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Differential effects of dietary restriction combined with exercise vs dietary restriction alone on visceral and subcutaneous adipose tissues: A systematic review

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ABSTRACT

Visceral adipose tissue (VAT) and subcutaneous adipose tissue (SAT) are associated with cardio metabolic risk factors. A number of studies have reported the effects of lifestyle interventions on VAT and SAT loss. In this review, we aimed to compare the effects of dietary restriction (DR) alone vs DR combined with exercise (DR + E) on VAT and SAT loss in healthy adults. Specifically, we aimed to assess the differential effects of different lifestyle interventions including DR vs DR combined with exercise on VAT and ASAT loss. Of sixteen studies that met the eligibility criteria's, one study had DR vs AE (aerobic exercise) vs DR + AE (DRAE) groups, five studies had DR vs DR + AE (DRAE) vs DR + RE (resistance exercise) (DRRE) groups, nine studies had DR vs DR + AE (DRAE) groups (of which two studies also had C (control) group), and one study had C vs DR vs DR + RE (DRRE). Results observed significant VAT and SAT loss in all intervention groups with no statistically significant difference among intervention groups. In conclusion, fat loss of all types (visceral and subcutaneous) is mostly related to energy deficit, i.e. the differential between energy intake and expenditure, independent of the method used to achieve the deficit (dietary restriction alone or dietary restriction plus exercise).

1. Introduction

Obesity is a major public health problem globally (Hurt et al., 2010; Organisation WH 2015). Overweight and Obesity are defined as excessive body fat accumulation that can lead to adverse health outcomes (Arroyo-Johnson and Mincey, 2016; Abdelaal et al., 2017; Lenz et al., 2009). The imbalance between energy intake and energy expenditure is the key factor in obesity development (Racette et al., 2003). Body fat is distributed in the visceral adipose tissue (VAT) and subcutaneous adipose tissue (SAT) (Flegal et al., 2009; Kamel et al., 1999). The amount of visceral adipose tissue increases with age in both genders and then declines after the age of 80 (Arroyo-Johnson and Mincey, 2016; Abdelaal et al., 2017). Both VAT and SAT are risk factors for cardio metabolic disorders (Neeland et al., 2013; Fox et al., 2007; Jensen, 2006). However, VAT is much stronger risk factor for impaired fasting glucose (Lenz et al., 2009; Racette et al., 2003; Flegal et al., 2009; Kamel et al., 1999), insulin resistance (Lenz et al., 2009; Flegal et al., 2009), hyperlipidemia (Lenz et al., 2009), hypertension (Lenz et al., 2009; Racette et al., 2003), the metabolic syndrome (Lenz et al., 2009; Racette et al., 2003; Flegal et al., 2009), type 2 diabetes mellitus (Lenz et al., 2009; Racette et al., 2003; Kamel et al., 1999), cardiovascular disease (Neeland et al., 2013; Fox et al., 2007), inflammation (Vachharajani and Granger, 2009) and cancer (Neeland et al., 2013; Vachharajani and Granger, 2009). This could be related to high lipolitically activity of VAT which exposes liver to high amount of free fatty acid (Despres, 2012; Micklesfield et al., 2012). Computerized tomography scan (CT scan), Magnetic resonance imaging (MRI) and Dual-energy X-ray absorptiometry (DXA) are relatively new methods used for body composition measurement. MRI and CT scan are the most reliable and precise methods and are considered as the "gold standard" for measuring VAT and SAT depots (Despres, 2012; Micklesfield et al., 2012; Shuster et al., 2012).

Lifestyle interventions, including dietary restriction (DR) alone or in combination with exercise (DR + E), are effective strategies for VAT and SAT loss (Redman et al., 2007; Janssen and Ross, 1999). Kay et al. (Kay and Fiatarone Singh, 2006), Ismail et al. (2012) and Vissers et al. (2013) conducted meta-analysis to investigated the effects of physical activity/exercise trainings on VAT and/or abdominal fat (VAT and abdominal SAT (ASAT)) reduction and observed that physical activity/exercise trainings have beneficial effects on reduction of VAT and/or abdominal fat. Chaston et al. (Chaston and Dixon, 2008) and Smith et al. (Smith and Zachwieja, 1999) investigated the effects of weight

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loss on abdominal VAT and SAT and found that moderate weight loss interventions including DR and E can lead to significant VAT loss, however the effect can be attenuated by greater weight loss (Chaston and Dixon, 2008; Smith and Zachwieja, 1999).

The aim of this study was to conduct a systematic review to assess the effects of different lifestyle interventions of VAT and ASAT loss. Specifically, we aimed to assess the differential effects of different lifestyle interventions including DR vs DR combined with exercise on VAT and ASAT loss. For this purpose the results of studies that assessed the VAT and ASAT changes followed by lifestyle interventions including DR vs DR combined with exercise were evaluated.

2. Methods

2.1. Database search

Pubmed database was searched from the earliest time to the end of March 2016. A combination of the following keywords was used: lifestyle intervention, physical activity, exercise, dietary restriction, diet, visceral adipose tissue, subcutaneous adipose tissue, CT scan and MRI. Only articles in English language were searched. The process of articles screening and selection has been conducted by two reviewers working independently.

Randomized controlled trials (RCTs) and non RCTs were included if they compared the DR group vs DR combined with exercise group, but excluded if they had made comparisons with control group only.

