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A systematic review and meta-analysis of the effect of exercise on psychosocial outcomes in adults with obesity: A call for more research

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ABSTRACT

Background: Reviews show that exercise reduces many obesity-related physical health problems. However, it is unclear whether those benefits extend to psychosocial outcomes. The aim of this review was to evaluate the effect of exercise on psychosocial outcomes in adults with obesity.
Method: Seven databases (Pubmed, Cochrane Library, EMBASE, CINAHL, Psyarticle, SportDiscus, Proquest) were searched until October 2017 to identify relevant studies published in peer-reviewed journals. Two reviewers independently screened articles against the following inclusion criteria: used an experimental or quasi-experimental design, involved adults with a body mass index $\geq$30 kg/m^2, delivered an intervention consisting of supervised or semi-supervised exercise, and assessed quality of life (QoL), depression, anxiety, and/or body image as outcomes.
Results: Twenty two articles were included in this review; 16 were randomized controlled trials (RCT). Most interventions were supervised and lasted $\leq$16 weeks. Meta-analysis of RCTs with available data on QoL (k = 7) and depression (k = 4) did not show that exercise was significantly superior to control conditions for physical QoL (g = 0.16, 95%CI [-0.05,0.37]), mental QoL (g = 0.20, 95%CI [-0.09,0.48]), or depression (g = −0.26, 95%CI [-0.70,0.19]). Only three studies reported data on anxiety and body image.
Conclusions: Current evidence does not suggest exercise is successful in significantly enhancing psychosocial health in adults with obesity. Limitations associated with the reviewed studies could have biased the results toward a lack of effect. Additional high-quality RCTs are needed to improve evidence-based knowledge.

Contents

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1. Introduction

Adults with obesity are at increased risk for several serious diseases and health conditions (e.g., type 2 diabetes, cancers, mood disorders) (Dixon, 2010; Guh et al., 2009; Luppino et al., 2010; Scott, McGee, Wells, & Browne, 2008; Wang, McPherson, Marsh, Gortmaker, & Brown, 2011). They may also have impaired physical and psychological functioning (Dixon, 2010; Guh et al., 2009; Luppino et al., 2010; Scott et al., 2008; Wang et al., 2011), negative body image, and poor quality of life (QoL) (Ul-Haq, Mackay, Fenwick, & Pell, 2013; Weinberger, Kersting, Riedel-Heller, & Luck-Sikorski, 2016).

Scholars have focused on the role of exercise in preventing and treating obesity in adults. Evidence from individual studies has been summarized in reviews and shows that adults with obesity who exercise regularly can lose weight (Donnelly et al., 2009; Janiszewski & Ross, 2007; Swift, Johannsen, Lavie, Earnest, & Church, 2014). The role of exercise in reducing the risk for several physical health conditions in adults with obesity has also been examined. The evidence shows that exercise can improve body composition, cardiovascular biomarkers, and insulin resistance in adults with obesity, irrespective of weight loss (Donnelly et al., 2009; Janiszewski & Ross, 2007). In addition, numerous meta-analyses demonstrate that exercise can be used to prevent or treat mood disorders (i.e., depression, anxiety) improve QoL, and reduce negative body image in non-clinical and clinical populations (Bartley, Hay, & Bloch, 2013; Bridle, Spanjers, Patel, Atherton, & Lamb, 2012; Buffart et al., 2017; Campbell & Hausenblas, 2009; Chen & Rimmer, 2011; Chou, Hwang, & Wu, 2012; Ekkekakis, 2015; Fukuta, Goto, Wakami, & Ohte, 2016; Herring, O'Connor, & Dishman, 2010; Herring, Puetz, O'Connor, & Dishman, 2012; Rebar et al., 2015; Wipfli, Rethorst, & Landers, 2008). This finding is particularly relevant because prevention and treatment of obesity should not only focus on reducing weight, but should also seek to enhance adults' subjective well-being in the era of patient-centered health care because many adults may still experience depression, poor QoL, and negative body image after weight loss. Yet, evidence regarding the effect of exercise on these outcomes is less conclusive in adults with obesity based on a recent systematic review (Baker, Sirois-Leclerc, & Tulloch, 2016), whereby the authors reported no evidence concerning the benefits of exercise on QoL, and mood disorders (i.e., depression, anxiety) in overweight and obese postmenopausal women. However, not all studies examining the effect of exercise on psychosocial outcomes were included in the review given the restricted population inclusion criteria, therefore limiting our ability to draw generalizable conclusions. Thus, the objective of this systematic review and meta-analysis was to provide an evaluation of the effect of exercise on four keys psychosocial outcomes in adults with obesity, identify knowledge gaps, and highlight areas in need of additional research. Considering there is no unanimous agreement on which psychosocial outcomes are the most important to assess in adults with obesity, we chose to focus on QoL, depression, anxiety, and body image because: (1) QoL is an important patient-reported outcome that should be examined when assessing the effects of therapeutic interventions (Fontaine & Barofsky, 2001; Kolotkin, Meter, & Williams, 2001), (2) depression and anxiety are prevalent mood disorders in this population and are a leading cause of disability (Carpiniello et al., 2009; Rajan & Menon, 2017), (3) adults with obesity are at increased risk of body image issues due to high societal pressures (Latner, Barile, Durso, & O'Brien, 2014; Puhl & Heuer, 2009), (4) many adults still experience negative body image after weight loss (Foster, Wadden, & Vogt, 1997; Gilmartin, 2013; Schwartz & Brownell, 2004), and (5) mood disorders, body image, and QoL affect sex life, self-esteem, and social function (Fontaine & Barofsky, 2001; Lillis, Levin, & Hayes, 2011; Puhl & Heuer, 2009).

2. Methods

2.1. Protocol and registration

This review was undertaken following the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009). The protocol was registered in PROSPERO (CRD42016036510).

