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RESEARCH ARTICLE

Exercise Addiction Inventory-3 (EAI-3): Psychometric properties of the Hungarian version

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ABSTRACT

Background and aims: The Exercise Addiction Inventory (EAI), based on the components model addictions, is a 6-item instrument used to assess the *risk of exercise addiction* (REA). Its revised version (EAI-R) was published in 2019 but only differed from the original scale in the response rating range (using a 6-point rather than 5-point Likert scale). In 2023, the EAI-3 was released with two new items (guilt when missing training and exercising despite injury). We aimed to test the validity and reliability of the Hungarian EAI-3 (EAI-3-HU). *Methods:* We tested 507 regular exercisers (M_{age} = 38.7 years, SD_{age} = 10.63 years, $range_{age}$: 18–78 years; 62.7% females) who completed the EAI-3-HU, the obsessive passion subscale of the Passion Scale, and exercise habits questions on the online Qualtrics research platform during autumn/winter 2023–2024. *Results:* Confirmatory factor analysis resulted in a good model fit for the two factor EAI-3-HU (CFI = .96; TLI = .94; RMSEA = .07; SRMR = .04). However, the covariance between the latent factors was .97, indicating that they measure an identical concept. Thus, a single-factor solution was appropriate (CFI = .96; TLI = .94; RMSEA = .07; SRMR = .04). Testing measurement invariance revealed the partial scalar invariance across genders. The internal reliability of the scale was good (Cronbach's α = .81). The scale had good convergent validity with obsessive passion (r = .72), and discriminant validity based on exercise frequency as well as exercise intensity (p < .001). *Conclusion:* The 8-item single factor EAI-3-HU adequately assesses the Hungarian samples' REA. Nevertheless, it should be kept in perspective that the revised tool, like its predecessors, only assesses a level of 'risk', which does not imply morbidity, thus it has no clinical diagnostic value.

KEYWORDS:

behavioral addiction, exercise addiction, Exercise Addiction Inventory, reliability, validity

Testedzésfüggőség Kérdőív-3 (EAI-3): A magyar változat pszichometriai tulajdonságai

ABSZTRAKT

Háttér és cél: A komponens modellre épülő Testedzésfüggőség Kérdőív (EAI) immár világszerte használt 6 tételes mérőeszköz, amely a testedzésfüggőség kockázatának felmérését szolgálja. Ennek módosított változata (EAI-R) 2019-ben jelent meg, amely csak válasz értékelésben különbözött az eredeti skálától (5-fokú helyett 6-fokú Likert-skála lett). Viszont 2023-ban az EAI-3 már két új tétellel (bűntudat edzés hiányában és sérülés ellenére történő edzés) bővülve lett validálva. Jelen munkánk célja a magyar EAI-3 (EAI-3-HU) modell validitásának és megbízhatóságának vizsgálata. *Módszerek:* Az EAI-3-HU-ra, a Passzió Skála obszesszív szenvedélyes alskálájára, és testmozgási szokásokra vonatkozó kérdésekre összesen 507 rendszeresen edző személy (átlagéletkor: 38,7 év, SD = 10,63 év, terjedelem: 18–78 év; 62,7% nő) válaszolt az online Qualtrics kutatási felületen a 2023–2024 őszi/téli

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félévben. *Eredmények:* A megerősítő faktorelemzés eredménye alátámasztotta az elméleti kétfaktoros struktúrát (CFI = 0,96; TLI = 0,94; RMSEA = 0,07; SRMR = 0,03). Azonban a látens faktorok közötti kovariancia 0,97 volt, ami arra utal, hogy ugyanazt a fogalmat mérik. Így az EAI-3-HU-ra az egy faktoros megoldás bizonyult megfelelőnek (CFI = 0,96; TLI = 0,94; RMSEA = 0,07; SRMR = 0,04). A belső megbízhatóság (Cronbach-α) 0,81 volt, továbbá az EAI-3-jó konvergens validitást mutatott az obszesszív szenvedéllyel (r = 0,72), és a diszkrimináns validitása is jó volt az edzésgyakoriság és edzésintenzitás tekintetében ($p < .001$). *Következtetés:* A 8-tételes egyfaktoros EAI-3-HU megfelelő eszköznek bizonyul a testedzésfüggőség kockázatának mérésére magyar mintákon. Ugyanakkor figyelembe kell venni, hogy a mérőeszköz, akárcsak elődjei, csak egy „kockázati” szintet sugall, amely nem jelent morbiditást, így az EAI-3-HU-nak nincs klinikai diagnosztikai funkciója.

KULCSSZAVAK:

viselkedési függőség, testedzésfüggőség, Testedzésfüggőség Kérdőív, reliabilitás, validitás

1. INTRODUCTION

While regular physical activity should be part of the contemporary healthy lifestyle (Bull et al., 2020), planned exercise training can be abused to the extent of self-harm (Szabo & Demetrovics, 2022). This behavior, referred to as *exercise addiction*, is studied within the scholastic field of behavioral addictions. Exercise addiction is characterized by a loss of control over exercise behavior (Szabo, 2010) and emerges via two paths: 1) therapeutic, and 2) mastery (Dinardi et al., 2021). The former is associated with coping with or escaping from stress and trauma, while the latter is connected to the failure or unwillingness to recognize one's physical limits, pushing the training over barriers of pain, resulting in injury or even termination of one's athletic career (Egorov & Szabo, 2013).

Although currently over 2,000 publications exist in the field (based on a Google Scholar title search with the terms exercise addiction and its synonyms adopted in the literature like exercise dependence, compulsive exercise, obsessive exercise, and exercise abuse), *diagnosed* cases of exercise addiction do not exist since there are no clinical diagnostic criteria for it. At the same time, a clinical model has been forwarded for exercise addiction (Dinardi et al., 2021; Egorov & Szabo, 2013). Still, this *presumed* dysfunction is not included in the latest edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5; American Psychiatric Association, 2013). Why is it only a presumed dysfunction? The reason is twofold. First, few published clinical attention-demanding cases are reported in the literature, and the dysfunctional cases meet medical doctors in healthcare settings rather than researchers in sports, exercise, or university settings (Juwono & Szabo, 2020). The second reason is that most research using paper and pencil (nowadays online) tools assesses only the *risk* of exercise addiction based on various questionnaire cut-off scores, which may not imply morbidity of clinical significance (Szabo & Demetrovics, 2022).

