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Which sports are more at risk of physical exercise addiction: A systematic review

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HIGHLIGHTS

- Exercise addiction is a recent, yet poorly understood entity with heterogeneous prevalence.
- Endurance sports seem associated with the highest risk for exercise addiction.
- The Exercise Addiction Inventory seems to screen a higher proportion of individuals at risk of physical exercise addiction.
- A more rigorous selection of target populations and scales is encouraged to better understanding of exercise addiction.

ABSTRACT

Introduction: Excessive physical exercise may evolve into physical exercise addiction, a recently identified entity with many yet unclear aspects, such as global prevalence and variability according to different types of physical exercise.
Methods: We systematically reviewed the current literature up to June 2018 to collect all studies screening exercise addiction with two of the most frequently used screening scales: the Exercise Addiction Inventory (EAI) and the Exercise Dependence Scale (EDS).
Results: We detected forty-eight studies (20 using the EAI, 26 the EDS, and 2 both scales) reporting variable point prevalence of exercise addiction risk, depending on the target population and the investigated sport. The EAI identifies a higher proportion of people at risk for physical exercise addiction among endurance athletes (14,2%) followed by ball games (10,4%), fitness centre attendees (8,2%) and power disciplines (6,4%), while a frequency of 3,0% was reported in the general population. Studies using the EDS found discrepant results.
Discussion: This systematic review suggests that sport disciplines are associated with different vulnerability for physical exercise addiction. Besides the different addictive potential of each sport, the heterogeneity of results may be also due to socio-demographic and cultural characteristics of the target populations. The EAI and the EDS identify different proportions of individuals at risk for exercise addiction both in general population and in specific sport categories. As the EAI screens a higher proportion of subjects at risk, especially in endurance disciplines, it could be more appropriate for early detection of at-risk subjects and/or disciplines.
Conclusion: Tailored prevention strategies for each discipline could help better preserving benefits of sports. More precision in research methods and the use of the most appropriate scale are required to allow a better comparability of prevalence among physical exercise disciplines and in general population.

1. Introduction

A large amount of evidence highlights the physical, psychological and physiological benefits of regular physical exercise (Hausenblas & Downs, 2002; Veale, 1987). Physical exercise is a powerful stimulant and has mood regulating properties (Meyer, Taranis, & Goodwin, 2011). The minimum amount of exercise required to experience such benefits was fixed at 2 h and 30 min a week of moderate-intensity, or 1 h and 15 min a week of vigorous-intensity aerobic physical activity, or a combination of the two (UDHHS, 2008). Additional benefits experienced are proportional to an increase of the amount of exercise (Costa, Cuzzocrea, Hausenblas, Larcan, & Oliva, 2012), but this colinearity brakes when negative consequences of excessive exercise appear. Exercise can indeed become an all-consuming activity (Hausenblas & Giacobbi, 2004) and occasionally evolve into a compulsive behaviour or an addiction (Veale, 1987), with all the core characteristics of this entity (Lejoyeux, Guillot, Chalvin, Petit, & Lequen, 2012). The same diagnostic criteria as DSM-IV behavioural addictions (American Psychiatric Association, 2013) adapted to sport practice (Marquez & De la Vega, 2015) have been proposed for "exercise addiction" (EA). The consequences of EA may more specifically concern physical injuries, social marginalisation and psychological tense occasioned by