2.2. Eligibility criteria

To be included, studies had to: 1) be a primary study published in a peer-reviewed journal; 2) have full-text available in English or French; 3) include adults with a body mass index (BMI) $\geq$30 kg/m^2; 4) use a randomized controlled trial (RCT), controlled clinical trial (CCT), or before-and-after study design; 5) deliver a supervised or semi-supervised exercise intervention, and; 6) assess QoL, depression, anxiety, and/or body image as outcomes. Studies employing multicomponent interventions (e.g., exercise paired with a psychoeducational intervention or with diet) were excluded.

2.3. Information sources

Seven electronic databases were searched for eligible studies: Pubmed, Cochrane Library, EMBASE, CINAHL, Psyarticle, SportDiscus, and Proquest. The search was performed in April 2016 using keywords and Medical Subject Headings (Mesh) terms. An updated search was performed on October 31 (2017) to retrieved any studies published since the initial search, five studies met the inclusion criteria (Casilda-Lopez et al., 2017; Megakli, Vlachopoulos, & Theodorakis, 2016; Megakli, Vlachopoulos, Thøgersen-Ntoumani, & Theodorakis, 2017; Svensson, Eek, Christiansen, & A., 2017; Vasconcelos et al., 2016). However, the two publications of Megakli et al. were considered as the same study since the population and methodology were the same. See supplemental material S1 for detailed search strategies.

2.4. Search and study selection

Titles and abstracts retrieved during the electronic database search were screened by two reviewers (AnB, SS). Full-texts were then screened by two review authors (AT, SS). Disagreements were resolved by a third author (AB). Agreement between reviewers was calculated using Cohen's kappa coefficient (McHugh, 2012). Reference lists from eligible studies were manually checked by two review authors (AT, SS) to identify other potentially relevant studies not identified during the database search.

2.5. Data extraction

The following data were extracted by one review author (SS) using a form developed for this review: authors' names; publication year; study setting; study design; sample size; participant characteristics (age, sex, BMI, comorbidities); intervention(s) design, and; QoL, depression, anxiety, and body image measures and results (means with standard deviations (SD) of pre and post-intervention with p-values). All extracted data were verified by another review author (AT). Disagreements were resolved by having a third author (AB) return to the full-text(s) to check the accuracy of extracted data. Study authors were contacted by email for additional information if necessary.

2.6. Risk of bias

Risk of bias for each of the included studies was assessed by two review authors (AB, AJR) using criteria set forth by PeDroscale (Maher, Sherrington, Herbert, Moseley, & Elkins, 2003) and adapted for this review. Ten criteria were assessed: 1) random and concealed allocation to groups; 2) similarity of groups or relevant confounders controlled; 3) sample size calculation and target achievement; 4) blinding of participants for the aim of the study; 5) blinding of personnel for the aim of the study who administered the training; 6) blinding of the intervention or exposure status of participants for the assessor(s); 7) "intention-to-treat" analysis; 8) exercise adherence >70%; 9) drop-out $\leq$15%, and; 10) reasons for drop-out stated if applicable. Each criteria was assessed as having been fulfilled (1 point) or not fulfilled/insufficient information for adequate assessment (0 points), leading to a global score on 10 for RCTs and CCTs, on 7 for before-and-after studies with drop-outs, or on 6 for before-and-after studies without drop-outs. Scores were then converted to percentage to permit direct comparison across studies.

2.7. Statistical analysis

In addition to providing a narrative summary of the studies included, statistical analyses were carried out for RCTs. The standardized mean difference (SMD) using raw score standardization was calculated for both treatment and control groups (Hedges, 1981). The difference between two SMDs per study served after adjustment for estimation bias as the effect size, served as the effect size for each study. Non-adjusted means and pretest standard deviations (SDpre) reported were used. If SDpre was not reported, it was estimated via the reported change score SD or pre-test range (see supplemental material S2 for additional details). To calculate the overall effect of exercise, relevant groups from multiple arm RCTs were collapsed (J. P. T. Higgins & Green, 2011). If recurrent control groups (e.g., diet) were identified, sensibility analyses were performed. Random effects models were performed due to the expected heterogeneity between studies. SMD values of 0.20, 0.50, and 0.80 can be interpreted as representing small, medium, and large effects, respectively. Heterogeneity was quantified using the I^2 statistic for each outcome, which can range from 0% to 100% (small: <25%; moderate: 25–50%; large: $\geq$50%) (J. P. Higgins & Thompson, 2002; J. P. Higgins, Thompson, Deeks, & Altman, 2003). Risk of publication bias was evaluated by using funnel plot representation (See supplemental material S3). All analyses were carried out in R 3.3 using the metafor package (Viechtbauer, 2010).

3. Results

3.1. Study selection

The electronic searches yielded 1490 studies; which was reduced to 1084 after removing duplicates. Twenty two studies (RCTs, CCTs, and before-and-after studies) were included in this review after all the rounds of screening were completed, and 11 RCTs providing sufficient information were used in the meta-analysis (see Fig. 1). Agreement between reviewers was moderate during title and abstract screening (kappa between SS and AnB = 0.66) and full-text screening (kappa between SS and AT = 0.73).

