# Exercise addiction measure through the *Exercise Addiction Inventory* (EAI) and health in habitual exercisers. A systematic review and meta-analysis

## *Adicción al ejercicio medida a través del* Exercise Addiction Inventory *(EAI) y salud en deportistas habituales. Una revisión sistemática y meta-análisis*

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## Abstract

Research on physical exercise addiction is becoming more frequent due to the importance of excessive physical activity on health in general. Different studies have investigated the prevalence of risk of exercise addiction (REA) and its consequences. Furthermore, there exist a series of contradictions regarding the relationship between REA and other variables associated with physical training. One goal of this systematic review and meta-analysis consists of analysing possible differences in prevalence, age, general health (mental and physical quality of life, eating disorders) and physical training (hours/week) between groups with REA and non-addicted groups. The Exercise Addiction Inventory (EAI) was used to undertake this research. Research was carried out in electronic databases such as Pubmed, SPORTDiscus or Scopus. Inclusion criteria: Studies were eligible as long as participants were measured with EAI, results showed prevalence of REA and/or EAI score, and the study was observational. Twenty studies met the established eligibility criteria for inclusion in the systematic review, whereas seventeen studies were included in the meta-analysis. Regarding mental quality of life, results showed lower values for the exercise addiction risk group, compared with the non-addicted group. The exercise addiction group was younger than the non-addicted group and dedicated more weekly hours to physical training. Subjects with REA have a lower health profile than those with non-REA. However, more research is required, given the lack of consensus on how to measure exercise addiction and the scarce number of studies to date.

*Keywords:* Addiction; Disorder; Physical activity; Quality of life; Training.

## Resumen

Cada vez es más frecuente la investigación sobre adicción al ejercicio debido a la importancia del exceso de actividad física en la salud general. Diferentes estudios han investigado la prevalencia del riesgo de adicción al ejercicio (RAE) y sus consecuencias, existiendo contradicciones con respecto a la asociación entre el RAE y las variables asociadas al entrenamiento. Uno de los objetivos de esta revisión sistemática fue analizar los estudios que han usado el *Exercise Addiction Inventory* (EAI) para valorar el RAE, así como realizar un meta-análisis para observar las posibles diferencias entre grupos con y sin RAE respecto a la prevalencia, edad, variables de salud (calidad de vida física y mental, desórdenes alimentarios) o de entrenamiento físico (horas/semana). Las búsquedas de estudios se realizaron en bases de datos electrónicas como Pubmed, SPORTDiscus o Scopus, y se hicieron utilizando términos de indexación y palabras clave relacionados con materias médicas o ciencias del deporte. Los criterios de inclusión fueron: participantes evaluados con el EAI; resultados reportados de prevalencia de RAE y/o puntuación en dicho cuestionario; diseño observacional. Veinte estudios cumplieron los criterios de elegibilidad para la revisión sistemática y 17 fueron incluidos en el meta-análisis. Los resultados mostraron peores valores en calidad de vida mental y trastornos de alimentación en el grupo con RAE comparado con el grupo sin RAE. Además, el grupo con RAE era más joven y realizaba más horas de entrenamiento semanal. No obstante, es necesaria más investigación.

*Palabras clave:* Adicción; Trastorno; Actividad física; Calidad de vida; Entrenamiento.

*Received: June 2017; Accepted: February 2018.*

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Although benefits of physical exercise are commonly well-known (Kokkinos & Myers, 2010), there is now a growing literature that a small minority of people can experience various negative consequences of over practicing exercise (Berczik et al., 2012). This is the reason why it has been suggested that there may exist a limit in the exercise volume that results in negative health effects, such as the risk of exercise addiction (Szabo, Griffiths, de La Vega Marcos, Mervó & Demetrovics, 2015). Exercise addiction has been described as a morbid pattern of behavior in which the usually exercising individual loses control over his or her exercise habits and acts compulsively, exhibits dependence and experiences negative consequences on health as well as on his or her social and professional life (Szabo et al., 2015). In this systematic review, the term "addiction" has been considered to be the most appropriate one, because some scholars (Berczik et al., 2012) have emphasized this term since it includes both dependence and compulsion (Goodman, 1990). A significant limitation is the use of multiples terminologies to describe the same phenomenon, including 'exercise addiction' (Berczik et al., 2012), 'exercise dependence' (Hausenblas & Downs, 2002a; Pasman & Thompson, 1988), 'obligatory exercising' (Pasman & Thompson, 1988), 'exercise abuse' (Davis, 2000), and 'compulsive exercise' (Dalle Grave, Calugi & Marchesini, 2008). To assess the negative effects of excessive exercise, several instruments have been developed and reviewed (Allegre, Souville, Therme & Griffiths, 2009), such as the 'Compulsive Exercise Test' (Taranis, Touyz & Meyer, 2011), the 'Exercise Dependence Scale' (Hausenblas & Downs, 2002a), the 'Exercise Dependence Questionnaire' (Ogden, Veale, & Summers, 1997) and the 'Exercise Addiction Inventory' (EAI) (Griffiths, Szabo, & Terry, 2005), that provide a range of risk scores instead of a diagnosis (Szabo et al., 2015). Although people with exercise addiction develop loss of control in such ways that exercise becomes an obligation and overage (Szabo et al., 2015; Mónok et al., 2012), the exercise addiction has not officially been classified as a mental disorder in the latest (fifht) edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (*American Psychiatric Association*, 2013).

On the basis of symptoms derived from exercise addiction (Szabo et al., 2015), the EAI was developed to screen for this pathology (Griffiths et al., 2005). It consists of 6 questions based on the 6 general components of addiction (salience, mood modification, tolerance, withdrawal symptoms, social conflict, and relapse) (Griffiths, 1996). The responses are rated on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*) and a sum score is calculated (range 6-30 points), where a score ≥ 24 indicates probable exercise addiction. Regarding psychometric properties of EAI, they have shown satisfactory results in different studies, with adequate values on validity and reliability (Lichtenstein, Christiansen, Bilenberg, & Stoving, 2014; Lichtenstein & Jensen, 2016; Mónok et al., 2012; Sicilia, Alias-Garcia, Ferriz, & Moreno-Murcia, 2013). Furthermore, a recent cross-cultural re-evaluation of the EAI in five countries showed that despite some inter-country differences, the EAI is still an appropiate instrument to assess exercise addiction (Griffiths et al., 2015).

Several studies have researched exercise addiction using the EAI in distinct population samples and the prevalence of exercise addiction risk and/or the relationship of this on different physical and mental health variables (Cunningham, Pearman, & Brewerton, 2016; De la Vega, Parastatidou, Ruiz-Barquin & Szabo, 2016; Li, Nie & Ren, 2015; Lichtenstein, Andries, Hansen, Frystyk & Stoving, 2015; Lichtenstein, Christiansen, Elklit, Bilenberg & Stoving, 2014; Lichtenstein & Jensen, 2016; Maraz, Urban, Griffiths & Demetrovics, 2015; Mayolas-Pi et al., 2017; Mónok et al., 2012; Sicilia et al., 2013; Szabo, De la Vega, Ruiz-Barquín & Rivera, 2013; Weinstein, Maayan & Weinstein, 2015). Nonetheless, there is a large variability among studies on the prevalence of REA (Szabo et al., 2015 Furthermore, overtraining volume has been highlighted among the numerous objective and subjective factors that could explain this variability (Adams, Miller & Kraus, 2003; Chapman & De Castro, 1990). Currently, the relationship between REA and training volume is contradictory (Cook et al., 2013; Szabo et al., 2013) since several authors affirm that exercising excessively does not necessarily indicate a disorder and that this fact is not necessarily maladaptive (Szabo et al., 2015). The relationship between REA and other variables associated with training such as weekly frequency, hours per week and others, is also confusing or unknown (Freimuth, Moniz, & Kim, 2011; Youngman & Simpson, 2014). A previous systematic review carried out by Hausenblas & Downs (Hausenblas & Downs, 2002b) about exercise dependence, concluded that results had been inconclusive due, in part, to a lack of experimental research, inconsistent or nonexistent control groups, discrepant operational criteria or inappropriate measures of exercise dependence. Therefore and because of the increasing number of studies on exercise addiction in recent years (Szabo et al., 2015), a meta-analytic review is needed to clarify and join these results to advance through knowledge in the area, evaluate methodological limitations and provide an overview of exercise addiction defined by the EAI-score. This might be a starting point for future systematic reviews that include more instruments to assess the mentioned disorder.

Accordingly, the main objective of the present study was, in habitual exercisers:

– To evaluate the possible existing of differences in quality of life (physical and mental) among people with REA and people without REA.