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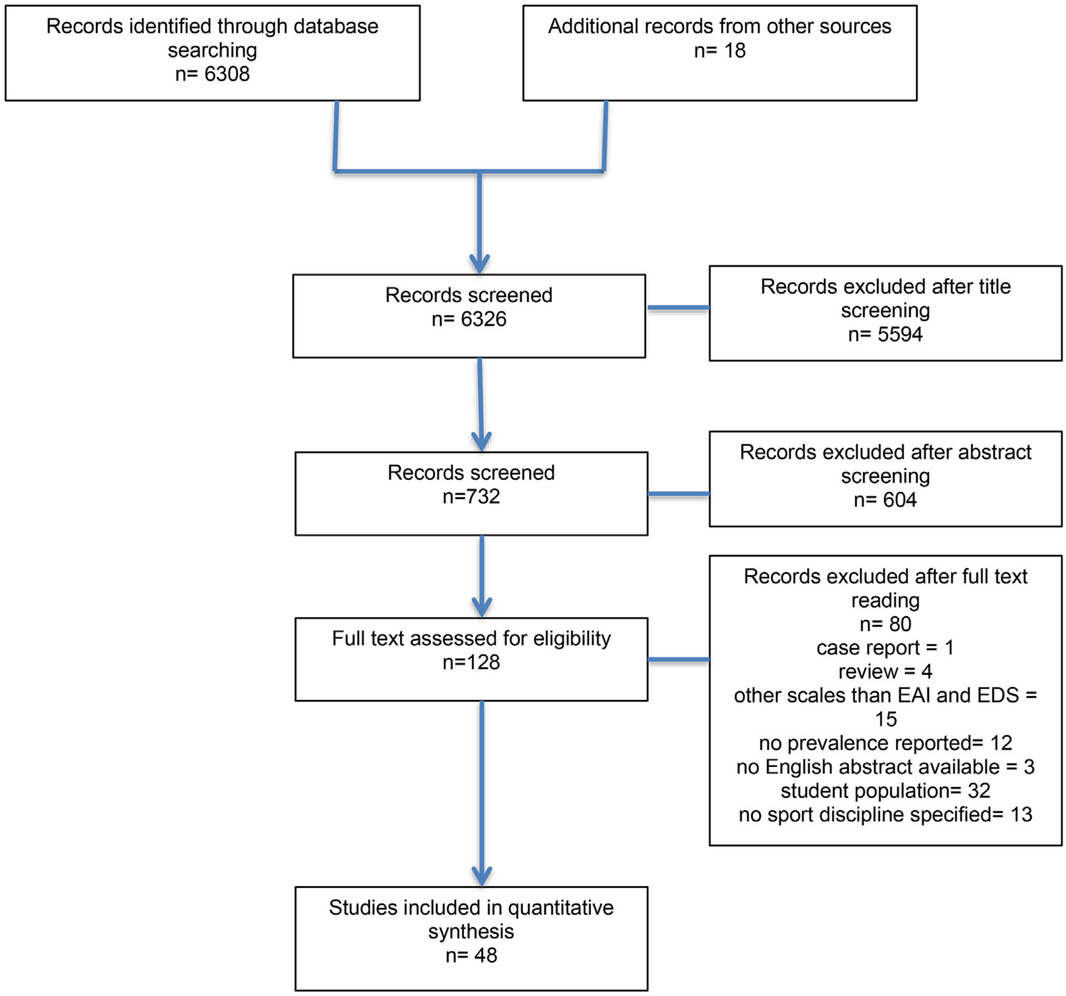

Fig. 1. flowchart describing research procedure.

withdrawal (Di Lodovico, Dubertret, & Ameller, 2018).

The debate on the prevalence of EA is still alive: results show great variability depending on the chosen screening tool (Griffiths et al., 2015; Lejoyeux, Avril, Richoux, Embouazza, & Nivoli, 2008; Mónok et al., 2012; Weik & Hale, 2009), the target population (Cunningham, Pearman, & Brewerton, 2016; Meulemans, Pribis, Grajales, & Krivak, 2014), the practiced discipline (Blaydon & Lindner, 2002; Szabo, De La Vega, Ruiz-Barquín, & Rivera, 2013) and even the established nomenclature (Noetel, Dawson, Hay, & Touyz, 2017). Indeed, the terms of EA, “exercise dependence”, “compulsive exercise”, “excessive exercise” are used interchangeably and concur to the fragmentation of conclusions. In this review the term EA will be preferred as the best synthesis of both concepts of “dependence” and “compulsion” (Berczik et al., 2012).

Some of the existing EA screening instruments explore several dimensions of this entity while others focus on a particular key aspect of dependence, some inquiries use validated questionnaires while others exploit structured or ad-hoc interviews (Lejoyeux, Avril, & Richoux, 2008). The two screening questionnaires of reference are the Exercise Dependence Scale (EDS) (Hausenblas & Downs, 2002), and the Exercise Addiction Inventory (EAI) (Terry, Szabo, & Griffiths, 2004). Both scales are validated in different languages, including French (Ferreira, 2016; Kern, 2007), and the EAI is also available in a youth version (Lichtenstein, Griffiths, Hemmingsen, & Støving, 2018).