3.2. Study characteristics

Study and participant characteristics are described in Table 1. There were 16 (73%) RCTs (Abou-Raya, Abou-Raya, & Helmii, 2014; Casilda-Lopez et al., 2017; Christensen et al., 2015; Horwich et al., 2011; Imayama et al., 2011; Kitzman et al., 2016; Labrunee et al., 2012; Megakli et al., 2016, 2017; Napoli et al., 2014; Nieman, Custer, Butterworth, Utter, & Henson, 2000; Plotnikoff et al., 2010; Sarsan, Ardiç, Özgen, Topuz, & Sermez, 2006; Sukala et al., 2013; Svensson et al., 2017; Vasconcelos et al., 2016; Villareal et al., 2011), 1 (5%) CCT (Rica et al., 2013), and 5 (23%) before-and-after studies (Baillot, Vibarel-Rebot, Amiot, Emy, & Collomp, 2012; del Rey-Moya, Castilla-, Á, lvarez, Pichiule-Casta, ñ, eda, Rico-Bl, á, zquez, Escortell-Mayor, G, ó, & mez-Quevedo, 2013; Lucha-LÓPez et al., 2012; Muller-Pinget, Carrard, Ybarra, & Golay, 2012; Wouters, Nunen, Geenen, Kolotkin, & Vingerhoets, 2010). The 22 studies included

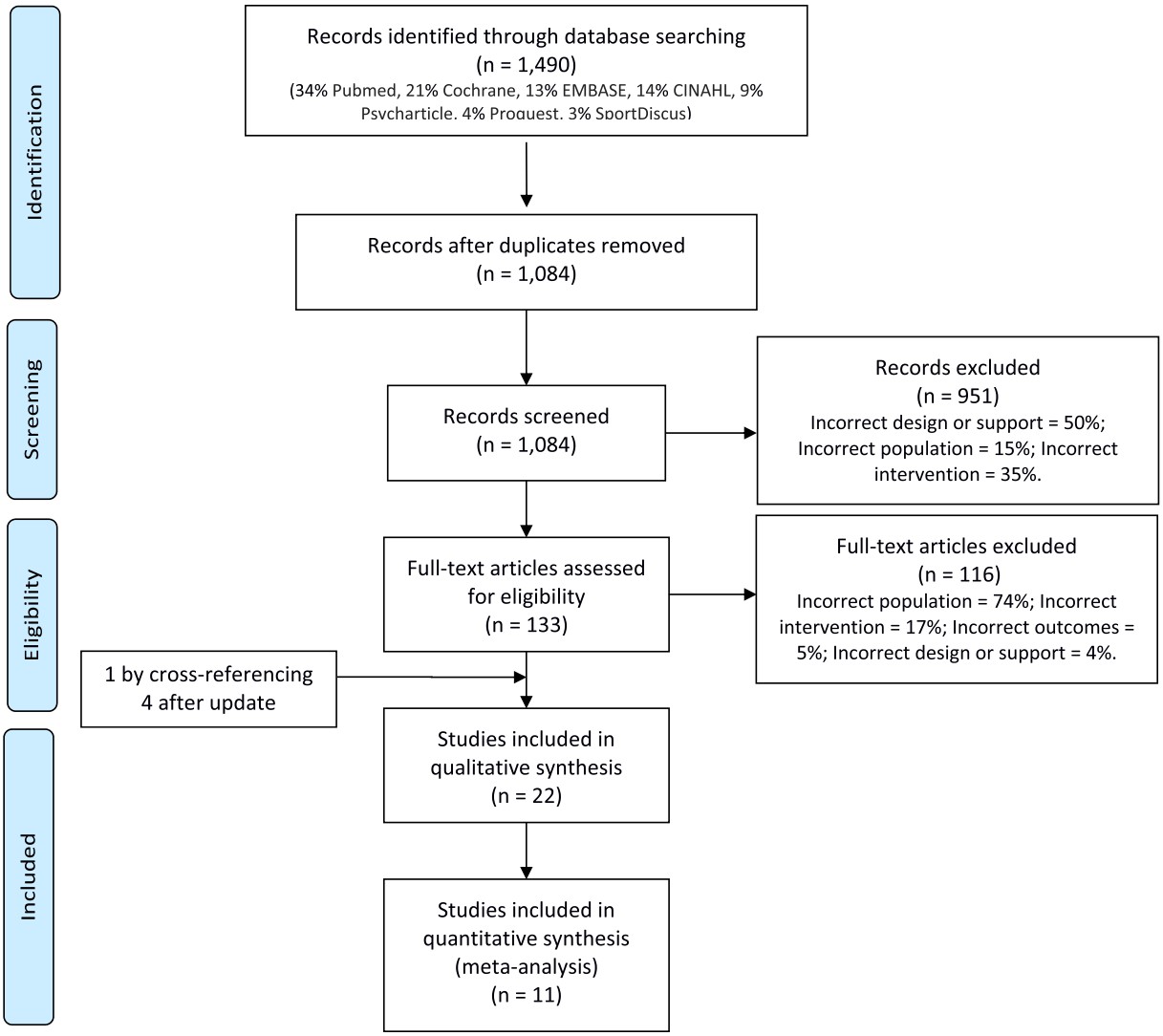

Fig. 1. PRISMA 2009 flow diagram.

2510 adults (median: 64, range 8–1142) with a mean age of 58.4 ± 10.7 years (median: 60, range: 42–72). More than half of the studies included >75% of women in their sample (k = 12) (Casilda-Lopez et al., 2017; Christensen et al., 2015; del Rey-Moya et al., 2013; Kitzman et al., 2016; Lucha-LÓPez et al., 2012; Megakli et al., 2016, 2017; Muller-Pinget et al., 2012; Nieman et al., 2000; Rica et al., 2013; Sarsan et al., 2006; Vasconcelos et al., 2016; Wouters et al., 2010), 36% (k = 8) included only women (Casilda-Lopez et al., 2017; del Rey-Moya et al., 2013; Megakli et al., 2016, 2017; Muller-Pinget et al., 2012; Nieman et al., 2000; Rica et al., 2013; Sarsan et al., 2006; Vasconcelos et al., 2016), and 5% (k = 1) included only men (Baillot et al., 2012).

