitive topics such as addiction.

Conclusion

Based on a sample of regular exercisers working out at least 150 min per week, and following the recommendation of the WHO, the present study supported the reliability of the EAI-3 scores for screening the risk of exercise addiction among Danish exercisers. The use of the EAI-3 in research and applied settings could help facilitate early identification of dysfunctional exercise behavior that could help in better understanding and in the potential future clinical diagnosis of exercise addiction as a psychiatric dysfunction, as well as interventions in problematic exercise behavior. Further research should focus on longitudinal studies and clinical validations to enhance the understanding and management of exercise addiction.

Appendix

EAI-3 items, English version.

Subscale	Item wording
HR	1. Exercise is the most important thing in my life
HR	3. I use exercise as a way of changing my mood (e.g., to get a buzz, to escape, etc.)
HR	4. Over time I have increased the amount of exercise I do in a day
HR	6. If I cut down the amount of exercise I do and then start again, I always end up exercising as often as I did before
AT	2. Concerns have arisen between me and my family and/or my partner about the amount of exercise I do
AT	5. If I have to miss an exercise session, I feel moody and irritable
AT	7. I feel guilty if I miss planned training or if my training does not go as well as planned
AT	8. I am inclined to train when (or before completely recovered from) illness or injury

EAI-3 items, Danish version.

Subscale	Item wording
HR	1. Træning er det vigtigste i mit liv
HR	3. Jeg bruger træning som en måde til at ændre mit humør (f.eks. for at blive glad, at distrahere mig selv osv.)
HR	4. Jeg har gennem tiden øget omfanget af min daglige træning.
HR	6. Hvis jeg skærer ned på min træning, ender jeg med at træne lige så ofte som før
AT	2. Min familie og/eller partner er bekymret for mine træningsmængder
AT	5. Hvis jeg misser et træsningspas, bliver jeg irritabel og nedtrykt
AT	7. Jeg føler mig skyldig, hvis jeg savner planlagt træning, eller hvis min træning ikke går så godt som planlagt
AT	8. Jeg har en tendens til at træne, selvom jeg er syg eller skadet, eller inden jeg er helt frisk igen

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Data availability Data can be shared upon reasonable request to the corresponding author.

Declarations

Ethical approval The study received approval from the University of Padova, Faculty of Psychology ethics committee (Unicode: 18F7D-86802A124B1E783A3074ED80641) and adhered to the principles of the Declaration of Helsinki (World Medical Association, 2013).

Patient consent statement No patients were involved in the present study.

Permission to reproduce material from other sources Not applicable.

Clinical trial registration Not applicable.

Conflict of interest disclosure The authors reported no conflict of interest.

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