The EDS is a multidimensional, theoretical-based measure of EA symptoms according to the operationalized DSM-IV criteria of behavioural addiction for EA (Hausenblas & Downs, 2002). Its 29 questions (21 in the revised version « EDS-R » (Symons Downs, Hausenblas, & Nigg, 2004)) search for the cardinal symptoms of addiction: tolerance, withdrawal, intention effects, lack of control, lost time, reduction in other activities, and continuance instead of problems. The EDS-R yields both a mean score (i.e., interval data) and categorization (i.e., nominal data) distinguishing individuals ‘at-risk’ of EA from those who are ‘nondependent symptomatic’ and ‘nondependent asymptomatic’ (Costa et al., 2012). This scale shows excellent internal consistency (Cronbach's *alpha* = 0.95) and adequate test-retest reliability (r = 0.92) (Hausenblas & Downs, 2002).

The EAI is composed of six self-constructed statements based on a modified version of the components of behavioural addiction (Griffiths, 1996). Each statement was designed to indicate one of the addictive behaviour components and has a five point Likert response option. A score of at least 24 out of 30 identifies ‘at-risk’ individuals, a score between 12 and 23 identifies individuals with ‘some symptoms’ of EA (Terry et al., 2004), and a score below 12 indicates ‘asymptomatic’ subjects. The internal consistency of EAI is of 84% and the test-restest reliability is 0,85 (Griffiths, 2005).

Other EA screening instruments were considered as having good psychometric properties (Berczik et al., 2012) such as the Exercise Dependence Questionnaire (EDQ) (Ogden, Veale, & Summers, 1997), the Commitment to Exercise Scale (CES) (Davis, Brewer, & Ratusny, 1993) and the Obligatory Exercise Questionnaire (OEQ) (Ackard, Brehm, & Steffen, 2002; Pasman & Thompson, 1988). The EDQ encompasses 29 items and provides a multidimensional assessment of compulsive exercise behaviour in all forms of exercise (Berczik et al., 2012; Ogden et al., 1997). The CES is an eight-item questionnaire designed to assess an individual's psychological commitment to physical exercising (Davis et al., 1993). The OEQ relies on the three factors of exercise fixation, exercise frequency and exercise commitment and is composed of 20 items assessed with a 4-point Likert scale (Ackard et al., 2002).

In order to better understand the prevalence of EA, overall and among physically active populations, our scope is to make the first extensive review of all works screening for EA by the EAI or the EDS. Their brevity, easy scoring and availability of translated forms allowed their adoption in a consistent number of publications on different sport disciplines (Berczik et al., 2012) and their results have been considered as arguably comparable (Szabo, Griffiths, de La Vega Marcos, Mervó, & Demetrovics, 2015).

2. Methods

To perform our review, we systematically analysed the literature published up to June 2018 in PubMed®, Science Direct® and search engines such as Google® to collect all studies reporting prevalence of EA. Research was effectuated by typing on the research tab the following terms: “exercise dependence”, “exercise addiction”, “excessive exercising”, “excessive exercise”, “compulsive exercising”, “compulsive exercise”, “sport dependence”, and “sport addiction”. Fig. 1 illustrates the research procedure.

Only observational studies that employed the EAI, the EDS or the EDS-R were included. We excluded studies that were not written or did not provide any abstract in English, besides the ones that targeted general populations of students or did not focus on a particular sport discipline (Fig. 1).

We merged articles according to the scale used and the type of discipline practiced by the target population, using the classification of sport activities provided by Caselli et al. (2015) that distinguishes subgroups in relation to the predominant characteristics of training: (1) “Endurance disciplines” (e.g. long-distance running, marathon, cycling, swimming and triathlon); (2) “Power disciplines” (i.e. weightlifting, bodybuilding and crossfit), (3) “Mixed disciplines” including team sports such as soccer, basketball or volleyball, also called “Ball games” in the study of Trana (2014). Following the example of Shin and You (2015), we further introduced a fourth category (4) “Health and fitness” in order to gather the numerous works conducted on fitness centres attendees. We lastly identified the category of (5) “General population” to collect nationwide studies on samples representative of the general population.