QoL was assessed in 20 (91%) studies (Abou-Raya et al., 2014; Baillot et al., 2012; Casilda-Lopez et al., 2017; Christensen et al., 2015; del Rey-Moya et al., 2013; Horwich et al., 2011; Imayama et al., 2011; Kitzman et al., 2016; Labrunee et al., 2012; Lucha-LÓPez et al., 2012; Megakli et al., 2016; Muller-Pinget et al., 2012; Napoli et al., 2014; Plotnikoff et al., 2010; Rica et al., 2013; Sukala et al., 2013; Svensson et al., 2017; Vasconcelos et al., 2016; Villareal et al., 2011; Wouters et al., 2010), depression in 4 (18%) studies (Abou-Raya et al., 2014; Napoli et al., 2014; Nieman et al., 2000; Sarsan et al., 2006), anxiety in 1 (5%) study (Nieman et al., 2000), and body image in 2 (9%) studies (Megakli et al., 2017; Muller-Pinget et al., 2012). However, QoL was reported as the primary outcome in 7 (32%) studies (Casilda-Lopez et al., 2017; Imayama et al., 2011; Kitzman et al., 2016; Megakli et al., 2016; Napoli et al., 2014; Sukala et al., 2013; Svensson et al., 2017), body image in 2 (9%) studies (Megakli et al., 2017; Muller-Pinget et al., 2012) and depression, anxiety in 1 (5%) study (Nieman et al., 2000). Seven (32%) studies did not provide information on their primary outcome (Abou-Raya et al., 2014; Baillot et al., 2012; Labrunee et al., 2012; Lucha-LÓPez et al., 2012; Rica et al., 2013; Sarsan et al., 2006; Wouters et al., 2010).

3.3. Exercise interventions

Table 2 presents the characteristics of exercise interventions. Most interventions delivered lasted ≤16 weeks (k = 15; 68%) (Baillot et al., 2012; Casilda-Lopez et al., 2017; del Rey-Moya et al., 2013; Horwich et al., 2011; Labrunee et al., 2012; Lucha-LÓPez et al., 2012; Megakli et al., 2016, 2017; Nieman et al., 2000; Plotnikoff et al., 2010; Rica et al., 2013; Sarsan et al., 2006; Sukala et al., 2013; Svensson et al., 2017; Vasconcelos et al., 2016; Wouters et al., 2010), were supervised (k = 16; 73%) (Baillot et al., 2012; Casilda-Lopez

Table 1
Studies and participants characteristics.

(Ref. Year) Country	Group names	N by group (% Women)	Age years± SD or (range)	BMI kg/m^2 ±SD or (range)	Comorbidities (%)
Randomized controlled studies					
(Abou-Raya et al., 2014)	E	55 (NR)	NR	NR	Psoriatic arthritis (100%)
Egypt	Diet + E				
	Diet				
	Control				
(Christensen et al., 2015)	E	64 (81)	63 ± 6	37 ± 4	Osteoarthritis (100%)
Denmark	Diet	64 (81)	63 ± 7	38 ± 5	
	Control	64 (80)	62 ± 7	38 ± 5	
(Horwich et al., 2011)	E	576 (31)	40–67	NR	Heart Failure (100%); Ischemic etiology (42%)
USA	Control	566 (31)		NR	Myocardial infarction (33%); HTA (68%); T2D (42%)
(Imayama et al., 2011)	E	43 (44)	56 ± 7	34 ± 3	NR
USA	Control	44 (43)	56 ± 7	34 ± 3	
(Kitzman et al., 2016)	E	26 (81)	68 ± 6	40 ± 8	Heart failure (100%); HTA (96%); T2D (38%)
	Diet + E	25 (80)	66 ± 5	41 ± 6	Heart failure (100%); HTA (92%); T2D (44%)
	Diet	24 (83)	67 ± 5	37 ± 4	Heart failure (100%); HTA (96%); T2D (21%)
	Control	25 (80)	66 ± 5	39 ± 6	Heart failure (100%); HTA (96%); T2D (36%)
(Labrunee et al., 2012)	E	11 (46)	52 ± 8	39 ± 10	T2D (100%)
France	Control	12 (67)	53 ± 9	40 ± 7	
(Casilda-Lopez et al., 2017)	E	17 (100)	66 ± 7	31 ± 2	Comorbidity index 2 ± 0.7
Spain	Control	17 (100)	66 ± 6	34 ± 3	Comorbidity index 2 ± 0.5
(Megakli et al., 2016; Megakli et al., 2017)	E	35 (100)	32 ± 7	36 ± 5	NR
	Control	37 (100)	32 ± 8	37 ± 5	
Greece					
(Napoli et al., 2014)	E	26 (61)	70 ± 4	37 ± 5	CVD (27%)
USA	Diet + E	28 (57)	70 ± 4	37 ± 5	CVD (31%)
	Diet	26 (65)	70 ± 4	37 ± 5	CVD (31%)
	Control	27 (67)	69 ± 4	37 ± 5	CVD (30%)
(Nieman et al., 2000)	E	21 (100)	NR	NR	NR
USA	Diet + E	22 (100)			
	Diet	26 (100)			
	Control	22 (100)			
(Plotnikoff et al., 2010)	E	27 (70)	55 ± 12	35 ± 8	T2D (100%)
Canada	Control	21 (62)	54 ± 12	36 ± 5	
(Sarsan et al., 2006)	Aerobic	26 (100)	42 ± 8	35 ± 5	NR
Turkey	Resistance	26 (100)	43 ± 10	34 ± 3	
	Control	24 (100)	44 ± 7	36 ± 4	
(Sukala et al., 2013)	Aerobic	13 (54)	51 ± 4	45 ± 7	T2D (100%)
New-Zeland	Resistance	13 (46)	48 ± 6	43 ± 12	Myocardial infarction (11%)
(Svensson et al., 2017)	High Intensity	49 (76)	44 ± 8	42 ± 5	NR
Sweden	Moderate Intensity	39 (74)	47 ± 10	43 ± 8	
	Control	22 (73)	47 ± 9	45 ± 5	
(Vasconcelos et al., 2016)	E	16 (100)	72 ± 5	32 ± 2	NR
Brazil	C	15 (100)	72 ± 4	33 ± 3	
(Villareal et al., 2011)	Diet + E	28 (57)	70 ± 4	37 ± 5	≈2 ± 1 chronic diseases
USA	Diet	26 (65)	70 ± 4	37 ± 5	
	Control	27 (67)	69 ± 4	37 ± 5	
Controlled clinical trial					
(Rica et al., 2013)	E	28 (100)	69 ± 6	33 ± 4	NR
Brasil	Control	10 (100)	68 ± 4	34 ± 3	
Before-after studies (without control group)					
(Baillot et al., 2012)	E	8 (0)	60 ± 2	36 ± 2	T2D (100%)
France					
(del Rey-Moya et al., 2013)	E	174 (100)	58 ± NR	34 ± 3	NR
Spain					
(Lucha-LÓPez et al., 2012)	E	25 (80)	58 ± 8	35 ± 6	T2D (100%)
Spain					Musculoskeletal pain (84%)
					Vascular complications (4%)
					Neuropathic complications (8%)
(Muller-Pinget et al., 2012)	E	18 (100)	45 ± 2	37 ± 1	Several obesity co-morbidities (T2D, HTA, hyperlipidemia, coronary artery disease, depression, and bipolar disorder)
Switzerland					
(Wouters et al., 2010)	E	15 (87)	44 ± NR	38 ± 5	NR
Netherlands					