2.2. Participants

Studies on adults, females and/or males were included. Studies conducted on elderly (> 70 years old) and diabetics were excluded.

2.3. Outcome measure

Studies that measured VAT and SAT by multi or single slice CT scan or MRI were included.

2.4. Data extraction and synthesis

The data were extracted independently by two researchers and the disagreements were resolved by discussions. The extracted data included information regarding the participants' characteristics (gender, mean age, and Body Mass Index (BMI), intervention characteristics (duration and types of interventions, study design (RCT vs non RCT), and numbers of participants), outcome measurement techniques (MRI, CT scan and DXA) and the outcomes of the individual studies (total FM, VAT, ASAT changes among intervention groups from baseline to the end of follow-up). The outcomes of interest was summarized qualitatively.

2.5. Quality appraisal

To assess the overall quality of the included studies, the following factors were selected: 1) study design (RCT/non RCT), 2) sample size justification, 3) intervention compliance and 4) fat mass (FM) measured (Table 1).

3. Results

3.1. Results of the search

The PRISMA flow diagram 2009 (The PRISMA, 2009) was used to depict the different stages of study selection. The Initial database search resulted in 2807 articles, and after eliminating duplications1735 articles remained. After screening at title/abstract level 1694 studies were excluded. The full text of 41 studies were screened, and 16 studies were selected for the final analysis. The reasons for exclusion were as follow: three studies had DR vs E vs C (control) groups, three studies were conducted in diabetics, five studies were performed in a population aged > 70 years old, ten studies had only DR + E groups, and four studies excluded because they were part of studies already included (Fig. 1).

Results of studies quality appraisal are presented in Table 1. Randomization was reported in twelve studies, however the process of randomization were described only in two studies (Nicklas et al., 2009; Goodpaster et al., 2010). The sample size was not justified in most of the studies. The level of compliance was variable, and compliance percentage was not calculated in most of the studies. Total FM measurement was not performed in two studies (Garcia-Unciti et al., 2012; Trussardi Fayh et al., 2013).

3.2. Study characteristics

General characteristics of participants are presented in Table 2. The sample size varied from 33 to 225 subjects. Mean age of study subjects varied from 30.1 ± 5.5 to 59.0 ± 5.0 years old in most studies. BMI varied from 27.1 ± 1.4 kg/m^2 to 43.5 ± 5.9 kg/m^2. Six studies included both genders (Redman et al., 2007; Janssen and Ross, 1999; Goodpaster et al., 2010; Trussardi Fayh et al., 2013; Christiansen et al., 2009; Larson-Meyer et al., 2006). Two studies included only male subjects (Ross et al., 1996; Rice et al., 1999) and eight studies included only female subjects (Nicklas et al., 2009; Garcia-Unciti et al., 2012; Janssen et al., 2002; Fisher et al., 2011; Okura et al., 2003, 2002, 2005; Ryan et al., 2006). The menopausal status of female subjects were as follow, three studies had both pre and postmenopausal female subjects (Garcia-Unciti et al., 2012; Okura et al., 2003, 2002, 2005), four studies had only premenopausal female subjects (Redman et al., 2007; Janssen and Ross, 1999; Janssen et al., 2002; Fisher et al., 2011), two studies had only postmenopausal female subjects (Nicklas et al., 2009; Ryan et al., 2006) and in four studies the menopausal status of the subjects was not mentioned.

The interventions' characteristics are presented in Table 3. The primary aim of thirteen studies was to investigate the impact of lifestyle interventions on body composition and/or fat distribution. The duration of interventions varied between 12 weeks and 12 months in most of the interventions except two in which the duration of intervention was based on weight loss threshold (Trussardi Fayh et al., 2013; Fisher et al., 2011), instead of a fixed follow up period. The VAT and SAT were measured by MRI or CT scan in all studies at baseline and after completion of intervention. The abdominal SAT was measured in all of the studies except two in which the whole body SAT was measured (Ross et al., 1996; Rice et al., 1999). For this reason ASAT changes were used to determine SAT changes.

Out of sixteen studies included, one study had DR vs AE (aerobic exercise) vs DR + AE (DRAE) groups (Christiansen et al., 2009), five studies had DR vs DRAE vs DR + RE (resistance exercise) (DRRE) groups (Janssen and Ross, 1999; Ross et al., 1996; Rice et al., 1999; Janssen et al., 2002; Fisher et al., 2011), one study had C vs DR vs DR + RE (DRRE) groups (Garcia-Unciti et al., 2012) and the remaining nine studies had DR vs DR + AE (DRAE) groups (of which two studies had also C groups (Redman et al., 2007; Larson-Meyer et al., 2006)).

Table 4 presents the dietary restriction and exercise protocols. Five studies applied a very low energy diet (Christiansen et al., 2009; Fisher et al., 2011; Okura et al., 2003, 2002, 2005). Four studies matched the total energy deficits between groups (Redman et al., 2007; Nicklas et al., 2009; Christiansen et al., 2009; Larson-Meyer et al., 2006). Energy intake reduction were variable across intervention groups (250–350 kcal/day (Ryan et al., 2006), 400 kcal/day (Nicklas et al., 2009), 500 kcal/day (Garcia-Unciti et al., 2012), 500–1000 kcal/day (Trussardi Fayh et al., 2013), 1000 kcal/day(17, 30–32), 1200–2100 kcal/day(25), and 12.5% and 25% caloric restriction from initial energy requirements in DR + E and DR groups respectively