We calculated the weighted average of the prevalence of EA risk ($p=\Sigma_{i=1}{}^{n}wiXi/\Sigma_{i=1}{}^{n}wi$), where p is the weighted prevalence, w the size of each sample, n the total number of subjects and X the risk prevalence of each study. Confidence intervals for each study, each scale and each subgroup are illustrated. We performed a Chi-square test to compare prevalence rates of each subgroup of disciplines assessed by the same scale (to ascertain a significant difference of EA risk according to the sport practiced) and to compare prevalence rates assessed by the two scales for the same subgroup of disciplines (to verify if the results brought by the two scales are comparable).

The data analyses and figure realisation relied on worksheets constructed using MetaWin Software version 2.0 (Rosenberg, 2000).

3. Results

We collected a total of forty-eight cross sectional, observational studies (20 used the EAI; 26 the EDS, and 2 both scales) (Fig. 1).

According to the studies that employed the EAI, EA risk prevalence spans from 0,5% to 43,0% (Fig. 2). Endurance disciplines are characterized by highest prevalence rates of EA risk (14,2%). Mixed disciplines (10,4%) have a significantly lower prevalence than endurance disciplines (χ^2 = 18,671; df = 1; p < 0,01), but higher than health and fitness disciplines (8,2%) (χ^2 = 8969; df = 1; p < 0,01). Power disciplines (6,4%) have a lower prevalence than health and fitness disciplines (χ^2 = 2629; df = 1; p > 0,05), but higher than the general population (3,0%) (χ^2 = 20,185; df = 1; p < 0,01). Confidence intervals among categories do not overlap (Fig. 2).

When the EDS is used (Table 1), the prevalence of EA spans from 0,3% in a general population sample to 18,3% in competitive athletes involved in ball games, the latter category having the highest risk prevalence of EA (15,3%) followed by power disciplines (10,7%) (χ^2 = 4201; df = 1; p = 0,04). Health and fitness disciplines (6,0%) show lower risk prevalence than power disciplines (χ^2 = 270,759; df = 1; p < 0,01) but higher than endurance disciplines (3,5%) (χ^2 = 96,700; df = 1; p < 0,01), the latter harbouring higher EA risk prevalence than the general population (1,9%) (χ^2 = 27,241; df = 1; p < 0,01). Confidence intervals of weighed prevalence in different disciplines overlap (Table 1).

Comparisons between EA risk prevalence respectively assessed by the EAI vs the EDS show significant differences in endurance disciplines (14,2% vs 3,5%) (χ^2 = 278,966; df = 1; p < 0,01), mixed disciplines (10,4% vs 15,3%) (χ^2 = 13,297; df = 1; p < 0,01), health and fitness disciplines (8,2% vs 6,0%) (χ^2 = 17,606; df = 1; p < 0,01), power disciplines (6,4% vs 10,7%) (χ^2 = 6087; df = 1; p = 0,01) and general population (3,0% vs 1,9%) (χ^2 = 14,333; df = 1; p < 0,01).

4. Discussion

This is to our knowledge the first work reviewing all studies that assessed the point risk prevalence of EA among sport disciplines by means of the two most employed screening instruments: the EDS and the EAI. Our results confirm that the prevalence of EA risk is generally higher among regular exercisers than in the general population (Mónok et al., 2012). All sports are potentially concerned, but some are characterized by higher EA risk. Specific factors could play a predominant role in each sport category, so that complications, diagnostic and therapeutic implications could change from one discipline to another. For example, the most strenuous activities were reported to harbour the highest risk rates of EA (Hausenblas & Downs, 2002) and this could in part explain the highest prevalence of EA rates in endurance sports. The intrinsic characteristics of endurance training seem to favour the development of physical and psychological tolerance (Magee, Buchanan, & Barrie, 2016) and other important factors either moderate, or may be confused with, a proneness to EA, like obsessive passion and dedication (De La Vega, Parastatidou, Ruiz-Barquin, & Szabo, 2016; Lane & Wilson, 2011), social physique anxiety (Cook, Hausenblas, Crosby, Cao, & Wonderlich, 2015), eating disorders (Müller, Loeber, Söchtig, Te Wildt, & De Zwaan, 2015), commitment (Szabo et al., 2015), weight and shape concerns and motivation depending on the specific characteristics of the physical activity (Nogueira, Molinero, Salguero, & Márquez, 2018).