E = exercise; NR = not reported; HTA= Arterial hypertension; T2D = type 2 diabetes; CVD = cardiovascular diseases.

Table 2
Exercise intervention description.

	Length (weeks)	Supervision	Exercise format	Location	Exercise type	Volume
Randomized controlled studies						
(Abou-Raya et al., 2014)	52	NR	NR	NR	NR	NR
(Christensen et al., 2015)	52	SS	I	H + F	Circuit training (Weight bearing exercises)	- 3 × 60 min/wk.
(Horwich et al., 2011)	12	S	I + G	H + F	Walking treadmill stationary Bicycle	- 3–5 x at least 40 min/wk.
(Imayama et al., 2011)	52	SS	I	H + F	Aerobic	- 6 × 60 min (60–85% HR max)/wk.
(Kitzman et al., 2016)	20	S	I	F	Walking	- 3 × 60 min (40–70% HR reserve)/wk.
(Labrunee et al., 2012)	12	SS	I	H + F	Cyclergometer	- 7 × 30 min (ventilatory threshold)/wk.
(Casilda-Lopez et al., 2017)	8	S	G	F	Aquatic dancing	- 3 × 45 min (12 min warm-up, 21 min dance exercise, 12 min cool down)/wk.
	8	S	G	F	Aquatic exercises	- 3 × 45 min (12 min warm-up, 21 min exercises, 12 min cool down)/wk.
(Megakli et al., 2016; Megakli et al., 2017)	12	S	G	F	Aerobic and circuit training	- 3 x ~30 min/wk.
(Napoli et al., 2014)	52	S	G	F	Aerobic W-L machines Balance, flexibility	−3 x 30 min (65–85% HR peak)/wk. - 3 ×/wk. 1–3 x 6–12 reps for 8 exercises (65–80% 1-RM) - 3 × 30 min/wk.
(Nieman et al., 2000)	12	SS	I	H + F	Walking	- 5 × 45 min (60–80% HR max.)/wk.
	12	SS	I	F	Calisthenics + stretching	- 4 × 45 min (under 100 bpm)/wk.
(Plotnikoff et al., 2010)	16	SS	I	H	W-L machines	- 3 ×/wk. 2–3 x 8–12 reps for 8 exercises (50–80% 1-RM)
(Sarsan et al., 2006)	12	S	I	F	Walking Cyclergomenter	- 3–5 x 12–45 min (50–85% HR reserve)/wk.
	12	S	I	F	Stationary weights	- 3 ×/wk. 1–3 × 10 reps for 6 exercises (40–80% 1-RM)
(Sukala et al., 2013)	16	S	I	F	Cyclergomenter	- 3 × 40–60 min (65–85% HR reserve)/wk.
	16	S	I	F	Machine based weights	- 3 ×/wk. 2–3 x 6–8 reps for 8 exercises (10 reps perfect form then added weight)
(Svensson et al., 2017)	16	S	I	F	Aerobic machines Resistance machines	- 3 × 60 min (85–95% HR max)/wk.
	16	S	I	H + F	Aerobic machines Resistance machines	- 3 × 30 min (76–85% HR max)/wk. - 3 × 30 min (40–55% HR max)/wk.
(Vasconcelos et al., 2016)	10	S	G	F	Resistance	- 2 × 60 min (2–3 x 8–12 reps for 8 exercises (50–60% 1-RM))/wk
(Villareal et al., 2011)	52	S	I	NR	Treadmill, Stationary cycling, Stair climbing W-L machines Flexibility, balance	- 3 × 30 min (65–85% HR peak)/wk. - 3 ×/wk. 1–3 x 6–12 reps for 9 exercises (65–85% 1-RM) - 3 ×/wk. 30 min
Controlled clinical trial						
(Rica et al., 2013)	12	S	G	F	Water exercise	- 3 × 60 min (70% age-predicted HR max)/wk. 10-15 repetitions of each exercises
Before-after studies (without control group)						
(Baillot et al., 2012)	8	S	I	H + F	Walking Cyclergomenter	- 2 × 45 min (75% HR peak)/wk. - 1 × 45 min (2min-85% HR peak + 3 min - 60% HR peak)/wk.
(del Rey-Moya et al., 2013)	7	S	G	F	Walking Stretching	- 3 × 60 min (40–65% HR max)/wk.
(Lucha-LÓPez et al., 2012)	12	S	G	F	Aerobic Stabilizer movements + stretching	- 2 × 20 min (light-moderate intensity)/wk. - 2 × 55 min/wk.
(Muller-Pinget et al., 2012)	36	S	G	F	Dance therapy workshop	- 120 min/wk.
(Wouters et al., 2010)	6	S	G	F	Aquajogging	- 2 × 60 min (stimulated to gradually increase the intensity)/wk.