A secondary objective was, in habitual exercisers:

– To assess possible differences in eating disorders, age and hours of weekly training among people with REA and people without REA.

## Method

This review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher et al., 2015). The review was registered in the International Database of Prospectively Systematic Reviews (PROSPERO registration number: CRD42017065252).

### *Inclusion and Exclusion Criteria*

Studies were included in the systematic review if:

– The exercise addiction was assessed with the EAI.

– The studies showed results about the prevalence of exercise addiction and/or the score in the questionnaire EAI.

– Design was observational study.

We excluded studies that only assess exercise addiction using questionnaires different from the EAI due to the conceptual dispersion in which the current state of the matter is found, and because EAI is the recommended instrument to assess exercise addiction in general (Griffiths et al., 2015). We excluded studies whose language was different from English or Spanish. In addition to the previous ones, the inclusion criteria for meta-analyse were:

The study reported prevalence of REA and/or results on physical and mental quality of life, age or eating disorders between REA group and non-addicted group.

### *Information Sources and Search Strategy*

Initial electronic database searches were performed up to March 27th 2017 using Pubmed, SPORTDiscus, Scopus, Science Direct and ProQuest Psychology Database. The electronic database search was updated on May 30th 2017. Medical subject headings (MeSH), database indexing terms, keywords and Boolean operators (AND/OR) were used in the search strategy. Terms were grouped into themes related to exercise addiction, dependence of exercise and health. For Pubmed, search terms included: "exercise addiction" [Title] OR "dependence exercise" [Title] AND EAI [Title/Abstract] OR "Exercise Addiction Inventory [Title/Abstract]. For SPORTDiscus we used limiters like English and Spanish; Journal Academical; TI (Title) "Exercise addiction" OR "dependence of exercise" AND AB (Abstract) "EAI" OR AB (Abstract) "Exercise Addiction Inventory". All searches were leaded by the same author (JS). Search results were collated using Endnote software (Thomson Reuters, New York), and duplicates were removed. The title and abstract of the remaining studies were screened for relevance (JS). Full texts of potentially appropiate studies were obtained and independently assesed for elegibility by two authors (JS/NE) according to the inclusion criteria. Reference lists and citations of selected manuscripts and relevant review articles were examined for potentially eligible studies (JS).

### *Data Extraction Process*

Study characteristics including sample size, age, weight, height, education level, marital status, characterisation of samples, exercise mode, measures, groups, score-EAI and/or prevalence of exercise addiction (EA), variables analized (injury risk, REA, activity level, physical and mental quality of life, eating disorders, etc), type of study and outcomes; were extracted for selected studies (JS). Means (standard deviations) and frequencies (proportions) of the primary (physical and mental quality of life) and secondary outcomes (age, prevalence of EA and hours of training) for exercise addiction group and comparator groups were extracted (JS). Reviewers (JS/NE) were not blinded by authors or institutions at any stage of the selection or data collection process.

### *Data Items*

Exercise addiction risk (score-EAI) was the primary outcome. It has been described as a morbid pattern of behaviour in which the habitually exercising individual loses control over his or her exercise habits and acts compulsively, exhibits dependence and experiences negative consequences on health as well as in his or her social and professional life (Szabo et al., 2015). Prevalence of EA was defined as the proportion of the participants who were found to score above 24 on the EAI. Age (years) was defined as the length of time during which a being or thing has existed. Quality of life (score-SF36) was defined as an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns (Saxena, Carlson, & Billington, 2001). Eating disorder (score-EDI-2) (Garner, 1991; Garner, Olmstead, & Polivy, 1983) describes illnesses that are characterized by irregular eating habits and severe distress or concern about body weight or shape. These disorders have become an emerging pathology in developed and developing countries, becoming the third most common chronic disease found among teenagers after obesity and asthma (Gonzalez, Kohn, & Clarke, 2007). Hours per week of exercise is a variable associated with training, such as weekly frequency, intensity or years of sports practice.

### *Risk of Bias in Individual Studies*

Risk of bias was assessed by using the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) (Vandenbroucke et al., 2014). Two authors (JS/NE) independently assessed risk of bias. Appraisal of

study quality was performed according to subject expertise (led by JM) and guided by the risk of bias assessment tool.

### *Data management*

The mean and standard deviation (SD) of participant physical characteristics, age and score-EAI, education level, marital status, sample size, country, exercise mode and comparison groups were used to subjectively determine methodological heterogeneity of the meta-analysis (JS/JMM). Data for exercise addiction risk group and non-addicted group were analysed using OpenMetaAnalyst version 3.1.0, and they were expressed as a standardised mean difference (adjusted Hedges' g), and a 95% confidence interval (95% CI). If the 95% CI included zero, we concluded there were no signficant effects. Statistical heterogeneity was assessed using the *I2* statistic in order to determine the percentage of the variability in estimations of the effect due to heterogeneity rather than sampling error. Pooled estimations of the effect, and 95% CIs, as a weighted average of the standardized mean difference estimated in individual studies were calculated. A random-effects model was used to figure out the pooled effect, because high levels of heterogeneity were expected. We performed a subsequent analysis to obtain the overall mean age, and the overall mean prevalence of exercise addiction on the studies analyzed.

## Results

### *Participants and Included Studies*

Figure 1 details the PRISMA (Moher et al., 2015) flow chart. This search was carried out in 5 databases and after removing duplicates, fifty-two studies were screened. Twenty studies out of the previously mentioned fifty-two, were selected to systematic review and seven studies were not included. Seventeen of them were included in the meta-analysis and three of them were not included because they did not analyze prevalence or target variables. Participant characteristics are shown in Table 1 and study details in Table 2. Participants of the studies selected were born in England (n=3), China (n=1), France (n=1), Spain (n=3), EEUU (n=2), Hungary (n=3), Italy (n=2) and Denmark (n=4). The studies included were published between 2005 and 2017. The overall age range of participants in the different studies was 16-40 years. The mode of exercise analyzed in the different studies was very varied and it included weight lifters, crossfitters, triathletes, cyclists,

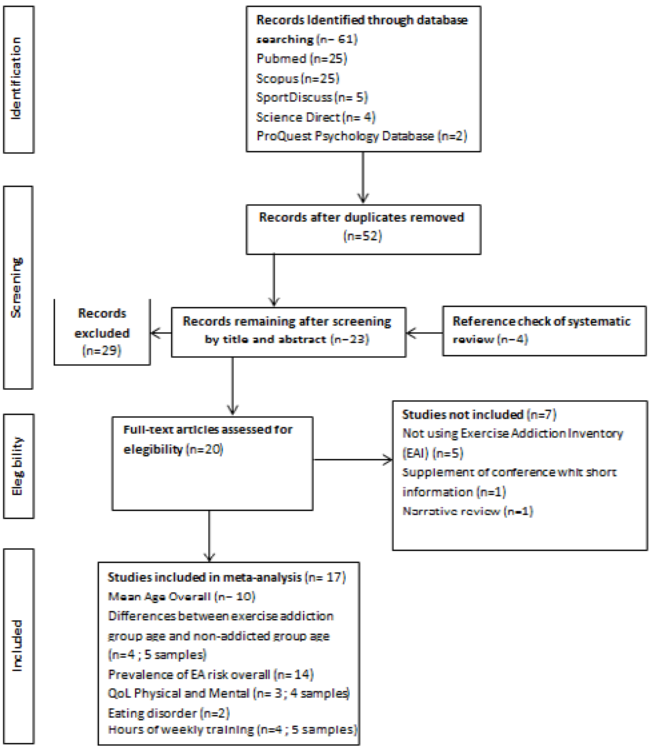


*Figure 1.* PRISMA flow diagram. PRISMA Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Shamseer et al., 2015)