Besides the type of discipline practised, variable EA risk prevalence among disciplines could be attributable to the target population and the choice of the screening instrument even after restricting our research to two arguably comparable scales. Astonishingly, significantly lower risk prevalence is reported in studies employing the EDS, a scale recognised with excellent psychometric properties (Costa et al., 2012; Hausenblas & Downs, 2002; Kern, 2007; Mónok et al., 2012; Symons Downs et al., 2004). It is worth noting that the study with the lowest risk prevalence for endurance sports (Cook et al., 2013) was performed on an occasional sample of participants to a long distance race, hypothetically merging occasional runners with endurance athletes and thus potentially underestimating prevalence. Alternatively, a weaker sensitivity for this category could be supposed but not proved as true positive and false negative rates are not being known.

Only two studies assessed the frequency of EA risk in the general population (Cunningham et al., 2016; Mónok et al., 2012) according to both EDS and EAI. Both samples showed higher EA risk when using the EAI, this difference being significant in only one case (Cunningham

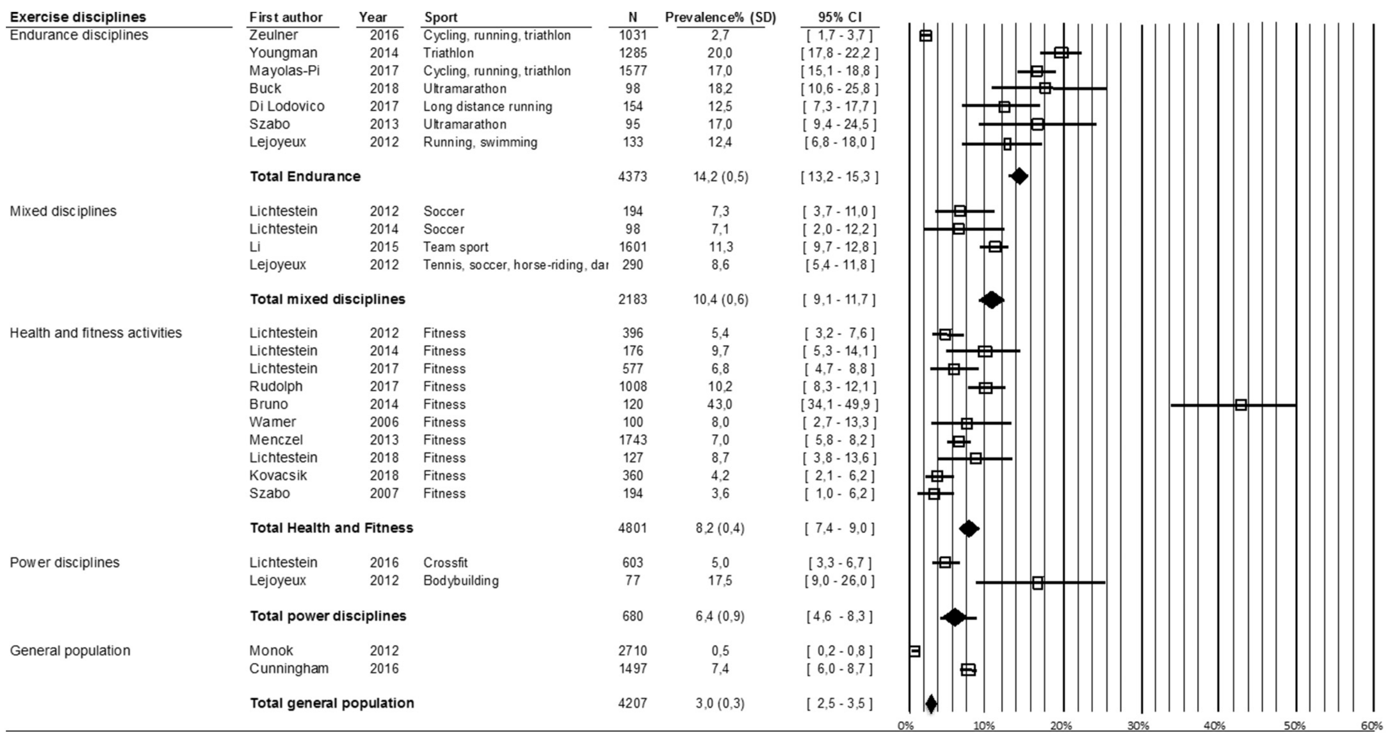

Fig. 2. prevalence of EA risk according to the subgroup of disciplines in publications using the EAI.

Table 1
Prevalence of EA risk according to the subgroup of disciplines in studies using the EDS.

Discipline	Number of studies	Population size	Lower c.i. (%)	Prevalence (%)	Upper c.i. (%)	Standard deviation (%)
Mixed disciplines/ball games	3	774	12,8	15,3	17,9	1,3
Power disciplines	3	371	7,6	10,7	13,8	1,3
Health and fitness activities	13	4797	5,3	6,0	6,7	0,3
Endurance disciplines	5	3817	2,9	3,5	4,1	0,3
General population	4	7274	1,6	1,9	2,2	0,2

et al., 2016). The discrepancy between the two scales could be understood as using different definitions of problematic exercise (Terry et al., 2004): the EDS assesses the risk for exercise dependence, described as a craving for exercise at the origin of uncontrolled physical activity, having a physical and/or physiological presentation (Hausenblas & Downs, 2002). As already observed, the EDS is based on the 'gold standard' of the criteria of psychoactive substance use dependence of the Diagnostic and Statistical Manual-4th edition adapted to a behavioural addiction (Mónok et al., 2012; Szabo et al., 2015; Terry et al., 2004). The items of the EAI are, on the other hand, the operationalization of the components of behavioural addictions, which are theory-driven and derived from a conceptual basis (Mónok et al., 2012) rather than from