Still, questionnaires could serve for the *surface screening* of exercise addiction. Then, the follow-up of high-scoring individuals with deep clinical interviews can establish whether there is a medical issue. Indeed, Szabo and Demetrovics (2022) propose a collaboration model between researchers and clinicians that might be productive in collecting clinical evidence for including exercise addiction in medical reference manuals. A starting point of collaboration, despite the time pressure experienced by many medical doctors (Ádám et al., 2008), is the administration of the short Exercise Addiction Inventory (EAI; Terry et al., 2004; Szabo et al., 2019; Szabo, 2021) by the orthopedist who encounters several exercise-related injuries and, more importantly, re-injuries in a person. The doctor or her/his assistant can ask the patient to fill out the EAI, which takes less than two minutes, and then look at the total score. If that is above the cut-off point, the patient should be referred for psychiatric evaluation to rule out psychiatric problems.

Indeed, the EAI is a brief, quick-to-administer screening instrument for the risk of exercise addiction. The original English EAI (Terry et al., 2004) has been translated and validated in several languages: Hungarian, Spanish, Danish, Italian, Mexican, and Persian (Aydın et al., 2023). The EAI is probably used in hundreds of papers, based on 1,280 results yielded by an exact term search on Google Scholar (2024.02.11). Its revised version, the EAI-R (Szabo et al., 2019), is identical to the original tool. However, instead of a 5-point Likert scale, the authors eliminated the neutral point (3) and resorted to three levels of disagreement and agreement answer options, adopting a 6-point Likert scale. The answers, forming two three-items-based groups of *agree* and *disagree*, can be dichotomized if necessary. The EAI-R has already been translated and validated into Hungarian (Szabo, 2021), Chinese (Wang et al., 2022), and Italian (Soraci et al., 2023).

However, there were arguments that the EAI based on the components model (Griffiths, 2005), comprising six symptoms of addictions (salience, conflict, mood modification, withdrawal, tolerance, and relapse), might miss specific symptoms related to exercise addiction, such as guilt when missing a planned training session (Lichtenstein & Jensen, 2016) and training despite injury or prior recovery from an illness or injury (Lichtenstein & Jensen, 2016; Pálfi et al., 2021). While testing a large international sample, Granziol et al. (2023) tried to address this possible shortcoming of the original EAI by adding feelings of guilt, exercising despite an injury, and suffering negative personal consequences to an expanded initially 9-item-based EAI, renamed as EAI-3. The authors found good psychometric properties for 8/9 items because the 'suffering of negative personal consequences' did not fit the model. The two-factor model yielded a *health-related* and *addiction-related* subscale. The internal reliability (Cronbach's α) of the EAI-3 was .81, the health-related subscale .70, and the addiction-related subscale .71. However, the covariance between the latent factors was relatively high (.71). Granziol et al. (2023) determined that the cut-off score of the EAI-3 is 34 (out of 48 as maximum), above which a person might be at risk of exercise addiction (REA).

Why is the EAI-3 superior to its predecessor, the EAI? First, on the EAI, a total score less than 13 implies an *asymptomatic* profile, while a score between 13 and 23 suggests a *symptomatic* profile. In contrast, a score equal to or above 24 suggested an *at-risk* profile (Griffiths et al., 2015). Based on this classification, most research participants can be considered as '*symptomatic*' (i.e., 84.7%: Lichtenstein et al., 2012; 65.3%: Pálfi et al., 2021; 56.5%: Salazar et al., 2021). Using common sense, the chance of finding >50% of a sample being *symptomatic* of exercise addiction is unlikely. Second, the EAI did not include two critical factors that mirror warning signs of addiction, which are *guilt when exercise is not possible* and *exercising despite an injury or unrecovered illness* (Lichtenstein & Jensen, 2016; Pálfi et al., 2021). A better estimate of the REA can be achieved on the EAI-3, which also allows the quantification of these items. Third, the EAI-3 has an established cut-off point (34) above which the REA might be prevalent and does not separate those scoring below this threshold into symptomatic or asymptomatic categories. Finally, the EAI-3 has two factors, one that may not necessarily be related to addiction and one that is addiction-related, which could be an advantage in determining the REA. Still, the high covariance between the latent factors calls for future investigation and validation of these subscales.

Considering the EAI-3's above-listed advantages in contrast to its earlier versions, this study aimed to validate a Hungarian version of the EAI-3 (EAI-3-HU). Since the EAI-3 was developed based on a multinational sample, our hypothesis was that the EAI-3-HU would also demonstrate good model fit, as well as good internal reliability, discriminant validity, and convergent validity. Further, based on a past literature review on gender differences in REA, emphasizing the need for more evidence for measurement invariance (Dumitru et al., 2018), we also calculated EAI-3-HU's invariance across genders. At an exploratory level, gender differences in REA and its prevalence in the total sample were also calculated separately for males and females.

2. METHODS

2.1. Participants and procedure

Participants were recruited in person from various fitness and CrossFit centers in Budapest and via calls for participation on social media, such as Facebook, Instagram, LinkedIn, and Twitter. Those interested in completing the survey were given the link to the online data-collection platform. The participation criteria for inclusion in this study were regular weekly exercise, age 18 or over, and giving consent to participation. Participation was voluntary and anonymous. Respondents completed the survey on the *Qualtrics* research platform (Qualtrics, 2017), which had a unique Uniform Resource Locator (URL) for this research. Before accessing the questionnaires, volunteers read the consent form and agreed to participate by selecting an *"I agree"* button. This study received ethical approval for conducting research with human participants (2023/538) issued by the Research Ethics Committee of the Faculty of Education and Psychology at ELTE Eötvös Loránd University in Budapest. The work also conformed to the Helsinki Declaration concerning research with humans (World Medical Association, 2013).

The online data collection occurred during the fall and winter of 2023–2024. It was halted after gathering 970 responses. However, many participants (n =141) stopped completing the survey before answering 50% of the questions. Further, 160 respondents did not exercise regularly. Thus, we examined 669 incoming responses, but many (n = 150) still had missing data, and a dozen (12) were completed too fast (i.e., <150s), which is unrealistic.