Table 1. *Characteristics of participants in included studies*

| Study | Number of Participants and country | Age (years) M (SD) | Height (cm) M (SD) | Weight (kg) M (SD) | Education (%) | Marital Status (%) | Characterisation |
|---|---|---|---|---|---|---|---|
| Babusa et al. 2015 | 304 participants (Hungary) | 27.8±7.40 | 179.5±6.05 | 87.5±14.63 | Less than high education (19%)<br>Graduated in high school (49,7%)<br>Graduated in college (31,3%) | Single (53,6%)<br>Married or cohabiting (43,8%)<br>Divorced (2,6%) | Male weightlifters |
| Bruno et al. 2014 | 150 participants (Italy) | HEA risk group (29,7±7,1)<br>LEA risk group (32,2±10,1) | - | - | - | - | Consecutive gym attenders<br>HEA risk group (males: 33; females: 18)<br>LEA risk group (males: 36, females: 33) |
| Cunningham et al. 2016 | 1497 participants (EEUU) | Total Sample (33,2±12,4) | - | - | - | - | Adults (608 men, 885 women, 4 other)<br>625 Participants in this sample (university participant) using Amazon Mechanical Turk received either $1.00 or $1.20 for completing the surveys. 872 respondents in this sample (e.g., triathletes, cyclist, runners, powerlifters) using email, social media, and printed fliers were entered for a chance to win an iPad Air |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| De la Vega et al. 2016 | 313 participants | Men (31.1±10.1)<br>Women (28.6±7.4)<br>Non-competitive, leisure exercisers (31.5±9.3)<br>Local/regional athletes (29.3±8.7)<br>National/International athletes (28.7±11.3) | - | - | - | - | Adults (204 men, 109 women) Participants took part in 17 different sports. However, they represented predominantly (85%) seven sports, including gymnastics (n=81), athletics (n=73), football (n=50), duathlon (n=26), swimming (n=25), triathlon (n=24), and basketball (n=12). |
| Griffiths et al. 2005 | 200 particip. (phase 1)<br>79 particip. (phase 2)<br>(England) | 21.24±3.77 | - | - | - | - | Habitual male and female exercisers. The sample included those who engaged in many different forms of exercise. The age range was 18-40 years. |
| Lejoyeux et al. 2012 | 500 participants (Francia) | All subjects (29±10.3)<br>ED+ (27.1±8.6)<br>ED- (29.8±10.8) | - | - | College undergraduates (2,6%)<br>College graduates (29%)<br>High school graduates (68%) | - | Customers of a Parisian sport (male and female) shop aged 18 years old and over. Male (n=285); Female (n=215). |
| Li et al. 2015 | 1601 participants (China) | All subjects (20.51) | - | - | High school graduates (100%) | - | College students from three universities in Hunan (China). Male (n=984) ; Female (n=617). The range of age was 19 to 22 year. |
| Lichtenstein et al. 2014 | 121 participants (Denmark) | HEA (28,3±7,5)<br>LEA (33,5±9,1) | - | - | - | - | Exercisers males (n=79) and females (n=42). The range of age was 19-56 years. |
| Lichtenstein et al. 2015 | 58 participants (Denmark) | HEA (30,3±7,9)<br>LEA (37,4±6,8) | - | - | - | - | Habitual men amateur exercisers. |
| Lichtenstein & Stoving 2016 | 452 participants (Denmark) | - | - | - | - | - | Adolescents and patients from an eating disorder (age range 11-20 years). |
| Lichtenstein & Jensen 2016 | 603 participants (Denmark) | - 30 years (n=290)<br>31 + years (n=285) | - | - | - | - | Crossfitters male (n=328) and female (n=270). |
| Maraz et al. 2015 | 457 participants (Hungary) | 32.8±8.6 | - | - | Graduated education (70%)<br>Secondary school (28%)<br>Education lower than secondary school (2%) | - | Salsa and ballroom dancers female (n=305) and male (n=152) |
| Mayolas et al. 2017 | 1577 participants (Spain) | HEA men (37.2±8.8)<br>LEA men (38.4±8.4)<br>HEA women (34.4±10)<br>LEA women (37.4±7.4) | - | - | - | - | Amateur endurance cyclist male (n=751) and female (n=108) and inactive subjects male (n=307) and female (n=411). |
| Mónok et al. 2012 | 474 participants. (Hungary) | 33.2±12.1 | | | Less than high school education (18.3%)<br>Finished high school education (35.8%)<br>College or university education (45.9%) | Married (37.3%)<br>In a relationship (10.6%)<br>Single (43.4%)<br>Divorced (8.6%) | Exercisers male (n=270) and female (n=204). |
| Sicilia et al. 2013 | 584 participants (Spain) | 22.13±3.93 | - | - | College or university education (100%) | - | Participants male (378) and female (206). 437 participants of the total sample were students of Physical Education and Sport Sciences, whereas 147 studyng other disciplines (business administration, psychology, etc.). Range of aged 18 to 55 years. |
| Szabo y Griffiths 2007 | 455 participants (England) | - | - | - | - | - | A total of 455 male and female participants (261 sports science students ; 194 gym users). The age range of Sport science student group was 19-23 years and the age range of general exercising population group was 17-74 years. |
| Szabo et al. 2013 | 242 particip. (Spain) | 27.54±10.65 | - | - | - | - | 242 athletes (164 men and 78 women) were recruited from Madrid Metropolitan area. |
| Villella et al. 2010 | 2853 participants (Italy) | 16.7±1.9 | - | - | - | - | The population was made of 1142 girls (40%) and 1711 boys (60%). The age range was 13-20. |
| Warner & Griffiths 2006 | 100 participants (England) | 37.6 ±12.6 | - | - | - | - | Opportunistic gym-based volunteers aged 18 to 74 years (46 male and 54 female) |
| Youngman et al. 2014 | 1273 participants (EEUU) | 37.93±9.35 | 172.21±9.75 | 70.23±13.20 | Trade/Technical Training (0.7%)<br>Graduated from High School (1.3%)<br>Some College (5.7%)<br>Doctorate (14.6%)<br>Bachelor's Degree (41.9%) | Married (59.9%)<br>Single (19.6%)<br>Divorced/Separated (7.5%)<br>Significant Other (12.8%)<br>Widowed (2%) | Of the 1273 triathletes, 589 (46.3%) were male and 684 (53.7%) were female. |

*Note*. M, average ; SD, standard deviation ; EA, Exercise Addiction ; HEA, High Exercise Addiction ; LEA, Low Exercise Addiction ; ED+, Exercise dependence ; ED-, without exercise dependence.

Table 2. *Details of included studies that used Exercise Addiction Inventory (EAI)*