BPM=Beats per minute; E = Exercise; NR=Not reported; S=Supervised; SS=Semi-supervised; H=Home; F=Facility-based; I=Individual; G = Group; HTA= Arterial hypertension; T2D = Type 2 diabetes; HR=Heart rate; CVD=Cardiovascular diseases; 1-RM = One-repetition maximum; W-L=Weight-lifting.

et al., 2017; del Rey-Moya et al., 2013; Horwich et al., 2011; Kitzman et al., 2016; Lucha-LÓPez et al., 2012; Megakli et al., 2016, 2017; Muller-Pinget et al., 2012; Napoli et al., 2014; Rica et al., 2013; Sarsan et al., 2006; Sukala et al., 2013; Svensson et al., 2017; Vasconcelos et al., 2016; Villareal et al., 2011; Wouters et al., 2010), and delivered one-on-one (k = 10; 45%) (Christensen et al., 2015; Imayama et al., 2011; Kitzman et al., 2016; Labrunee et al., 2012; Nieman et al., 2000; Plotnikoff et al., 2010; Sarsan et al., 2006; Sukala et al., 2013; Svensson et al., 2017; Villareal et al., 2011). Eleven (50%) included endurance training (Baillot et al., 2012; Casilda-Lopez et al., 2017; del Rey-Moya et al., 2013; Horwich et al., 2011; Imayama et al., 2011; Kitzman et al., 2016; Labrunee et al., 2012; Lucha-LÓPez et al., 2012; Muller-Pinget et al., 2012; Nieman et al., 2000; Wouters et al., 2010), 3 (14%) resistance training (Christensen et al., 2015; Plotnikoff et al., 2010; Vasconcelos et al., 2016), 5 (23%) a combination of endurance and resistance training (Megakli et al., 2016, 2017; Napoli et al., 2014; Rica et al., 2013; Svensson et al., 2017; Villareal et al., 2011), and 2 (9%) compared endurance to resistance training (Sarsan et al., 2006; Sukala et al., 2013). Exercise session duration ranged from 12 to 90 min, with a frequency between 2 and 5 sessions per week, except for 2 (12%) studies that reported 6 or 7 sessions per week (Imayama et al., 2011; Labrunee et al., 2012). Exercise intensity varied from light to moderate in 16 (73%) studies and 6 (27%)

studies did not report information on exercise intensity (Abou-Raya et al., 2014; Casilda-Lopez et al., 2017; Christensen et al., 2015; Horwich et al., 2011; Megakli et al., 2016, 2017; Muller-Pinget et al., 2012).

3.4. Risk of bias

Risk of bias assessments are presented in Fig. 2. Two (9%) of the 16 RCTs obtained a score >75%, and 14 (64%) studies had scores suggestive of high risk of bias (<50% overall score).

3.5. Findings for QoL

3.5.1. RCTs

Of the 14 RCTs that reported results on QoL (Abou-Raya et al., 2014; Casilda-Lopez et al., 2017; Christensen et al., 2015; Horwich et al., 2011; Imayama et al., 2011; Kitzman et al., 2016; Labrunee et al., 2012; Megakli et al., 2016, 2017; Napoli et al., 2014; Plotnikoff et al., 2010; Sukala et al., 2013; Svensson et al., 2017; Vasconcelos et al., 2016; Villareal et al., 2011), 10 used generic QoL questionnaires (i.e., Short-Form 36 or 12 Health Status questionnaire) (Christensen et al., 2015; Imayama et al., 2011; Kitzman et al., 2016; Labrunee et al., 2012; Megakli et al., 2016; Plotnikoff et al., 2010; Sukala et al., 2013; Svensson et al., 2017; Vasconcelos et al., 2016; Villareal et al., 2011), 5 used disease-related questionnaires (i.e., Health Assessment Questionnaire-Disability Index, Health Assessment Questionnaire-Disability Index, Knee injury and Osteoarthritis Outcome Score, Kansas City Cardiomyopathy Questionnaire, Minnesota Living with Heart Failure Questionnaire, Western Ontario and McMaster Universities Osteoarthritis Index) (Abou-Raya et al., 2014; Casilda-Lopez et al., 2017; Christensen et al., 2015; Horwich et al., 2011; Kitzman et al., 2016), and 1 used an obesity-related questionnaire (i.e., Short form of impact of Weight on QoL questionnaire (i.e., IWQOL-Lite) (Napoli et al., 2014). Six of the 10 RCTs using generic QoL questionnaires did not report significant differences in change in QoL between exercise and control groups (Christensen et al., 2015; Imayama et al., 2011; Kitzman et al., 2016; Labrunee et al., 2012; Plotnikoff et al., 2010; Vasconcelos et al., 2016), 1 reported significant improvements in QoL in the endurance and the resistance exercise groups relative to pre-intervention with no significant difference between these two groups (Sukala et al., 2013), 1 reported significant differences in change in physical QoL (but not mental QoL) between groups favoring the exercise group (Villareal et al., 2011), and 2 found significant differences in change in several physical and mental QoL subscores between groups favoring the exercise group (Megakli et al., 2016; Svensson et al., 2017). Of the 6 RCTs using disease- or obesity-related QoL questionnaires (Abou-Raya et al., 2014; Casilda-Lopez et al., 2017; Christensen et al., 2015; Horwich et al., 2011; Kitzman et al., 2016; Napoli et al., 2014), 3 reported that exercise significantly improved QoL compared to the control condition (Casilda-Lopez et al., 2017; Horwich et al., 2011; Napoli et al., 2014), 2 did not find significant differences in change in QoL between exercise and control groups (Christensen et al., 2015; Kitzman et al., 2016), and 1 did not provide results on between group differences (Abou-Raya et al., 2014).