Hence, the final sample with a 100% completion rate included 507 regular exercisers. This sample size can be considered *'very good'* for confirmatory factor analysis (CFA), yielding robust results (Tabachnick & Fidell, 2007). Notably, fewer males than females volunteered to participate (37.3%), a general trend in online survey research (Becker, 2022). Participants practiced aerobics (n = 23), ball games (n = 9), CrossFit[1] (n = 238), fitness (n = 67), running (n = 70), cycling (n = 16), triathlon (n = 4), swimming and other water sports (n = 19), racquetball sports (n = 2), martial arts (n = 6), and other non-categorized sports (n = 53). CrossFit was overrepresented in the sample because CrossFit training centers specialize in this *one* exercise form and stand apart from other fitness venues offering a wider variety of exercise forms. Participants' mean age was 38.7 (SD = 10.63, range: 18–78) years. They exercised an average of 392.11 (*SD* =

[1] CrossFit is a high-intensity fitness program that combines elements of aerobic exercise, calisthenics (bodyweight exercises), and Olympic weightlifting. It involves varied functional movements performed at high intensity to develop overall fitness (Glassman, 2003).

195.53) minutes per week, and 90.7% were training four or more times weekly. Their perceived and/or reported exercise intensity was 5.01 (SD = 1.07), corresponding to '*hard*' on the 7-category Borg scale (Borg, 1982). Further characteristics of the participants categorized by gender are presented in *Table 1*.

Table 1. Participants' characteristics based on gender classification

Variables	Females (n = 318)	Males (n = 189)	Statistic	p	Effect size
Age (years) M(SD)	38.43 (10.74)	39.18 (10.50)	F = 0.59	.441[a]	$p\eta^2$ = .001
Partnership status % (n)					
Cohabiting	54.40 (173)	63.50 (120)	$\chi^2(2)$ = 6.54	.038[bd]	V = .080
Not cohabiting	14.20 (45)	7.40 (14)			
Single	31.40 (100)	29.10 (55)			
Work status % (n)					
Student	11.60 (37)	5.30 (10)	$\chi^2(2)$ = 5.65	.059[b]	V = .074
Working	85.50 (272)	92.00 (174)			
Unemployed	2.80 (9)	2.70 (5)			
Perceived health (range 0–100) M (SD)	85.02 (11.11)	83.31 (12.11)	F = 2.63	.106[a]	$p\eta^2$ = .005
Weekly exercise frequency (days) M (SD)[e]	5.61 (2.13)	5.75 (1.66)	F = 0.57	.462[a]	$p\eta^2$ = .001
Estimated exercise volume (minutes) M (SD)	375.70 (196.72)	420.13 (191.23)	F = 6.17	.013[a]	$p\eta^2$ = .012*
Estimated exercise intensity (range 1–7) M (SD)	4.88 (1.06)	5.22 (1.05)	F = 12.17	<.001[a]	$p\eta^2$ = .024*
Obsessive passion (6-42) M (SD)	19.53 (8.52)	19.95 (8.13)	F = 0.31	.580[a]	$p\eta^2$ = .001
Total score on the EAI-R-3 (range 8–48) M (SD)	26.36 (7.79)	26.62 (7.47)	F = 0.14	.713[a]	$p\eta^2$ = .001
Proportion at risk of exercise addiction (REA) % (n)	19.20 (61)	18.50 (35)	$\chi^2(1)$ = 0.03	.854[bc]	V = .008

Notes: * $p < 0.05$; superscripts: [a] = based on MANOVA; [b] = based on Chi-Square test; [c] = based on the one-factor EAI-3-HU using the cutoff score of Granziol et al. (2023); [d] = not statistically significant after alpha correction (α = .017) using the Bonferroni method for multiple tests; [e] = 10 (5.3%) of men and 37 (11.6%) of women) exercised less than four times a week despite the relatively high average number of weekly workouts; $p\eta^2$= partial eta squared, V = Cramer's V.

2.2. Materials

Demographic questions asked the participants their age, gender, perceived health (from very bad [0] to excellent [100]), and exercise habits, including exercise frequency (number of training sessions per week), duration (minutes of exercise per session, and estimated habitual exercise intensity on a brief 7-point Borg scale (from very, very easy to very, very hard) containing the original seven categories of the scale (Borg, 1982).

The revised Hungarian version (Szabo, 2021) of the *Exercise Addiction Inventory-Revised* (EAI-R; Szabo et al., 2019) was complemented with two items from the EAI-3 (Granziol et al., 2023). These items were: "*I feel guilty if I miss planned training or if my training does not go as well as planned*" and "*I am inclined to train when (or before completely recovered from) illness or injury*" (Granziol et al., 2023; see *Appendix 2*). Two researchers translated these two items into Hungarian and translated them back to English, and a third independent researcher verified the correct semantic match of the Hungarian statements compared to the original ones who suggested simplification by excluding the second part of both questions (i.e., "*… or if my training does not go as well as planned*" and "*…(or before completely recovered from) illness or….,*" since they could provoke uncertainty through double meaning. For example, one may feel guilty for not completing a planned exercise, but not necessarily because of poorer than-expected performance during training. Similarly, when one has not entirely recovered from an injury, it implies that one is training while injured. Therefore, the last two questions were simplified and clarified: Q7: *"I feel guilty when I cannot fulfill a planned training"* and Q8: *"(sometimes) I go to train despite injuries."*

The EAI-3-HU is rated on a 6-point Likert scale ranging from *strongly disagree* to *strongly agree,* and the maximum score is 48 while the minimum is 8. Usually, it takes less than two minutes to complete this scale. Its rating is relatively simple as it only consists of the summing of the answers and comparing to the cut-off score of 34 (Granziol et al., 2023). A score of 34 or greater reflects a possible REA that should be followed up to understand why the responding individual gave high ratings since athletes, team exercisers, and possibly others might interpret the items of the EAI-3 differently (Griffiths et al., 2023; Juwono et al., 2021).

Participants also completed the validated Hungarian Passion Scale (PS; Tóth-Király et al., 2017) based on the revised PS (Marsh et al., 2013) to measure obsessive passion (OP), which shares significant variance with REA (de la Vega et al., 2020; Kovacsik et al., 2018a, b). This tool was used to test the convergent validity of the EAI-3-HU. The OP subscale comprises six items rated on a 7-point agreement-disagreement Likert scale. A sample item is *"If I could, I would only do my activity."* In this work, the word "activity" was replaced with sport/exercise to imply exercise behavior precisely. Higher scores reflect a greater obsession with exercise. The internal reliability reported for the original OP subscale was (Cronbach's α) .86 (Marsh et al., 2013). The OP subscale of the Hungarian PS has comparable internal reliability (α = .88, Tóth-Király et al., 2017). In the current study, the reliability of the OP subscale was α = .89.