| Study | Exercise mode | Measures | Groups | Score-EAI or prevalence of EA M(SE or SD) or (%) | Variables analized | Study | Outcomes |
|---|---|---|---|---|---|---|---|
| Babusa et al. 2015 | Weightlifting | Sociodemographic and anthropometric data<br>Exercise-related variables<br>Weight dissatisfaction<br>Muscle Appearance Satisfaction Scale (MASS)<br>EAI | Low risk MD (n=100)<br>Moderate risk MD (n=158)<br>High risk MD (n=46) | Low risk MD (12.16±0.34)<br>Moderate risk MD (17.42±0.31)<br>High risk MD (22.70±0.53) | Bodybuilding Dependence<br>Muscle cheking<br>Substance Use<br>Injury Risk<br>Muscle Satisfaction<br>Exercise Dependence<br>QF of exercise<br>Supplement use<br>Current AAS use<br>Lifetime AAS use | Transversal | The high risk MD had the highest means on all subscales of the MASS, except on the Muscle Satisfaction subscale. This group also displayed the highest level of exercise addiction, exercised most frequently, spent the most time working out, displayed more injury risk and most prevalence of supplement use (82,6%) comparing to the other two groups (Low risk MD: 49%; Moderate risk MD: 70,73%). |
| Bruno et al. 2014 | Gym training | Sociodemographic questionnaire<br>EAI<br>Narcissistic Personality Inventory (NPI)<br>Coopersmith Self-Esteem Inventory (SEI) | HEA risk group (n=51)<br>LEA risk group (n=69) | Prevalence rate of EA risk: 42.5% | Exercise Addiction<br>Self-esteem<br>Narcissistic components (seven factors) | Transversal | The prevalence rate of EA risk in gym attenders was 42,5%; no gender differences in the rate of risk for exercise addiction were found. HEA risk group reported significantly lower SEI total score (32.2 vs 36.4) and higher NPI total score (20.2 vs 14.6) than LEA risk group. The narcissism and self-esteem as a block were good predictors of days perweek exercise. |
| Cunningham et al. 2016 | Athletes (e.g., triathletes, cyclists, runners, powerlifters) and Non-Athletes | Godin Leisure-Time Exercise Questionnaire (GLTEQ)<br>Exercise Dependence Scale-21 (EDS-21)<br>EAI<br>Compulsive Exercise Test (CET)<br>Obligatory Exercise Questionnaire (OEQ)<br>Commitment to Exercise Scale (CES)<br>Exercise-Specific Dimensional Obsessive-Compulsive Scale<br>Eating Disorder Examination-Questionnaire (EDE-Q) | Athletes (n=381)<br>Non-Athletes (n=1116) | EAI score in Athletes (17.4±4.93) and Non-Athletes (15.1±5.39) | Physical fitness and activity level<br>Exercise dependence<br>Exercise Addiction<br>Compulsive Exercise<br>Obligatory Exercise<br>Psychological commitment to exercise<br>Obsessive-compulsive<br>Eating Disorder | Transversal | The GLTEQ proved to be an inaccurate measure of exercise in this study. The group of Athletes scored significantly higher than non-athletes on all measures (exercise dependence, exercise addiction, obligatory exercise, obsessive-compulsive and eating disorder), and effect sizes were moderate to large. There were no differences in results when adjusted for age and gender. The correlation coefficients between measures of exercise addiction (EDS-21 and EAI) were more significantly correlated with each other than they were with either measure of compulsive exercise (CES and CET). |
| De la Vega et al. 2016 | Athletes of 17 different sports | Demographic questionnaire<br>EAI<br>Passion Scale (SPS) | First Comparison<br>Leisure exercisers (n=139) vs Local/regional athletes (n=144) vs National/International athletes (n=30)<br>Second Comparison<br>Individual-sports athletes (n=244) vs Team-sports athletes (n=69) | First Comparison<br>Leisure exercisers (18±4.7) vs Local/regional athletes (19.3±3.8) vs National/international athletes (20.6±3.4)<br>Second comparison<br>Individual-sports athletes (18.8±4.4) vs Team-sports athletes (19.0±4) | Exercise Addiction<br>Harmonious passion<br>Obsessive passion<br>Dedication | Transversal | Obsessive passion and dedication to sports emerged as strong predictors of exercise addiction. Competitive athletes scored higher than leisure exercisers on all measures. Athletes competing at low high levels only differed in dedication to their sports from each other. Team-sports athletes reported greater harmonious and obsessive passions, and dedication to sports, but not different exercise addictions, than people taking part in individual sports. |
| Griffiths et al. 2005 | Habitual exercisers who took part in many different forms of exercise (team sports, aerobics, combat sports, gym, etc.) | EAI<br>OEQ<br>EDS | Not comparison | Prevalence rate of EA risk (3%) | Exercise Addiction | Transversal | Six of the participants (3%) were found to score above 24 on the EAI and to be"at risk" from exercise addiction. A correlation between weekly frequency of exercising and EAI scores was also performed, and it was found that the two variables share 29% of the variance. |
| Lejoyeux et al. 2012 | Consecutive customers that bought sports item (tennis, swimming, soccer, running, bodybuilding, horse-riding, dancing, martial arts, ski, rubgy) | Socio-demographic questionnaire<br>Type of items bought<br>EDS<br>EAI<br>DSM-IV-R<br>CAGE<br>Fagerström questionnaire<br>Whiteley Index | ED+ (n=148)<br>ED- (n=352) | Prevalence rate of EA risk (29.6%) | Exercise addiction<br>Alcohol consumption<br>Nicotine consumption<br>Susbtance use disorders<br>Hypochondria<br>Bulimia<br>Compulsive buying | Transversal | In this study the autors confirm an association between ED and bulimia. Exercise addicts more often presented binge eating and behavior of weight compensation. They also confirmed that exercise addicts are more often hypochondriacs and present a higher level of illness anxiety. |

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|---|---|---|---|---|---|---|---|
| Li et al. 2015 | College students members of physical exercise clubs (e.g., basketball club, volleyball club, football club, badminton club, dance club, aerobics club, martial art association, etc.) | EAI<br>Strate-trait Anxiety Inventory (STAI)<br>The Center for Studies Depresion Scale (CES-D)<br>Well-Being Scale (SWB) | HEA (n=181)<br>LEA (n=1420) | Prevalence rate of EA risk (11.3%) | Exercise addiction<br>Anxiety (state anxiety and trait anxiety)<br>Depression<br>Subjective well-being | Transversal | Exercise addiction positively affects the state anxiety, depression, and negative mood of the study subjects, but negatively affects their selfsatisfaction , social behavior, and energy. |
| Lichtenstein et al. 2014 | Exercisers recruited from fitness clubs and football teams. Further sports and medicine students at the University, and employees at the police station. | EAI<br>Self-report Short-Form (SF-36)<br>Eating Disorder Inventory version 2 (EDI-2)<br>NEO Personality Inventory Revised (NEO PI-R)<br>Revised Adult Attachment Scale (R-AAS) | HEA (n=41)<br>LEA (n=80) | Prevalence rate of EA risk (33,88%)<br>Score-EAI total (19.3±6) | Exercise addiction<br>Quality of life<br>Eating disorder symptoms<br>Personality traits<br>Attachment styles | Case-control study | The addiction group scored higher on eating disorder symptoms, especially on perfectionism but not as high as eating disorder populations. The addiction group reported more bodily pain and injuries. |
| Lichtenstein et al. 2015 | Habitual amateur exercisers participating in running, fitness, weight training, and biking. | EAI<br>EDI-2<br>SF-36<br>Blood samples and plasma concentrations<br>Dual-energy x-ray absorptiometry<br>Harpender stadiometer | HEA (n=29)<br>LEA (n=29) | HEA (25.4±1.6)<br>LEA (12.4±3.4) | Exercise addiction<br>Plasma leptin<br>Sex hormones<br>Body composition<br>Eating disorder symptoms | Transversal | The exercise addiction group had significantly lower leptin levels than controls. Even when adjusted for body fat percentage, the addiction group had significantly lower leptin levels than the controls. None of the exercisers seemed to suffer from an eating disorder. |
| Lichtenstein & Stoving 2016 | Unidentified | EAI | Adolescents in sport settings (n=383)<br>Patients from an eating disorder department (n=69) | Prevalence rate of EA risk in adolescents (5,5%)<br>Prevalence rate of EA risk in eating disorder patients (21.2%) | Exercise addiction<br>Eating disorder symptoms | Transversal | In this study found a positive linear relationship between EAI-score and “high weekly exercise amounts”, “the tendency to exercise in spite of injury, “feelings of guilt when not exercising”, “reduced sport performance related to overtraining” and “food dominating life”. |
| Lichtenstein & Jensen 2016 | Crossfitters | EAI<br>Exercise amounts<br>Four additional items | HEA (n=29)<br>LEA (n= 543) | Prevalece rate of EA risk (4.8%)<br>Score EAI total (17.4±3.7) | Exercise addiction<br>Obsessive exercise<br>Take medication to exercise<br>Exercise in spite of pain/injury<br>Feeling guilt when missing exercise | Transversal | The autors found that 5% of the crossfitters were addicted to exercise and that young males had a higher risk. Also found significant positive associations between exercise addiction and the tendency to exercise in spite of injury, feelings of guiltwhen unable to exercise, passion turning into obsession and taking meditacion to be able to exercise. |
| Maraz et al. 2015 | Salsa and ballroom dancers | Dance Addiction Inventory (DAI) adapted of EAI<br>Brief Symptom Inventory (BSI)<br>Mental Health Continuum-short form (MHC)<br>Body mass index and body image<br>SCOFF questionnaire<br>McLean Screening Instrument for Borderline Personality Disorder (MSI-BDP)<br>Dance Motivation Inventory (DMI) | Class 1 (n=40)<br>Class 2 (n=56)<br>Class 3 (n=189)<br>Class 4 (n= 111)<br>Class 5 (n= 51) | Prevalence rate of risk with social conflict (11.4%) | Dance addiction based on exercise addiction<br>Relevant psychological symptoms<br>Subjective wellbeing<br>Body mass index<br>Body image<br>Eating disorder symptoms<br>Borderline symptoms<br>Dance motives | Transversal | Five latent classes were explored based on addiction symptoms with 11% of participants belonging to the most problematic class. DAI was positively associated with psychiatric distress, borderline personality and eating disorder symptoms. Dance addiction as assessed with the DAI is associated with indicators of mild psychopathology. |
| Mayolas et al. 2017 | Endurance cyclist | Sociodemographic questionnaire<br>Short Form Survey version 2.0 (SF-12v2)<br>Pittsburgh Sleep Quality Index (PSQI)<br>Hospital Anxiety and Depresion Scale (HADS)<br>International Physical Activity Questionnaire (IPAQ)<br>International Fitness Scale (IFIS)<br>Mediterranean Diet Adherence Screener (MEDAS)<br>Fagerström Test for Nicotine Dependence<br>Standard alcohol units | HEA men (n=125)<br>LEA men (n=626)<br>HEA women (n=17)<br>LEA women (n=91)<br>Inactive men (n=307)<br>Inactive women (n=411) | Score EAI HEA men (25.9±1.6)<br>Score EAI LEA men (17.9±3.4)<br>Score EAI HEA women (25.2±1.3)<br>Score EAI LEA women (17±4.1)<br>Prevalence rate of EA risk in men (16.64%)<br>Prevalence rate of EA risk in women (15.74%) | Exercise addiction<br>Physical QoL<br>Mental QoL<br>Sleep<br>Anxiety<br>Depression<br>Cardiometabolic risk | Transversal | In men, compared with the control group, the HEA and LEA groups had better indicator of physical QoL, mental QoL, anxity and cardiometabolic risk. Similar results were observed in women. In both sexes, the control group and the HEA group had comparable values of quality of sleep. In men, compared with the control group, the HEA group had worse indices of depression; no differences were observed between the groups in the sample of women. No result varied significantly as a function of road cycling practice or MTB. |