3.5.2. Meta-analysis of RCTs

Of the 14 RCTs that assessed QoL, 7 provided sufficient information to be included in the meta-analysis (Christensen et al., 2015; Labrunee et al., 2012; Megakli et al., 2016; Plotnikoff et al., 2010; Svensson et al., 2017; Vasconcelos et al., 2016; Villareal et al., 2011). Seven studies (8 exercise arms) included 252 (nexperimental = 268; ncontrol = 194) participants for physical QoL and, 6 studies (7 exercise arms) mental QoL (nexperimental = 254; ncontrol = 180). No significant effect favoring exercise was detected in the pooled analysis either for physical ($g = 0.16$; $p = .13$; 95% CI = [-0.05–0.37]) or mental QoL ($g = 0.20$; $p = .18$; 95% CI = [-0.09–0.48]) (see details in Supplementary file 4). In sensibility analysis comparing exercise to diet interventions, no significant differences in change in QoL between treatment groups were found.

3.5.3. CCTs and before-and-after studies

Using a generic QoL questionnaire (i.e., the WHOQoL questionnaire), 1 CCT yielded a significant between-group interaction favoring the exercise group (Rica et al., 2013). Among the 5 before-and-after studies, 3 used an obesity-related QoL questionnaires (i.e., IWQOL-Lite and Quality of Life, Obesity and Dietetics Questionnaire) (Baillot et al., 2012; Muller-Pinget et al., 2012; Wouters et al., 2010), 1 used a disease-related QoL questionnaire (i.e., Dartmouth COOP Functional Health Assesment Charts) (Lucha-LÓPez et al., 2012), and 1 used a generic QoL questionnaire (i.e., Gordon's Functional Pattern Assessment) (del Rey-Moya et al., 2013). All 5 reported significant improvements in several QoL domains (e.g., psychosocial functioning, physical functioning, self-esteem, public distress) (Baillot et al., 2012; del Rey-Moya et al., 2013; Lucha-LÓPez et al., 2012; Muller-Pinget et al., 2012; Wouters et al., 2010).

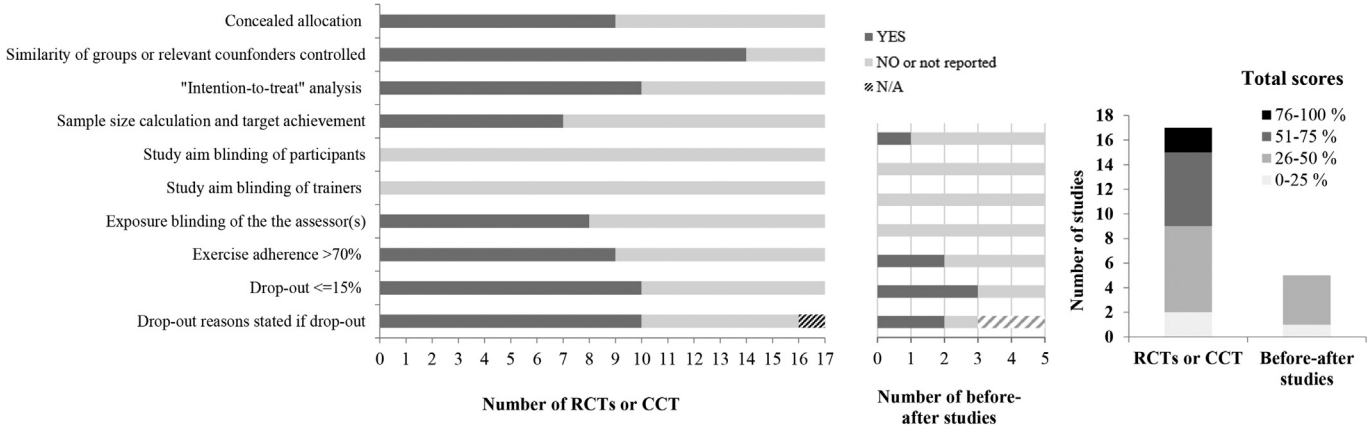

Fig. 2. Risk of bias assessment of the 22 included studies.

3.6. Findings for depression

Four RCTs reported results on depression (Abou-Raya et al., 2014; Napoli et al., 2014; Nieman et al., 2000; Sarsan et al., 2006), 2 of which used the Beck Depression Inventory (Abou-Raya et al., 2014; Sarsan et al., 2006), 1 used the Geriatric Depression Scale (Napoli et al., 2014), and 1 used the Profile of Mood Scale (Nieman et al., 2000). No CCT or before-and-after study reported results on depression.

3.6.1. Meta-analysis of RCTs

A sample size of 183 participants were included in these RCTs ($n_{experimental} = 100$; $n_{control} = 83$). The pooled effect size was $g = -0.23$ (95%CI [-0.70,0.19], $p = .25$, $I^2 = 31\%$), indicating no significant differences in change in depression between the exercise and control groups. Sensibility analyses did not detect any significant differences in change in depression between the exercise and control groups when exercise was combined with the diet group (see details in Supplementary file 4).

3.7. Findings for anxiety and body image

There was 1 RCT for anxiety (Nieman et al., 2000). No significant difference in change in tension-anxiety between the exercise and control groups as assessed using the Tools Profile of Mood States were found in this study.

There was one RCTs assessing body image (body attractiveness), which reported after intervention no significant difference between the endurance/resistance exercise group compared to the control group (Megakli et al., 2017). There was 1 before-and-after study (Muller-Pinget et al., 2012), which used the Laban movement analysis and developmental movement patterns from Cohen. The intervention resulted in significant improvements in body consciousness and mental representations.