2.3. Statistical analyses

Only fully completed (100%) answers were included in data analyses. Data were exported in a Statistical Package for Social Sciences (SPPS v. 26) file, and the calculations were done with the same software. To test gender differences for continuous data, including age, perceived health, exercise volume, exercise intensity, obsessive passion, and EAI-3-HU scores, we used multivariate analysis of variance (MANOVA) and partial Eta squared ($p\eta^2$) effect sizes. We employed Chi-squares (χ^2) tests with Cramer's V effect sizes for frequency data, including partnership status, work status, and prevalence of risk of exercise addiction.

Confirmatory factor analyses (CFA) and measurement invariance testing were conducted in R programming language version 4.3.2 (R Core Team, 2023), using 'lavaan' (Rosseel, 2012), 'semPlot' (Epskamp, 2022), and 'semTools' (Jorgensen et al., 2022) software packages. For the model fit, we adopted the following criteria: First, the non-significant χ^2 was ignored since the χ^2 test will likely be significant in large samples. Therefore, we relied on other commonly used fit indices (Tabachnick & Fidell, 2007). For the Tucker-Lewis Index (TLI), a cutoff value >.95 was considered acceptable, and for the Comparative Fit Index (CFI), we relied on the cut-off value >.95 (Hu & Bentler, 1999; Shi et al., 2019). We set the cut-off value of the Root Mean Square Error of Approximation (RMSEA) to <.07 (Steiger, 2007) and for the Standardized Root Mean Square Residual (SRMR) to <.08 (Hu & Bentler, 1999). Kline (2015) suggested that for CFA, a minimum of four indices should be reported (i.e., CFI, TLI, RMSEA, and SRMR); we report here the TLI results based on cut-off >.95. This measure is less sensitive to large (>100) samples, like one studied here (Taasoobshirazi & Wang, 2016). Further, despite sporadic use, we also report the Goodness of Fit Index (GFI) value with a cutoff criterion >.90 (Baumgartner & Homburg, 1996). Furthermore, we tested internal reliabilities by calculating Cronbach's α (compared to the standard values of T. Kárász et al. [2022]) and McDonald's ω coefficient.

We calculated partial correlations, controlling for gender, to assess EAI-3-HU's relationship with exercise parameters and its criterion measure, obsessive passion, used to assess convergent validity. We also calculated Pearson's r correlations coefficients in examining the relationship between EAI-3-HU and exercise parameters. In determining the discriminant validity of the EAI-3-HU, we used analyses of covariances (ANCOVA) with gender as a covariate and exercise frequency and intensity as dependent measures via median-split grouping.

3. RESULTS

3.1. Gender differences

The MANOVA revealed no age difference between the genders, but men scored higher than women on exercise duration and intensity, ranging from small to moderate effects, but not on exercise frequency (*Table 1*). No gender differences emerged on the EAI-3-HU, obsessive passion, and perceived health. Further, chi-square tests indicated that the prevalence of REA (based on the cutoff score of 34; Granziol et al., 2023), relationship, status, and work status were not different between the genders after correcting the α (.017) for multiple tests using the Bonferroni method (*Table 1*).

3.2. Confirmatory factor analysis of the EAI-3-HU

The basic descriptive statistics, with skewness and kurtosis values and associated histogram for EA-3-HU, are presented in *Appendix 1*. In testing the model fit, CFA was conducted to examine whether the data conform to the original model (Granziol et al., 2023). Since the data were not multivariate normally distributed (Henze-Zirkler [HZ] = 1.273, p < .001), model parameters in CFA were estimated using a robust maximum likelihood estimation (MLM), and, therefore, we presented the robust version of fit indices.

The CFA results suggested the good model fit of the EAI-3-HU in line with the theoretical (Granziol et al., 2023) two-factor eight-item model ($\chi^2(19) = 56.161$, CFI = .958; TLI = .938; RMSEA = .066; SRMR = .038; GFI = .970). Still, the TLI was slightly lower than the cut-off value, and, more strikingly, the covariance between the latent factors was high (.97), exceeding the commonly used criterion value of .85 (Brown, 2015; see *Figure 1*). The internal reliability of the *health-related* factor (Cronbach's α) was questionable (.63), yet acceptable for the *addiction-related* factor (.72). The full scale had good internal reliability (.80). Furthermore, the Heterotrait-Monotrait correlation ratio was >.90 (max. 1.0), implying no discriminant validity and that the two factors measure the same concept. Therefore, we examined the one-factor model based on Brown's (2015) suggestion.

The CFA of the one-factor model also resulted in good fit indices ($\chi^2(20) = 57.385$, CFI = .958; TLI = .941; RMSEA = .065; SRMR = .038; GFI = .970). However, we note that two of the factor loadings (EA2 and EA4) were under .40 (see *Figure 2*), and their R^2 was <.20 (.152 and .156, respectively). Based on George and Mallery (2003), the internal reliability of the eight-item scale was good, $\alpha = .80$. We compared our Cronbach's α values against the threshold recommendations given by T. Kárász et al. (2022). The appropriate cut-off value for Cronbach's α for an eight-item scale (with a 6-point Likert response scale) and a mean inter-item correlation of $r = .32$ would be .74. In addition to Cronbach's α, we calculated the McDonald's *omega* coefficient, which was $\omega = .81$ for the total single-factor scale.