*(Below Table 2)*

| Study | Exercise mode | Measures | Groups | Score-EAI or prevalence of EA M(SE or SD) or (%) | Variables analized | Study | Outcomes |
|---|---|---|---|---|---|---|---|
| Mónok et al. 2012 | Unidentified | Demographic data<br>Questions about sports, physical activity and frequently<br>EAI<br>EDS | Asymptomatic<br>Nondependent-symptomatic<br>At risk<br>Comparising in exercising population and in the general population | Prevalence rate of EA risk in exercisers based on EDS (1.9%) and EAI (3.2%)<br>Prevalence rate of EA risk in the general population based on EDS (0.3%) and EAI (0.5%) | Exercise addiction<br>Exercise dependence | Transversal | In this study, the Confirmatory Factor Analysis (CFA) indicate good fit both in the case of EAI and EDS and confirm the factor structure of the two scales. The correlation between the two measures was high. Results showed that 6.2% (EDS) and 10.1% (EAI) of the population were characterized as nondependent-symptomatic exercisers, while the proportion of the at-risk exercisers were 0.3% and 0.5% respectively. |
| Sicilia et al. 2013 | Unidentified | Demographic data<br>EAI<br>Questions about frequency and intensity of physical exercise | HEA (n=87)<br>LEA (n=440)<br>Asymptomatic (n=57) | Prevalence rate of EA risk (14.9%) | Exercise addiction | Tranversal | The results supported the factor structure of the EAI model. The structure of the model was invariant across gender. A group of 87 students (14.9%) obtained a total score equal to or higher than 24 in the EAI and were classified as being at risk of exercise addiction. Students exercising more than three days per week at high intensity obtained higher scores in exercise addiction than students exercising at low-medium intensity, regardless of their frequency. |
| Szabo & Griffiths 2007 | Sports science students and gym users | Demographic data<br>EAI | - | Prevalence rate of EA risk in Sport science students (6.9%) and general population (3.6%)<br>Score EAI in Sport science students (18.6±3.8)<br>Score EAI in general population (17.1±3.8) | Exercise addiction | Transversal | Sport science students scored higher on the EAI than exercisers from the general population. It was also found that 6.9% sport science students were possibly addicted to exercise compared to only 3.6% of the general exercising population, but this difference did not reach the conservative level of statistical significance. |
| Szabo et al. 2013 | University athletes involved in team and individual sports<br>Elite ultra-marathoners | Demographic data<br>EAI<br>Questions about frequency and intensity of physical exercise | Non-sport oriented university athletes (n=90)<br>Sport science university athletes (n=57)<br>Elite ultra-marathoners (n=95) | Prevalence rate of EA risk in the whole sample (12%)<br>Score EAI in men (19.4±3.5)<br>Score EAI in women (18.23±3.73)<br>Score EAI in elite runners (20.08±3.7)<br>Score EAI in university athletes (18.41±3.46 and 18.23±3.34 respectively) | Exercise addiction<br>Underlying themes of exercise behaviour | Transversal | In the current research 7% of the sport science athletes (8.8% of all university athletes), and 17% of the elite runners have scored 24 or above the EAI. From the whole sample 12% athletes scored 24 or more on EAI. The ratio of men was highter than that of women (21vs8), wich was statistically significant. |
| Villella et al. 2010 | Students | Demographic data<br>EAI<br>South Oaks Gambling Screen-Revised Adolescent (SOGS-RA)<br>Compulsive Buying Scale (CBS)<br>Work Addiction Risk Test (WART)<br>Internet Addiction Test (IAT) | - | Prevalence rate of EA risk (8.5%)<br>Prevalence rate of EA risk in Male (10.1%)<br>Prevalente rate of EA risk in Female (6.3%) | Exercise addiction<br>Problem gambling<br>Compulsive buying<br>Work addiction<br>Internet Addiction | Transversal | Overall prevalence was 7% for PG, 11.3% for CB, 1.2% for IA, 7.6% for WA, 8.5% for EA. PG and EA were more common among boys, while gender had no effect on the other conditions. CB was more common among younger (‹ 18 years old) students. The scores of all of these scales were significantly correlated. |
| Warner & Griffiths 2006 | Gym training | Demographic data<br>EAI<br>Open-ended questions designed to explore the underlying themes of exercise behaviour | - | Prevalence rate of EA risk (8%)<br>EAI scores (17.6±3.9) | Exercise addiction | Transversal | Results showed that 8% of the participants scored over 24 (out of 30) and were operationally defined as exercise addicts. The focus of this study was the addition of the qualitative open-ended questions exploring positive and negative experiences of exercise. Participants who were committed resopnded with understandable and functional psychological reasons for their exercise behaviour. Those who were identified as being at risk from exercise addiction indicated difficulties in other areas in their lives drove them to high and possibly dangerous levels of exercise. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Youngman et al. 2014 | Triathletes (Sprint, Olympic, Half-ironman and Ironman) | Demographic data EAI Items added to capture more robust information | HEA (n=237) LEA (n=943) Asymptomatic (n=10) | Prevalence rate of EA risk (20%) EAI scores (20.82±3.32) | Exercise addiction | Transversal | Results indicate that approximately 20% of triathletes are at risk for exercise addiction. 79% are committed exercisers who exhibit some symptoms of exercise addiction, and 1% are asymptomatic. Results also demonstrate that female triathletes are at greater risk for exercise addiction than male triathletes. The range of aged was 18-70 years. |

*Note*. n, number of subjects ; SE, standard error ; SD, standard deviation ; MD, muscle dysmorphia ; AAS, anabolic androgenic steroid ; EA, Exercise Addiction ; HEA, High Exercise Addiction ; LEA, Low Exercise Addiction; CAGE, Cut down, Annoyed, Guilty, Eye Opener ; Class 1, low-risk ; Class 2, medium-risk without social conflicts ; Class 3, medium-risk with social conflicts ; Class 4, at-risk with no social conflicts ; Class 5, at-risk with social conflict ; QoL, Quality of Life ; PG, Pathological Gambling ; CB, Compulsive Buying ; IA, Internet Addiction ; WA, Work Addiction

dancers, gym attenders, runners, powerlifters, swimmers, footballers, basketball players, regular exercisers, combat sport fighters or martial arts, horse-riders, tennis players, rugby players, skiers and ultra-marathoners. Participants' characteristics, mode of exercise and variables analyzed were considered to have a broad methodological heterogeneity among studies; and thus a meta-analysis was performed on outcomes assessed using random-effects mode. Few studies reported on the weight, height, education level or marital status of the sample. All studies included in the present investigation were observational; however, not all of the risk of bias assessment items were appropriate for all the selected studies (Table 3). The most repeated number of items fulfilled was 18.

### *Physical and Mental Quality of Life (QoL)*

We analyzed Physical and Mental quality of life and thus, we included three studies that compared exercise addiction group and non-addicted group (based on score-EAI). It is worth mentioning that all studies evaluated quality of life using the SF-36 questionnaire. There were no significant differences regarding physical quality of life between groups [Hedges' g = 0.057 (95% IC= -0.12 to 0.24)] (Fig. 3). The heterogeneity of studies regarding physical quality