already existing criteria for substance use disorders. It is therefore possible that the wording of the different questions from the EDS makes more obvious the pathological aspect of each problem related to EA than the EAI. Subjects with EA could then more easily quote the EAI item about tolerance presented as "Over time I have increased the amount of exercise I do in a day" than the equivalent from the EDS "I continually increase my exercise duration to achieve the desired effects/benefits". In the same line, they could more easily respond positively to the EAI item relevant for withdrawal "If I have to miss an exercise session I feel moody and irritable", but less easily to the EDS item "I am unable to reduce how often I exercise".

Cross-cultural evaluations of the EAI showed a robust metric invariance despite the impossibility of establishing scalar and gender invariance (Griffiths et al., 2015), this could explain the heterogeneity of point prevalence across studies. Partial factorial invariance was supported for age, gender and country of origin for all but two items of the EDS (Lindwall & Palmeira, 2009). This invites to particular caution when comparing the results from different countries, as conceptual, linguistic and psychometric discrepancies could potentially explain variable point prevalence.

One of the main limitations of our study is the lack of distinction between male and female responders: a different trend of answering is an already consolidated finding (Griffiths et al., 2015; Szabo et al., 2013; Youngman & Simpson, 2014). The absence of distinction between elite athletes and non-competitive exercisers may also play as a confounding factor: in elite athletes, radically different interpretation of questionnaires could occur, since their socio-economic status depends on trainings and performance (Szabo et al., 2015). The absence of paired strictly comparable populations among studies may exert a major influence that we cannot still estimate. For instance, "fitness centre attendees" is a wide, heterogeneous group of exercisers including different disciplines and a random involvement in training routines.

5. Conclusions

We performed the first extensive review on the prevalence of EA found by the two major screening instruments: the EDS and the EAI. Results are heterogeneous according to the scale used and the discipline investigated, suggesting a need for calibrated prevention strategies for each discipline. The EAI seems a more appropriate tool to screen the risk for EA in specific populations of exercisers, generally showing its potential to identify a higher proportion of individuals at risk for EA.