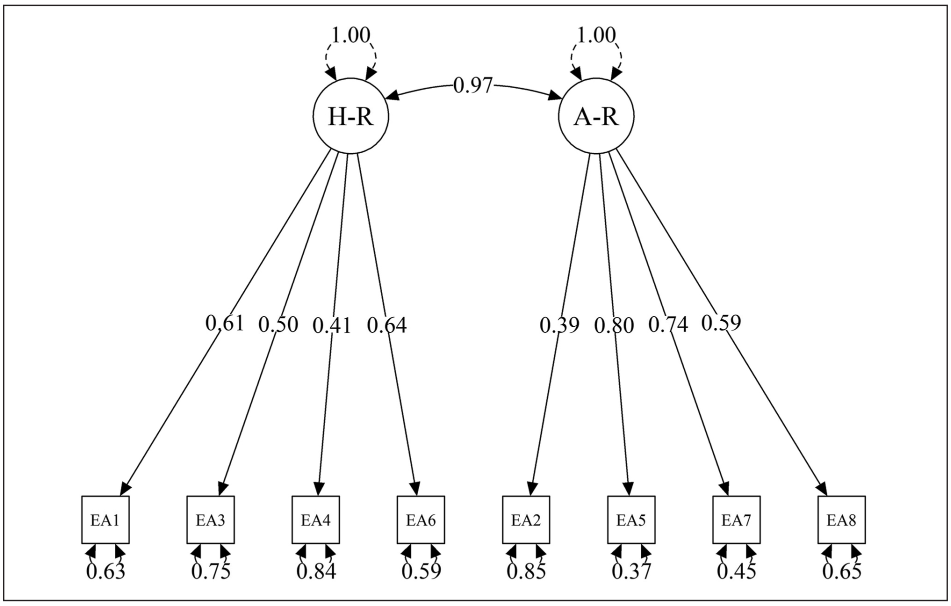

Figure 1. **The standardized parameter estimates of the two-factor model, eight-item EAI-3-HU**

Notes: H-R = Health-related subscale; A-R = Addiction-related subscale.

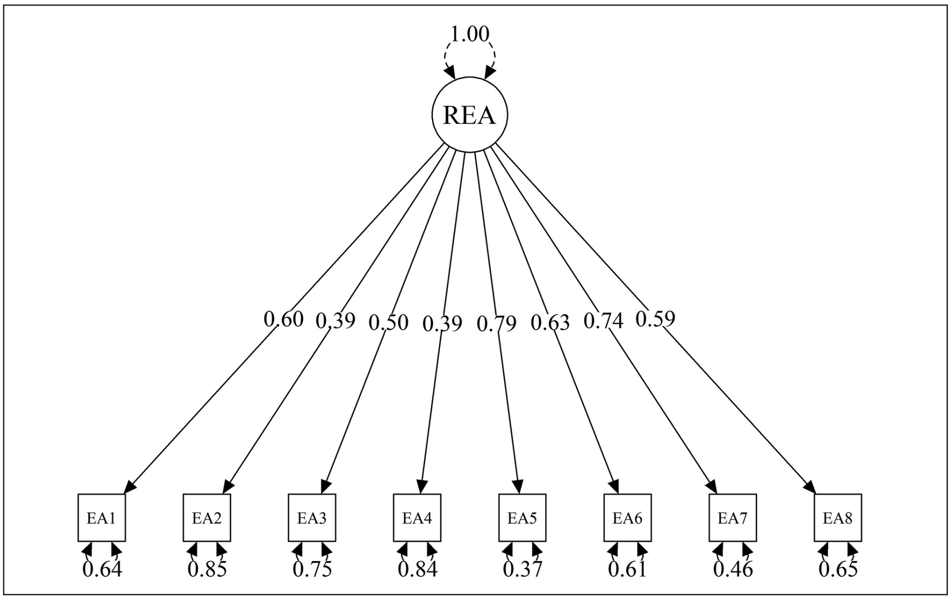

Figure 2. **The standardized parameter estimates of the one-factor model, eight-item EAI-3-HU**

3.3. Gender invariance

We tested the configural, metric and scalar invariance (van de Schoot et al., 2012) of the EAI-3-HU to determine 1) whether the same constructs are being measured across genders, 2) factor loadings are the same across the groups, and 3) the mean levels of the latent constructs are comparable across genders. As proposed by others (e.g., Cheung & Rensvold, 2002; Gilson et al., 2013), two criteria were focused upon to compare the models' fit and to discuss whether measurement invariance could be established: 1) the difference (Δ) between fit indices of the model, where we considered a CFI > 0.01 and an RMSEA > 0.015 as indicative of invariance violations, and 2) the overall fit of the model. The results for the one-factor model are presented in *Table 2*. This model fully supported the metric invariance (i.e., equal overall structure and factor loading among groups), as indicated by the ΔCFI and the scaled chi-square difference tests. However, scalar invariance was supported only partially by allowing the intercepts of items 3 and 8 to freely vary across the groups.

Table 2. Invariance test of the one-factor eight-item model across genders

Model	χ^2	*df*	CFI	TLI	RMSEA	SRMR	GFI		
Females (n = 318)	37.878	20	.969	.956	.057	.038	.968		
Males (n = 189)	31.939	20	.963	.948	.059	.048	.956		
Invariance								ΔCFI	$\Delta\chi^2$ p
Configural	69.929	40	.967	.953	.058	.038	.991	–	–
Metric	78.128	47	.965	.959	.054	.049	.990	.001	.327
Scalar	116.406	54	.933	.931	.070	.059	.986	.032	<.001
Partial scalar*	92.312	52	.956	.953	.058	.053	.989	.009	.009

Note: *In the partial scalar model, the intercepts of Item 3 and Item 8 were allowed to vary. The scaled chi-square difference test was used (Satorra-Bentler [2001] method). The partial scalar model was compared to the metric model.

Although the $\Delta\chi^2$ was still significant between the metric and partial scalar model, the ΔCFI was smaller than .01, despite being close to the threshold value of .01. Additionally, ΔRMSEA between the metric and the partial scalar model was –.004, which was smaller than the cut-off of .015. Thus, with caution, we could conclude that the partial scalar invariance between genders was established.

Examining item-by-item the differences on the one-factor, eight-item EAI-3-HU using a multivariate analysis of variance MANOVA, we found statistically significant multivariate effects (Pillai's Trace = .065, F [8, 498] = 4.31, p < .001, $p\eta^2$ = .065). The univariate tests revealed that males scored higher than females on *relapse* and *training when injured*. However, the significance level of the former was slightly above the conservative α level (see *Table 3*). Further, the effect sizes were small (converted to Cohen's d = .18 and .22, respectively). On the other hand, females scored higher on exercising for mood regulation. Despite statistical significance, the effect size was small ($p\eta^2$ of .023 reflects a Cohen's d value of .31). These differences are in line with the invariance testing results, where items 3 (mood modification) and 8 (training despite injury) did not appear invariant. Namely, the intercept of Item 3 was higher among females (3.984) than males (3.529). Conversely, males had a higher intercept of item 8 (3.596) than females (3.255). Indeed, the remaining items on the scale were not different between males and females (*Table 3*).