Table 3. *Risk of Bias Assessment*

| | Item 1 | Item 2 | Item 3 | Item 4 | Item 5 | Item 6 | Item 7 | Item 8 | Item 9 | Item 10 | Item 11 | Item 12 | Item 13 | Item 14 | Item 15 | Item 16 | Item 17 | Item 18 | Item 19 | Item 20 | Item 21 | Item 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Babusa et al. 2015 | * | * | * | * | ? | * | * | * | * | * | * | * | ? | ? | * | * | * | * | * | * | * | x |
| Bruno et al. 2014 | ? | * | * | * | ? | * | * | * | ? | * | * | * | ? | ? | * | ? | * | * | * | * | x | * |
| Cunningham et al. 2016 | ? | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | ? | * |
| De la Vega et al. 2016 | * | * | * | * | ? | * | * | * | * | * | * | * | ? | ? | * | ? | * | * | * | * | * | * |
| Griffiths et al. 2005 | ? | * | * | * | x | ? | ? | * | x | * | * | x | ? | ? | * | * | ? | * | x | * | * | * |
| Lejoyeux et al. 2012 | ? | * | * | * | * | * | * | * | ? | * | * | * | * | * | * | * | * | * | ? | * | * | x |
| Li et al. 2015 | ? | * | * | * | * | * | * | * | ? | * | * | * | * | * | * | * | * | * | x | * | * | * |
| Lichtenstein et al. 2014 | * | * | * | * | * | * | * | * | ? | * | * | * | ? | ? | * | * | * | * | * | * | * | * |
| Lichtenstein et al. 2015 | * | * | * | * | * | * | * | * | * | * | * | * | ? | ? | * | * | * | * | * | * | * | ? |
| Lichtenstein & Stoving 2016 | ? | ? | * | ? | x | ? | ? | ? | x | ? | x | x | x | x | ? | ? | x | x | x | x | * | ? |
| Lichtenstein & Jensen 2016 | ? | * | * | * | * | * | * | * | ? | * | * | ? | ? | * | * | * | * | * | * | * | * | ? |
| Maraz et al. 2015 | ? | * | * | * | * | * | * | * | ? | * | * | * | ? | ? | * | * | * | * | * | * | * | ? |
| Mayolas et al. 2017 | ? | * | * | * | * | * | * | * | * | * | * | * | ? | ? | * | * | * | * | * | * | * | * |
| Mónok et al. 2012 | * | * | * | * | * | * | * | * | * | * | * | * | ? | * | * | * | * | * | * | * | * | * |
| Sicilia et al. 2013 | * | * | * | * | ? | * | * | * | ? | * | * | * | ? | ? | * | * | * | * | * | * | * | x |
| Szabo & Griffiths 2007 | * | * | * | * | ? | * | x | ? | * | * | x | ? | x | x | * | * | * | * | * | * | * | ? |
| Szabo et al. 2013 | ? | * | * | * | ? | * | ? | * | ? | * | ? | x | x | x | * | * | * | * | ? | * | * | * |
| Villella et al. 2010 | * | * | * | * | * | * | * | * | ? | * | * | * | * | * | * | * | * | * | ? | ? | * | ? |
| Warner & Griffiths 2006 | * | * | * | * | * | * | * | * | x | * | ? | ? | ? | ? | * | * | x | * | * | * | * | x |
| Youngman et al. 2014 | * | * | * | * | * | * | * | * | * | * | * | ? | * | * | * | * | * | * | * | * | * | x |

*Note*. * Criteria fulfilled ; ? Incomplete criterion ; x Unfulfilled criterion ; Item 1, Title and abstract ; (Introduction) 2, Context/fundaments ; 3, Objectives ; (Methods) 4, study design ; 5, Setting ; 6, Participants ; 7, Variables ; 8, Data Sources/ Measurement ; 9, Bias ; 10, Study size ; 11, Quantitative variables ; 12, Statistical methods ; (Results) 13, Participants ; 14, Descriptive data ; 15, Outcome data ; 16, Main results ; 17, Other analyses ; (Discussion) 18, Key results ; 19, Limitations ; 20, Interpretation ; 21, Generalisability ; (Other information) 22, Funding.

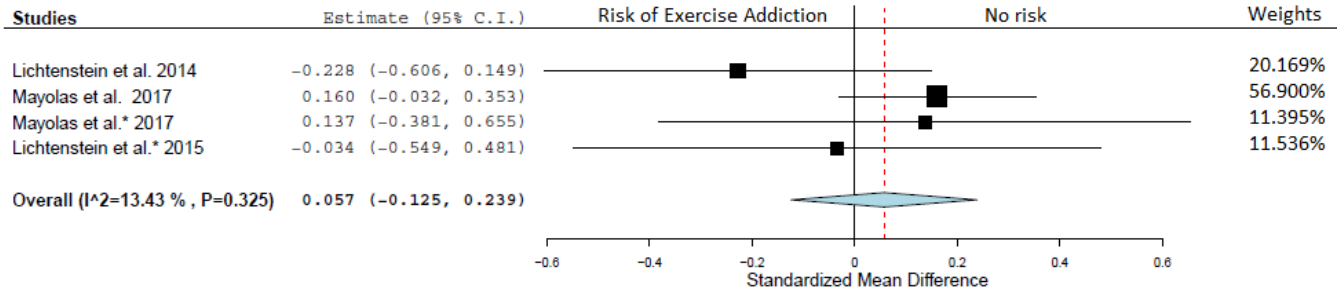


*Figure 3.* Observational effect estimates, 95% CIs and the Std for mean QoL physical.
CI confidence interval, Std standardised mean difference.

of life was low and no significant ($I2$ = 13.43%, p < 0.325). Considering mental quality of life, non-addicted group obtained better scores compared to exercise addiction group [Hedges` g = -0.58 (95% IC = -0.95 to -0.21)] (Fig. 4). The heterogeneity of studies regarding mental quality of life was high and significant ($I2$ = 73.1%, p < 0.011).

### *Prevalence of REA*

Thirteen studies included prevalence values of REA and they were analyzed. In the study of Mayolas-Pi et al. (2017) they analyzed two independent samples (male and female) and we also analyzed them independently, as it is referred above, and it was also done in the whole analysis. The mean prevalence of REA was 13.2% (95% IC = 9.9 - 16.5). The heterogeneity of studies regarding prevalence was very high ($I2$ = 96.2%, p < 0.001).

### *Age*

Mean age and SDs from ten studies where they were included, were statistically analyzed and we obtained an overall mean age of 28.62 years (95% CI = 23.36 - 33.88). The heterogeneity of studies regarding participants' age was very high ($I2$ = 99.95%, p < 0.001). Regarding the age, we also stadisticaly analyzed exercise addiction group and control group; thus, we selected four studies that compared both groups and showed the mean and standard deviations of the mentioned groups. Studies divided the samples according to scores in the EAI questionnaire and all the participants with a resulting score above 24, were assigned to the exercise addiction group and the rest of subjects were assigned to the non-addicted group. Age was lower in the exercise addiction group than in the non-addicted group [Hedges'g = -0.42 (95% CI = -0.68 to -0.14)] (Fig. 2). The heterogeneity of studies regarding exercise addiction group age and non-addicted group age was moderate but significant ($I2$ = 62.22%, p = 0.032).

### *Eating Disorder*

Two studies that used the *Eating Disorder Inventory-2* (EDI-2) to measure eating disorder were statisticaly analyzed to evaluate this outcome on exercise addiction group compared to non-addicted group. Exercise addiction group obtained higher-scores than non-addicted group [Hedges'g = 0.97 (95% IC = 0.65 to 1.29)] (Fig. 5).

### *Hours of Weekly Training*

Four studies that evaluated hours of weekly training were analyzed to assess this outcome on exercise addiction group compared to non-addicted group. Exercise addiction group used to train more hours per week than non-addicted group [Hedges'g = 1.48 (95% IC = 0.20 to 2.75)] (Fig. 6). Heterogeneity of studies regarding hours of weekly training was very high ($I2$ = 97.79% p < 0.001).

## Discussion

The purpose of this meta-analytical review was to investigate possible general health differences between subjects suffering from exercise addiction and non-addicted athletes in terms of quality of life, and eating behaviour, as well as the possible relationships with hours of weekly training and age. Results revealed differences between groups according to age, mental quality of life, eating disorders and hours of weekly training. In spite of the fact that these estimations show negative consequences of exercise addiction in variables such as quality of life mental and eating disorders and also, evidence of more hours of weekly training and lower age in exercise addiction groups, we understand these findings as being unclear and more data are required to increase confidence in the interpretation of these outcomes due to the low number of studies developed so far in this regard.