4. Discussion

4.1. Summary of evidence

A range of outcomes have been assessed in exercise trials in adults with obesity. Only one review has previously attempted to summarize evidence on the effect of exercise on psychosocial outcomes (Baker et al., 2016). Nevertheless, this review (Baker et al., 2016) focused on studies with post-menopausal overweight and obese women, and as a result, studies with other segments of the adult population with obesity were not included. To complement Baker et al.'s review (Baker et al., 2016) and inform the development of interventions to promote psychosocial functioning in adults with obesity, the present systematic review summarized evidence from studies on the effect of exercise on QoL, depression, anxiety, and body image in men and women with a BMI $\geq$30 kg/m^2.

Overall, exercise alone does not seem to be effective in enhancing QoL or reducing depression significantly in adults with obesity. This conclusion is in accordance with Baker et al.'s conclusion (Baker et al., 2016). However, it is at odds with previous reviews highlighting that exercise can effectively improve psychosocial outcomes (e.g., QoL, depression, anxiety, body image) in non-clinical and clinical populations (Bartley et al., 2013; Bridle et al., 2012; Buffart et al., 2017; Campbell & Hausenblas, 2009; Chen & Rimmer, 2011; Chou et al., 2012; Ekkekakis, 2015; Fukuta et al., 2016; Herring et al., 2010, 2012; Rebar et al., 2015; Wipfli et al., 2008). The non-significant effects found in this meta-analysis may reflect the low quality of available studies rather than signify that exercise is not effective. Indeed, only two studies reviewed had scores suggested a low risk of bias ($\geq$75% overall score) (Kitzman et al., 2016; Plotnikoff et al., 2010). Nevertheless, previous meta-analyses show that the overall effect size is negatively correlated with studies' quality score (Bernard et al., 2017). Consequently, the lack of effect is likely to be due to the small number of studies primarily focused on psychosocial outcomes (Casilda-Lopez et al., 2017; Imayama et al., 2011; Kitzman et al., 2016; Megakli et al., 2016, 2017; Muller-Pinget et al., 2012; Napoli et al., 2014; Nieman et al., 2000; Sukala et al., 2013; Svensson et al., 2017) and the small sample sizes. More trials with QoL and depression as the primary outcomes are required to be able to determine the effect of exercise on these outcomes.

In terms of anxiety and body image only three studies (Megakli et al., 2017; Muller-Pinget et al., 2012; Nieman et al., 2000) were found. Thus, more trials assessing anxiety and body image are needed before firm conclusions can be drawn regarding the effect of exercise on anxiety and body image in adults with obesity.

The absence of effects found in the majority of studies for QoL, depression and anxiety could be explained by several reasons. First, the effective modalities required to improve these outcomes remains unknown in adults with obesity. Higher doses or specific types of exercise might be required to improve psychosocial outcomes in adults with obesity. As an example, a previous review underlined the possibility of a dose-response effect of exercise on depression and anxiety reduction (Dunn, Trivedi, & O'Neal, 2001). Second, exercise interventions may need to consider preferences and pleasure. Exercise may further impact psychosocial outcomes if it is self-selected and enjoyable based on evidence showing that exercising at a preferred intensity yields a significant reduction in depression in women (Callaghan, Khalil, Morres, & Carter, 2011). Thus, factors known to moderate the effect of exercise on psychosocial outcomes should be considered during the intervention design process to facilitate the selection of effective exercise protocols. Finally, although there is evidence that psychotropic medications (i.e., antidepressants, anxiolytic) can confound the effect of exercise on depression and anxiety, particularly in obese adults with comorbidity (Bernard & Carayold, 2015), participants' use of psychotropic medications was not generally used as an exclusion criteria or considered in the analysis.

4.2. Strengths and limitations of this review

The main strength of this review is its systematic analysis of the relevant literature. The studies identified were the result of an extensive search of a number of different databases, and screening and data extraction were conducted by multiple reviewer authors to minimize bias. Nonetheless, it is possible that relevant studies were missed. Also, this review contains studies published in peer-reviewed journals with full-texts available in English or French only, and multicomponent interventions were not included. In addition, potential publication bias (i.e., under-representation of studies with null or negative effects) should be considered when interpreting the results. Last, the conclusions that can be drawn from this review are limited by the small number of available studies in this area and the methodological limitations associated with these studies.

4.3. Recommendations for future research

A major recommendation coming out of this review, echoing prior reviews (Baker et al., 2016), is that additional larger, methodologically sound trials are needed before firm conclusions can be made regarding the effect of exercise on psychosocial functioning in adults with obesity. Based on identified gaps, the first key direction is clearly to assess a range of psychosocial outcomes as primary outcomes. To date, most studies focused on a single

outcome. There is a need to consider using a combination of sensitive outcome measures that map onto general and specific aspects of psychosocial functioning as some aspects may be more or less impacted by exercise. There is also a strong need to determine the most effective protocols that can improve psychosocial functioning in adults with obesity as only three studies compared different exercise modalities (Sarsan et al., 2006; Sukala et al., 2013; Svensson et al., 2017). Thus, future research should focus testing differential effects of exercise training of varied type, format, duration, frequency, and intensity. In addition, research should be undertaken to establish which subgroups of adults may experience the greatest effects and which may require additional interventions to experience enhanced psychosocial functioning. In addition, most of the studies were conducted with women. Future studies are necessary to enable us to draw conclusions regarding the applicability of evidence to men, and whether effects are similar or different across sexes. Last, studies of mediators would be an asset to better understand the underlying mechanisms involved in the efficacy of exercise interventions regarding psychosocial outcomes in adults with obesity.

4.4. Conclusion

Despite the present lack of evidence on the beneficial effect of exercise on psychosocial outcomes in adults with obesity, exercise should still be recommended in obesity management due to its other important physical benefits. Nevertheless, to guide the decision whether exercise should be recommended as a non-pharmacologic alternative and/or complimentary approach to enhance psychosocial functioning in adults with obesity, more large-scale well-controlled trials (e.g., RCTs) using sensitive outcome measures are needed to improve evidence-based knowledge.

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Conflicts of interest

None.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.mhpa.2017.12.004.

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