Table 3. Comparison of the item-by-item responses of males and females in EAI-3-HU

EAI-3-HU Items	Males Mean *(SD)*	Females Mean *(SD)*	*F*	*p*	$p\eta^2$
Salience*	3.03 (1.40)	2.92 (1.41)	.776	.379	.002
Conflict*	2.05 (1.26)	1.96 (1.27)	.581	.446	.001
Mood modification*	3.53 (1.48)	3.98 (1.40)	11.719	< .001	.023†
Tolerance*	3.11 (1.62)	2.94 (1.47)	1.335	.248	.003
Withdrawal symptoms*	3.37 (1.41)	3.53 (1.54)	1.277	.259	.003
Relapse*	4.13 (1.41)	3.86 (1.57)	3.821	.051	.008
Guilt if not training$^{\#}$	3.79 (1.58)	3.87 (1.59)	.306	.580	.001
Training despite injury$^{\#}$	3.60 (1.54)	3.25 (1.62)	5.69	.017	.011†

Notes: * = items of the EAI reflecting six symptoms in the components model (Griffiths, 2005); $^{\#}$ = additional items in the EAI-3; † = statistically significant; $p\eta^2$ = effect size, partial eta squared. (For scale statements associated with the items, please refer to *Appendix 2*).

3.4. Validity

3.4.1. Discriminant validity

The discriminant validity of the EAI-3-HU was examined with univariate analysis of covariance (ANCOVAs), using gender as the covariate.[2] The ANCOVA was calculated to assess whether the scale could distinguish between 1) those who report higher and lower *exercise frequencies* and 2) those who report higher or lower *exercise intensities*. The groups were formed using median splits. In contrast to Gelman and Park's (2007) suggestion, we only deleted cases that fell on the median, using the *"less than"* rule for one group and the *"greater than"* rule for the other to avoid comparing only the extremities that artificially would generate a larger gap between the groups. Although this method implied excluding 101 cases from the exercise frequency and 180 from exercise intensity groups, we had sufficient statistical power for the ANCOVAs as calculated with post-hoc tests using G*Power (Faul et al., 2007). Indeed, the smallest effect size was .124 ($p\eta^2$; *Table 4*), which corresponded to Cohen's f .376, yielded a power (1–β) >.99. If we had followed Gelman and Park's (2007), a significantly larger number of cases would have been deleted.

There were two ANCOVAs, one for exercise frequency groups and another for exercise intensity groups (*Table 4*). The tests assessed the discriminant validity of the eight-item one-factor EAI-3-HU. The Bonferroni correction for multiple tests was applied, which resulted in a new lower α = .00125 (.05/2 = .025). As revealed in *Table 4*, both tests were statistically significant even with this lower *alpha* level. Finally, neither the Breusch-Pagan test of heteroscedasticity nor Levene's test of equality of error variances were statistically significant in these tests (p > .05), showing that the assumptions of homoscedasticity and equality of variances were met in the data.

Table 4. Results of analyses of covariance (ANCOVA) testing the discriminant of the EAI-3-HU based on two groupings (exercise frequency and exercise intensity)

	Group	*n*	Mean *(SD)*	*F*	*p*	$p\eta^2$
Discriminant Validity Based on Exercise Frequency Grouping						
EAI-3-HU	HF	180	29.62 (7.37)	67.63	<.001	.144
	LF	226	23.66 (7.21)			
Discriminant Validity Based on Exercise Intensity Grouping						
EAI-3-HU	HI	184	28.84 (7.53)	48.66	<.001	.131
	LI	143	23.01 (7.27)			

Notes: HF = high exercise frequency group (>6 times/week); LF = low exercise frequency group (<6 times/week); HI = high exercise intensity group; LI = low exercise intensity group; $p\eta^2$ = effect size, partial eta squared.

3.4.2. Convergent validity

The EAI-3-HU showed acceptable convergent validity with OP exceeding the recommended level of .70 (Carlson & Herdman, 2010), yielding r = .72 (p < .001, 95%CI [.67, .76]).

3.5. Correlations between EAI-3-HU and exercise characteristics

Partial correlations, controlling for gender, were calculated to assess EAI-3-HU's relationship with exercise parameters and its criterion measure, obsessive passion, used to assess convergent validity. The EAI-3-HU correlated positively with all other measures: exercise frequency (r = .40), average training duration in minutes (r = .17), and perceived exercise intensity (r = .33). All correlations were statistically significant at p < .001.

[2] It was deemed necessary because men and women differed on exercise parameter measures (see *Table 1*).

3.6. Prevalence of the risk of exercise addiction

Based on the cut-off point ≥34 (Granziol et al., 2023), the REA in the current sample was 18.9% considering the one-factor, eight-item version of the EAI-3-HU. However, given that CrossFit training was overrepresented in the sample and this exercise stands apart from all others, we calculated the prevalence of REA for this group compared to the rest. The REA among CrossFit practitioners was 25.2% (60/238) compared to almost half that rate (13.4%, 36/269) in the others combined. The difference was statistically significant ($\chi^2(1)$ = 11.53, p < .001).

4. DISCUSSION

This work aimed to examine the validity and reliability of the recently released Exercise Addiction Inventory-3 (EAI-3; Granziol et al., 2023) that expands the assessment of the risk of exercise addiction (REA) beyond the component model of addiction (Griffiths, 2005) as suggested by past research (e.g., Pálfi et al., 2021). The results indicated that the EAI-3-HU is a single-factor, unidimensional scale, in contrast to the two-factor EAI-3, developed by Granziol et al. (2023) based on an international sample of Chinese, German, Italian, Japanese, and Turkish volunteers. The two-factor model could not be supported in the Hungarian version because its latent factors were highly interrelated, exceeding the criterion level of .85 (Brown, 2015), unlike the original EAI-3 (.71). It should be stressed that the EAI-3 is a *composite multinational scale* stemming from five language (and five countries) versions of the scale. However, its psychometric validation in English has not yet been established. Accordingly, whether the scale is one or two-dimensional in English or other than the five languages studied by Granziol et al. is unclear.

The current study suggests that the EAI-3-HU is a single-factor scale with excellent model fit indices. The internal reliability of the EAI-3-HU was identical to the original EAI-3 reported by Granziol et al. (2023). Unfortunately, we cannot address how the EAI-3-HU's internal reliability relates to the scale's versions in other languages because despite reporting cultural invariances, the internal reliabilities were not reported separately for the five-nation subsamples in the Granziol et al. (2023) study. Still, compared to earlier versions of the scale, like the original EAI and the revised version (EAI-R), the here obtained Cronbach's α of .80 is greater than the α values reported for the Hungarian EAI (i.e., .61 to .71 by Griffiths et al., 2015, or .72 by Mónok et al., 2012) or the Hungarian EAI-R, which was .71 (Szabo, 2021). Thus, the EAI-3-HU demonstrated superior internal reliability compared to its predecessors.