The systematic search strategy developed identified 20 studies that met inclusion criteria, whereas a previous

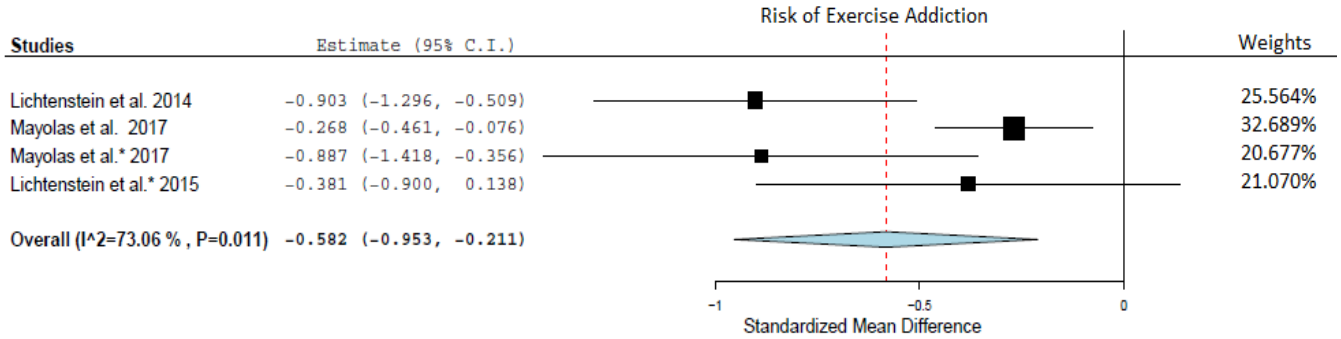


*Figure 4*. Observational effect estimates, 95% CIs and the Std for mean QoL mental.
CI confidence interval, Std standardised mean difference.

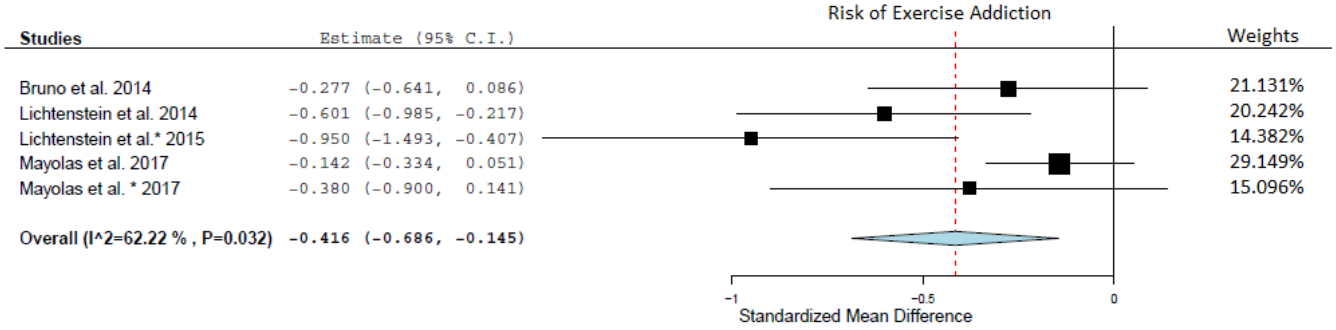


*Figure 2*. EObservational effect estimates, 95% CIs and the Std for mean age.
CI confidence interval, Std standardised mean difference.

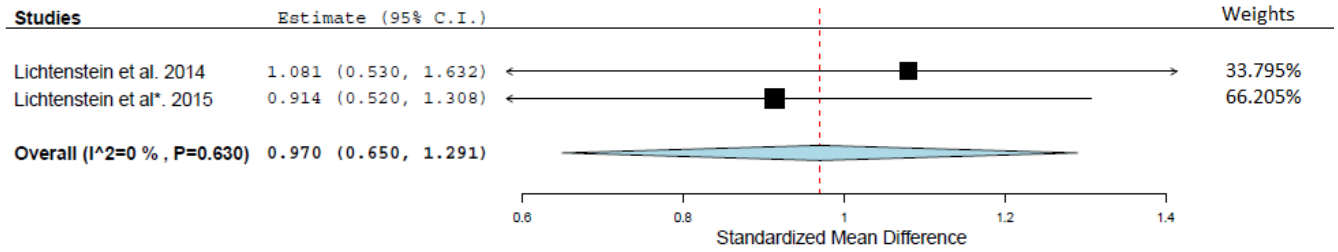


*Figure 5*. Observational effect estimates, 95% CIs and the Std for mean Eating disorder.
CI confidence interval, Std standardised mean difference.

cross-cultural re-evaluation of EAI study included up to nine studies (Griffiths et al., 2015). Griffiths et al. (2015) concluded that EAI factor scores from five countries were not comparable because the use or interpretation of the scale was different in the five nations. However, the covariates of exercise addiction can be studied from a cross-cultural perspective because of the metric invariance of the scale. Gender differences among exercisers in the interpretation of the scale also emerged. The implications of the results were discussed, and it was concluded that the findings that arose from the study, will facilitate a more robust and reliable use of the EAI in future research. Previous narrative reviews (Demetrovics & Kurimay, 2008; Egorov & Szabo, 2013; Landolfi, 2013; Szabo et al., 2015; Weinstein & Weinstein, 2014) approached the exercise addiction including different studies that used diverse measurement instruments. In the current study, they were excluded studies that did not used EAI to evaluate risk of exercise addiction or did not show prevalence of EA risk or EAI-score, trying not to disperse the construct towards related but different concepts. In spite of this, the included studies in the present work that evaluated prevalence of exercise addiction have reported rates varying from 0.3% (Mónok et al., 2012) to 42.5% (Bruno et al., 2014). Different factors (applied measures and criteria, sample selection, sample size and sampling method) contribute to the expansive

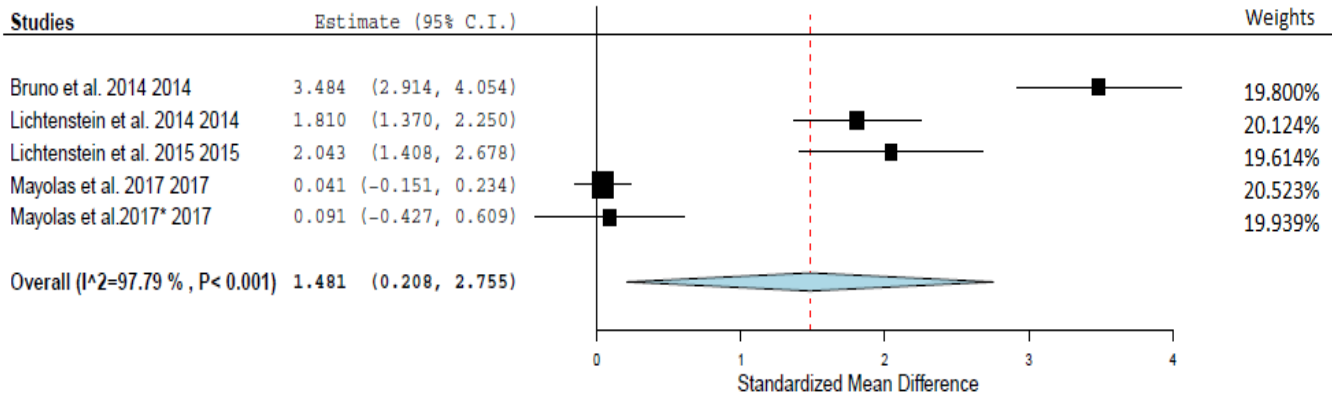


*Figure 6.* Observational effect estimates, 95% CIs and the Std for mean Hours of weekly training. CI confidence interval, Std standardised mean difference.

span in exercise addiction rates (Mónok et al., 2012). Furthermore, in the present review it was observed that the majority of studies fail to provide succinct descriptions of investigated population; therefore, the generalization is unfeasible. Only seven (Babusa, Czeglédi, Túry, Mayville & Urbán, 2015; Lejoyeux, Guillot, Chalvin, Petit & Lequen, 2012; Li et al., 2015; Maraz et al., 2015; Mónok et al., 2012; Sicilia et al., 2013; Youngman & Simpson, 2014) out of twenty studies provided education level of population. Height and weight only reported in two studies (Babusa et al., 2015; Youngman & Simpson, 2014) and the marital status was reported in three studies (Babusa et al., 2015; Mónok et al., 2012; Youngman & Simpson, 2014). This lack of data in the descriptions of population goes in concordance with Mónok et al. (Mónok et al., 2012). It was also observed that the mode of exercise, sample size and age of sample were varied, as well as the researched variables.