Appendix A. Publications employing the EDS. Population size, study design and prevalence of EA risk with related 95% confidence interval (C. I.) are reported

Author	Year	Study design	N	Population	Prevalence (%)	95% C.I. (%)
Mixed disciplines / ball games						
Shin (Shin & You, 2015)	2015	Observational	402	Habitual exercisers (ball games and racket predominantly)	15,4	11,9 - 18,9
Costa (Costa, Hausenblas, Oliva, Cuzzocrea, & Larcan, 2015)	2015	Observational	262	Competitive athletes in team sports	18,3	13,6–23,0
Maselli	2018	Observational	110	Team sport players	8,1	3,0–13,3
			774	Weighed average	15,3	12,8–17,9
Power disciplines						
Hale (Hale, Roth, DeLong, & Briggs, 2010)	2010	Observational	146	Weightlifters and bodybuilders	15,1	9,3 - 20,9
Hale (Hale, Diehl, Weaver, & Briggs, 2013)	2013	Observational	74	Weightlifters and bodybuilders	13,5	5,7–21,3
Soler (Soler, Helder, Oliveira Damasceno, & Silva Novaes, 2013)	2013	Observational	151	Bodybuilders and strength trainers	5,1	1,6–8,6
			371	Total weighed average	10,7	7,6–13,9
Health and fitness activities						
Müller (Müller et al., 2015)	2015	Observational	128	Fitness center attendees	7,8	3,1–12,4
Costa (Costa, Hausenblas, Oliva, Cuzzocrea, & Larcan, 2013)	2013	Observational	409	Fitness center attendees	4,4	2,4 - 6,4
Costa (Costa et al., 2012)	2012	Observational	519	Fitness center attendees	6,6	4,5 - 8,7
Menczel (Menczel et al., 2017)	2017	Observational	1743	Fitness center attendees	2,2	1,5–2,9
Parastatidou (Parastatidou, Doganis, Theodorakis, & Vlachopoulos, 2014)	2014	Observational	549	Fitness center attendees	12,4	9,6–15,0
Miller (Miller & Mesagno, 2014)	2014	Observational	90	Fitness center attendees	7,2	1,8–12,5
Müller (Müller et al., 2014)	2014	Observational	35	Fitness center attendees	11,4	0,9 - 22,0
Edmunds (Edmunds, Ntoumanis, & Duda, 2006)	2006	Observational	351	Fitness center attendees	3,4	1,5–5,3
Lease (Lease & Bond, 2013)	2013	Observational	302	Fitness center attendees	7,9	4,8 - 10,9
Hill (Hill, Robson, & Stamp, 2015)	2015	Observational	248	Fitness center attendees	9,5	5,8–13,1
Maselli	2018	Observational	101	Fitness center attendees	9,9	4,0–15,7
Müller (Müller et al., 2013)	2013	Observational	129	Fitness center attendees	12,4	6,7 - 18,1
Weik (Weik & Hale, 2009)	2009	Observational	193	Fitness center attendees	11,9	7,5–16,0
			4797	Weighed average	6,0	5,3 - 6,7
Endurance disciplines						
Magee(Magee et al., 2016)	2016	Observational	345	Ironman athletes	9,0	6,0–12,0
Cook	2013	Observational	2660	Road race runners	1,4	0,1–1,9
Allegre(B. Allegre & Therme, 2008)	2007	Observational	95	Ultramarathon runners	3,2	0,3 - 6,7
Maselli(Maselli, Gobbi, Probst, & Carraro, 2018)	2018	Observational	116	Endurance athletes	12,9	6,8–19,0
Tello(Tello et al., 2012)	2012	Observational	601	Commando exercisers	7,8	5,6 - 9,9
			3817	Weighed average	3,5	2,9 - 4,1
General population						
Monok	2012	Observational	2710	General population aged 18–64 years	0,3	0,1–0,5
Trana	2013	Observational	1456	General male population 18–65 years	0,4	0,1 - 0,7
Müller	2013	Observational	1611	General population aged 16–60 years	3,5	2,6–4,4
Cunningham	2016	Observational	1497	General population aged 18–79 years	4,7	3,6 - 5,8
			7274	Total general population	1,9	1,6 -2,2

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