We consider the EAI-R-HU a valid and reliable instrument for assessing the REA. However, this eight-item version includes a controversial item with relatively low but acceptable factor loading. This item is 'conflict' worded as "*Concerns have arisen between me and my family and/or my partner about the amount of exercise I do*" (for the Hungarian text, see the *Appendix 2*). This item's interpretation is not straightforward as it might refer to inner conflict (e.g., I do too much exercise and neglect my studies, work, or relationships) or interpersonal conflict. Further, what one considers 'concern' or 'conflict' may vary from another's interpretation (Skjørshammer, 2001). So, conflict' in the context of the REA may be an ambiguous item. This item had to be dropped from the Chinese version of the EAI-R (Wang et al., 2022). Further, another item exhibiting somewhat lower but still acceptable factor loading (.39) is 'tolerance,' which is worded "*Over time, I have increased the amount of exercise I do in a day.*" This item is part of the health-related factor of the original EAI-3, which makes sense because, over time, most people adapt to exercise and tend to increase its volume or intensity (MacInnis & Gibala, 2016). Thus, tolerance in exercise behavior might be a 'natural response' to adaptation to exercise rather than an addictive response like in substance use disorders. Considering these arguments, we must stress that conflict and tolerance could be considered ambiguous items in the EAI-3-HU.

The results demonstrated that the scalar invariance was not supported fully across the genders, which implies that the intercepts of items 3 and 8 were not equal across genders. Therefore, researchers should consider this finding when comparing the scores across the genders because the comparisons of the total EAI-3-HU score might be biased, most likely due to the different interpretations of the mentioned items through the personal meaning of their gender-related effects on men and women. Indeed, an item-by-item comparison of the EAI-3-HU showed that men were more inclined to train despite injury, and women were more prone to use exercise for mood modification. There was also a statistically non-significant trend suggesting that males were more likely to relapse when trying to control their exercise behavior than women. Nevertheless, the covariates of the REA can be examined across genders because the results supported the metric invariance (see *Table 2*). Our results fully agree with a comparative study of five nations, including Hungary (Griffiths et al., 2015), on the original EAI's psychometric properties (Terry et al., 2004), revealing that while metric invariance could be established, scalar invariance could not. These results suggest that gender comparison of the REA should be performed as covariates, while the direct comparison of the means should be avoided. It is also advised that different cutoff scores should be calculated for men and women.

The divergent validity of the scale was good. We used here the method adopted during EAI's first development (Terry et al., 2004) comparing high and low-frequency exercises and expanded the test by also examining whether the EAI-3-HU can differentiate between those claiming to exercise with very high and somewhat high or lower intensities. Not only does the literature support the positive relationship between exercise parameters and the REA (Szabo & Demetrovics, 2022), but the here calculated correlations, after controlling for gender, also yielded positive correlations between EAI-3-HU and exercise characteristics. It should be noted that these correlations were performed with the total sample, but the cases falling on the median were omitted while examining the discriminant validity.

The convergent validity of the EAI-3-HU was also supported by their correlation meeting the criterion cutoff value suggested in the literature. However, more than one instrument should be used in assessing convergent validity, which we deliberately failed to observe to minimize the survey completion time, which is an issue in getting people to volunteer for online research. Thus, we consider this omission a delimitation of the study; at the same time, we admit that it is also a major limitation. Therefore, we recommend that future studies examine the correlation of the EAI-3-HU with other tools gauging similar concepts and possess validated Hungarian versions.

However, should we worry about the 18.9% (or even higher among CrossFitters) rate of risk of addiction in a 507-participant sample? The answer is no because these instruments measure a risk factor that may never turn into dysfunctional behavior (Szabo & Demetrovics, 2022). Nevertheless, the "*may*" can only be clarified with some certainty if those at risk undergo an interview-based clinical evaluation. Indeed, Szabo & Demetrovics (2022) consider these measures as surface screening tools that should aid medical professionals in evaluating those with high REA if the behavioral circumstances warrant it. Thus, a network of interactions between scientists, individuals at REA, and clinicians is required to determine who among those at REA is medically problematic. Because this interaction does not seem to happen, based on *less than a dozen* clinical cases reported in the literature (Juwono & Szabo, 2020) despite over 1,000 papers published on exercise addiction (Szabo & Kovacsik, 2019), questionnaire works only yield a *relative risk factor*, that leads to a dead end. Nevertheless, the EAI-3-HU is a valid and reliable instrument for measuring the REA, and its usefulness would surge if the model proposed by Szabo and Demetrovics (2022) for exercise addiction is followed through the close interaction and collaboration of researchers and clinicians.

Nevertheless, the REA was higher among CrossFit practitioners than the rest of the sample doing different forms of exercises. The prevalence rate disclosed here closely matches the rate (24%) reported by Król et al. (2022) in female CrossFitters. However, we are unaware of comparative studies examining REA in CrossFit versus other forms of exercise or sports training. Therefore, based on the current findings and those reported by Król et al. (2022), research should examine whether CrossFitters are more susceptible to exercise addiction than other athletes or recreational exercisers.

The current work has limitations, too. The first is the online examination of volunteers over which the researcher has no control. Second, the current study included exercisers who only trained once or twice weekly (9.3%). Although their number was low and their inclusion helped establish the discriminant validity of the EAI-3-HU, theoretically, these individuals are unlikely to be at REA. Third, we did not screen for athletes and non-athletes or team-based versus individual exercisers among whom the expected REA might be expected to be different (Griffiths et al., 2023). Fourth, nearly half of the sample practiced CrossFit (46.9%), and in accord with our findings, research suggest that this exercise form might be closely related to REA (Di Lodovico et al., 2019; Król et al., 2022). Still, using the Danish version of the EAI, this tool was recommended for assessing the REA in CrossFit (Lichtenstein & Jensen, 2016). Last, instead of the 21-item Exercise Dependence Scale (EDS) used by Granziol et al. (2023), we used the 6-item obsessive passion (sub)scale to establish the convergent validity of the EAI-3-HU, which, despite leading to acceptable results, might have a weaker relationship with the REA than exercise dependence. Further, using only one instrument to determine convergent validity is also a limitation. Future studies using the Hungarian EAI-3 should consider these limitations and interpret their results accordingly. Finally, validation studies in specific exercise forms are also recommended.