### *Prevalence of REA*

As it is referred above, the studies included in the present systematic review, have reported prevalence rates varying from 0.3% in the general population (Mónok et al., 2012) to 42.5% in gym attenders (Bruno et al., 2014). There are studies that also reported low prevalence rates, under 5% such as the study developed by Griffiths et al. (Griffiths et al., 2005), that reported 3% of prevalence rate in usual exercisers who took part in many different forms of exercise, or the study carried out by Lichtenstein & Jensen (Lichtenstein & Jensen, 2016), who reported a prevalence rate of 4.8% in crossfitters. Moreover, in Szabo & Griffiths's study (Szabo & Griffiths, 2007) it was reported low prevalence rates (6.9 % in Sport Science students and 3.6% in general exercising population). The higher prevalence rates were observed in the study implemented by Bruno et al. (Bruno et al., 2014) where the value consisted of 42.5% in gym ussers. The study of Lichtenstein et al. (Lichtenstein, Christiansen, Bilenberg, et al., 2014), also reported a high value of prevalence rates (33.88%) in exercisers recruited from fitness clubs, football teams, employees at the police station and medicine students. Lejoyeux et al. (Lejoyeux et al., 2012) also reported a high prevalence rate (29.6%) in their study, whose sample was formed by consecutive customers that bought sport items. The average prevalence found in the present work was 13.2%±3.3. These results suggest that the exercise addiction is not odd, although some scholars conjectured that exercise addiction is rare (Szabo, 2000; Veale, 1995). Future researches at homogeneous and particular samples, for one mode of exercise and with adequate sampling designs, would seem an ideal strategy to obtain more adjusted prevalence rates of exercise addiction.

### *Age*

The meta-analysis showed that the exercise addiction group was younger than non-addicted group. This relationship goes on line with the results observed in the study undertaken by De Moor et al. (De Moor, Beem, Stubbe, Boomsma, & De Geus, 2006), who observed that exercise participation strongly declined with age. Thus as in the study of Szabo & Griffiths (Szabo & Griffiths, 2007) it was observed that students (19-23 years), in general, also reported more symptoms of exercise addiction than the general exercising population (17-74 years). Garman et al. (Garman, Hayduk, Crider, & Hodel, 2004) also obtained results that reported high incidence of exercise addiction among students in Health and Physical Education. Adjusting age of samples, and making comparisons between habitual exercisers (more homogeneous samples) with different ages could improve the understanding of the role of age factor in the exercise addiction risk.

### *Quality of Life*

Despite the results obtained in this study, the number of studies included in meta-analysis was low, this is a important limitation. A number of studies have yelded positive results

on the effectiveness of exercise as an adjunct treatment for mental disorders (Zschucke, Gaudlitz, & Ströhle, 2013). Nonetheless, exercise addiction can decrease the quality of mental life in people, as we have observed in the present meta-analysis –although the low number of studies included was an important limitation. This effect is supported by Sachs & Pargman (Sachs & Pargman, 1984), who said that the EA often has been identified on the basis of the presence of withdrawal symptoms (e.g. anxiety, depression, feelings of guilt and discomfort, tension, and restlessness). However, withdrawal symptoms in exercise addiction are only ones of some other critical symptoms universally observable in behavioural addictions (Brown, 1993; Griffiths et al., 2005). A broad number of scholars (Griffiths, 1997; Griffiths et al., 2005; Szabo, 1995) discussed whether it is incorrect to establish the presence of exercise addiction merely on the basis of withdrawal symptoms, because negative psychological feelings are reported by almost every usual exerciser whenever exercise is prevented due to an unexpected reason (Hausenblas & Downs, 2002b; Szabo, Frenkl, & Capulo, 1997). It is the intensity of these symptoms what is the crucial factor in separating committed and usual exercisers from addicted exercisers (Berczik et al., 2014). It is, therefore, that a lower score in mental quality of life in exercise addiction risk group suggested deeper negative psychological symptoms. Regarding physical quality of life, differences were not observed between-groups in the present study. Different studies (Pucci, Rech, Fermino & Reis, 2012) have evidenced that high volume training is associated with higher quality of life scores in the physical component in different populations. However, authors like Griffiths (Griffiths, 1997) affirm that injuries and re-injuries due to exaggerated amounts of exercise without proper rest and recuperation are a key characteristic of exercise addiction risk group. Furthermore, several authors (Chapman & De Castro, 1990; Smith, Wolfe, & Laframboise, 2001) says that high levels of exercise increase the risk of injury.

### *Eating disorders*

It was found a significant effect regarding eating disorders. However, the number of studies assessed was very low and this fact represents an important limitation. The exercise addiction risk group showed higher eating disorder scores than the non-addicted group. Nonetheless, only two studies were included in the analysis, thus, the generalizability is quite low. In the identification of exercise addiction, it is important to distinguish between exercise addiction –that is secondary to an eating disorder– and primary exercise addiction –where the exercise is an end in itself– (Lichtenstein, Christiansen, Elklit, et al., 2014). It is uncertain whether exercise addiction exists in the absence of an eating disorder or not. Many exercise addicts have a high risk of developing eating disorders such as anorexia nervosa and bulimia, as well as fear of being fat due to social pressure, disorted body image, lack of social relationships and poor self-esteem (Kreher & Schwartz, 2012; McGough, 2004). Disorted body image can lead, for example, to use of anabolic androgenic steroids, indicating also an eating disorder (González-Martí, Fernández-Bustos, Jordán & Sokolova, 2018). Furthermore, obligatory exercise traits have also been seen in individuals with eating disorders (Mondin et al., 1996).

### *Hours of weekly training*

The meta-analysis put into practice showed differences regarding the amount of hours of weekly training between exercise addiction risk group and the non-addicted one, being higher in the exercise addiction risk group than in the non-addicted group. However, if we consider the little number of studies included in the analysis, with distinct results obtained, these overall effects are unclear. For instance, the study with the highest sample size, and therefore the most powered in statistical terms (Mayolas-Pi et al., 2017) did not report significant effects in this regard. The controversy regarding the influence of volume of training on exercise addiction risk is important because some authors (Szabo et al., 2015) claim that exercising excessively is not necessarily maladaptive or it indicates a disorder. Furthermore, different studies with endurance athletes are scarce, and the relationship between REA and training volume is contradictory (Cook et al., 2013; Szabo et al., 2013). On the other hand, other authors (Adkins & Keel, 2005) suggest that exercise becomes unhealthy when the duration, frequency or intensity exceeds the amount required for physical health and, consequently, it increases the risk of sustaining physical injury. Landolfi (Landolfi, 2013) claims that it is not surprising that exercise addicts devote considerably longer time than recommended to physical activity. However, proffesional athletes also train more hours than recommended to physical activity and they do not show exercise addiction risk symptoms (Szabo et al., 2015). Future investigations that evaluate the amount of physical activity or volume of training (frequency, intensity and duration) with instruments as International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003) would help to better understand the influence of the amount of physical activity on REA. The heterogeneity observed in this meta-analysis may be produced due to the type of sport practiced by the participants, their age and even by the level of performance.

### *Limitations*

Firstly, a potential barrier to evaluate exercise addiction risk, is the great conceptual dispersion as a result of the different measurement instruments used to assess it. We tried to solve this problem selecting studies that used the same instrument, the EAI. Nonetheless, it meant a strong

reduction in the number of available studies, reducing the possibilities of analysis and generalization. Secondly, the notable differences of studies (regarding the age of samples, mode of exercise, population, country, etc.) might explain the high heterogeneity found, and it should be the subject of future studies. Thirdly, not all of the included studies presented the required information to evaluate possible sources of bias. In this sense, future researchers should report all the possible information regarding the study so that this information can also be helpful for sport psychologists, coaches, physical trainers, athletes and habitual exercisers.

## Recommendations

This work provides evidence that exercise addiction risk might be related to age and hours of weekly training and it could affect to mental quality of life and eating disorders. Nevertheless, the physical quality of life does not seem to modificate due to exercise addiction risk. Independently of our results, methodological and conceptual limitations hinder the possible development of knowledge in this field. It is necessary further investigations in order to provide broader informations, as well as a valid cut-off point from the scale. According to Szabo et al. (Szabo et al., 2015), differences in participants (gender, exercise mode, samples size, age and sociodemographic factors) do not allow to carry out a correct interpretation of the data. High scores could reflect different attitudes towards exercise, but not necessarily an exercise addiction risk. Methods like personal interviews made by sport psychologists to people with REA (based on items obtained from the EAI, for instance), could help to understand the exercise addiction and its conceptualization in each particular case. Experimental and longitudinal studies, in which we are able to evaluate score differences between groups that practice exercise with different volumes of training and changes in health variables, could provide answers about the influence of volume of training on REA. Furthermore, the control of variables such as exercise mode, age of sample, comparisons between groups, participants' gender, variables analyzed, instruments used, etc.) should be a priority in future research.

## Conclusions

REA seems to be related to worse mental quality of life and to more eating disorders. On the other hand, the younger the participants are and the more hours of weekly training, the higher exercise addiction risk. The considerable dispersion found in the prevalence values of REA suggests that it is necessary to be cautious when interpreting these findings due to the necessity of encouraging more future research in this area by focusing it on specific personal variables and populations.

## Conflict of Interest

Authors declare that they have no conflict of interest considering the content of this review.

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