5. CONCLUSIONS

The EAI-3-HU emerged with good model fit, internal reliability, discriminant validity, and potentially good convergent validity. The eight-item version comprises the symptoms of the components, and it is expanded with two items: guilt when missing a workout and training despite an injury. The full metric and a partial scalar invariance across genders were supported. Therefore, gender should be used as a covariate, with the cautious comparison of the item means, especially Item 3 and Item 8, in studies using the EAI-3-HU comparing males and females. Further, studies re-confirming the scale's convergent validity and psychometric properties in *specific* exercises are warranted.

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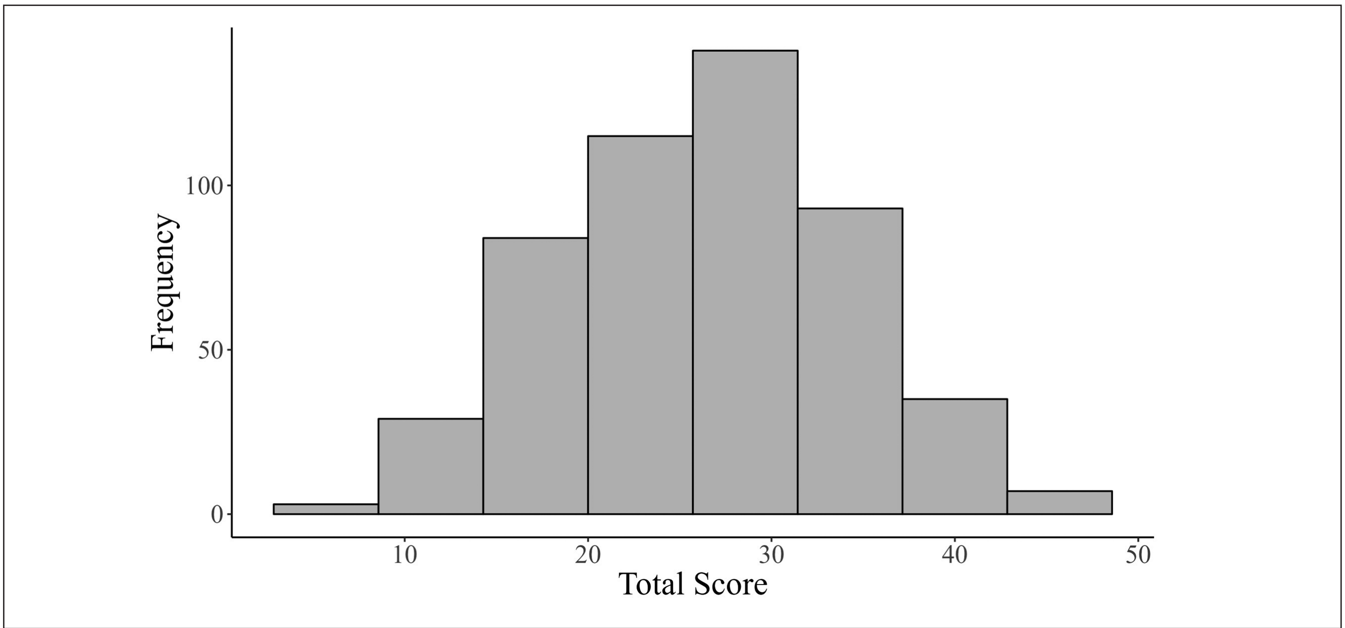
APPENDIX 1.

Descriptive of the EAI-3-HU items

EA item	*Mean*	*SD*	*Median*	*Skewness*	*Kurtosis*	*SE*
1	2.96	1.40	3	0.20	–0.95	0.06
2	1.99	1.26	2	1.24	0.75	0.06
3	3.82	1.45	4	–0.31	–0.77	0.06
4	3.00	1.53	3	0.39	–0.96	0.07
5	3.47	1.49	4	0.01	–0.93	0.07
6	3.96	1.51	4	–0.56	–0.68	0.07
7	3.84	1.58	4	–0.28	–0.95	0.07
8	3.38	1.60	4	0.01	–1.15	0.07

Notes: SD = Standard deviation; *SE* = Standard error.



Distribution of the eight item EA-3-HU scores

APPENDIX 2.

Testedzésfüggőség Kérdőív (EAI-3-HU)

Instrukció: Az alábbi skála segítségével, kérjük jelölje meg, mennyire igazak Önre az egyes állítások. Ne gondolkozzon sokat, hanem az első benyomás/gondolat alapján jelölje meg a válaszokat!

EAI-3-HU	Egyáltalán nem értek egyet	Nem értek egyet	Inkább nem értek egyet	Inkább egyetértek	Egyetértek	Teljes mértékben egyetértek
1. A testedzés a legfontosabb dolog az életemben.*	1	2	3	4	5	6
2. Konfliktusok adódnak köztem és a családom és/vagy partnerem között amiatt, hogy mennyit edzek.*	1	2	3	4	5	6
3. A testedzést arra használom, hogy a hangulatomon változtassak (pl., hogy kellemesebben érezzem magam, vagy hogy ne kelljen a problémáimmal foglalkoznom.)*	1	2	3	4	5	6
4. Az elmúlt időszak során növeltem a napi edzés-mennyiségemet.*	1	2	3	4	5	6
5. Ha ki kell hagynom egy edzést, rosszkedvű és ideges leszek.*	1	2	3	4	5	6
6. Ha lecsökkentem a szokásos edzésmennyiségemet, akkor amikor újra elkezdem az edzést, addig folytatom, amíg az eredeti mennyiséget el nem érem.*	1	2	3	4	5	6
7. Bűntudatom van, ha egy tervezett edzést nem viszek véghez.	1	2	3	4	5	6
8. (Olykor) sérülések ellenére is elmegyek edzeni.	1	2	3	4	5	6

The eight-item scale represents the one-factor EAI-3-HU (cutoff = 34). The items with a star (*) represent the EAI-R-HU (Szabo, 2021). Whichever scale is used, the rating is based on the sum of the constituent items, and there are no inversely rated items. The English version of the EAI-3 is available in the paper by Granziol et al. (2023).