DISSERTATION FROM THE
NORWEGIAN SCHOOL OF
SPORT SCIENCES
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Anne Mette Rustaden

The effect of BodyPump and resistance training with and without a personal trainer on overweight and obese women

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List of papers

This thesis is based on the following original research papers, which are referred to in the text by their Roman numerals I-IV:

I. Rustaden AM, Haakstad LAH, Paulsen G, Bø K. Effects of BodyPump and resistance training with and without a personal trainer on muscle strength and body composition in overweight and obese women – a randomised controlled trial. Obes Res Clin Pract, 2017; 11(6): 728-739, doi: 10.1016/j.orcp.2017.03.003.

II. Rustaden AM, Hagen Haakstad LA, Paulsen G, Bø K. Is there any effect of BodyPump and heavy load resistance training on prevalence of musculoskeletal pain in overweight and obese women? A randomized controlled trial. Currently, under revision in Physiotherapy.

III. Rustaden AM, Gjestvang C, Bø K, Hagen Haakstad LA, Paulsen G. BodyPump versus traditional heavy load resistance training on changes in resting metabolic rate in overweight untrained women. J Sports Med Phys Fitnes, 2017; Jul 25. doi: 10.23736/S0022-4707.17.07613-7J.

IV. Rustaden AM, Gjestvang C, Bø K, Hagen Haakstad LA, Paulsen G. Total workload and energy expenditure during high-repetition low-load resistance training versus traditional heavy load resistance training in overweight women. Currently, under revision in Research Quarterly for Exercise and Sport.

Definitions

Body mass index. A person`s weight in kilograms divided by the square of his height in meters (kg/m^2) (Branca et al., 2007, cap.1).

Obesity. A BMI equal to or greater than 30.0 kg/m^2 (Branca et al., 2007, cap.1).

Overweight. A BMI equal to or greater than 25.0 kg/m^2 (Branca et al., 2007, cap.1).

Physical activity. Any bodily movement produced by skeletal muscles that result in energy expenditure (Caspersen et al., 1985).

Exercise. Physical activity that is planned, structured, and repetitive and has as a final or intermediate objective the improvement or maintenance of physical fitness (Caspersen et al., 1985).

Resistance training. Any form of exercise that increase muscular strength (Knuttgen & Kraemer 1987).

Muscular strength. A health related component of physical fitness that relates to the amount of external force that a muscle can exert (Caspersen et al., 1985).

Maximal muscle strength. The maximal force a muscle or muscle group can generate at a specific or determined velocity (Knuttgren & Kraemer 1987).

Muscular endurance. A health-related component of physical fitness that relates to the ability of muscle groups to exert external force for many repetitions or successive exertions (Caspersen et al., 1985).

One repetition. One complete motion of an exercise, normally consists of two phases: the concentric muscle action, or lifting of the resistance, and the eccentric muscle action, lowering of the resistance. In some exercises one repetition may involve several movements and muscle actions (Fleck & Kraemer 2014, cap.1).

One repetition maximum. The maximum amount of weight that can be lifted, pushed or pulled one time (Fleck & Kraemer 2014, cap.1).

Rest periods. A rest period between sets of an exercise, between exercises and between training sessions that allow recovery. Rest period length are in large part determined by the goals of the training program (Fleck & Kraemer 2014, cap.1).

Intensity. Intensity of a resistance training exercise is estimated as a percentage of the 1RM or any RM resistance for the exercise (Fleck& Kraemer 2014, cap 1).

Training volume. A measure of the total amount of work performed in a training session, a week of training, a month of training or some other period of time (Fleck & Kraemer 2014, cap.1).

Periodization. A planned variation in the training volume and intensity (Fleck & Kraemer 2014, cap.1).

Non-linear periodization. Variation in intensity and volume within a cycle by rotating different protocols to train various components of neuromuscular performance (American College of Sports medicine 2009, Fleck 2011).

Body composition. A health related component of physical fitness that relates to the relative amounts of muscle, fat, bone and other vital parts of the body (Caspersen et al., 1985).

Fat mass. All extractable lipids from adipose and other tissue in the body (Heyward & Wagner 2004).

Lean body mass. Fat-free mass plus essential lipids (Heyward & Wagner 2004).

Energy expenditure. The total amount of energy (gross) expended during exercise, including the resting energy expenditure (resting energy expenditure + exercise energy expenditure). Energy expenditure may be articulated in METs, kilocalories or kilojoules (Swain 2000).

Excess post oxygen consumption (EPOC). The energy consumption during the course of the post-exercise level, where the metabolic level remains elevated over the pre-exercise level (Sedlock et al., 1989).

Resting metabolic rate (RMR). The energy consumption required for maintaining normal physiological processes during rest, which makes up for 60-75% of our total daily energy expenditure (Byrne & Wilmore 2000).

Respiratory exchange ratio (RER). A RER close to 1.0 is associated with greater carbohydrate oxidation at rest, and potentially a higher risk in developing metabolic diseases, while a lower RER (close to 0.70) is associated with higher fat oxidation and lower risk to develop metabolic diseases (McArdle, Katch & Katch 2010). All residual lipid free chemicals and tissues including water, muscle, bone, connective tissue, and internal organs (Heyward & Wagner 2004).

Adherence to exercise. Commitment to a behavioral standard, established as part of a negotiated agreement, alliance or contract, particularly in the context of behavioral change, therapeutic intervention and/or medical treatment. Described as a percentage of the prescribed dose that actually are completed across the specific time-period (Dishman & Ickes 1981).

Abbreviations

ADL	Activity of daily living
ACSM	American College of Sports Medicine
BMI	Body Mass Index
CI	Confidence Interval
DXA	Dual-energy X-ray Absorptiometry
EPOC	Excess post oxygen consumption
FFM	Fat free mass
FM	Fat mass
HR	Heart rate
ICC	Intraclass correlation
LBM	Lean body mass
MET	Metabolic equivalent
NSSS	Norwegian School of Sports Sciences
RER	Respiratory exchange ratio
RM	Repetition maximum
RMR	Resting metabolic rate
VO_2	Maximal oxygen consumption
WHO	World Health Organization

Sammendrag på norsk

Bakgrunn: Personer kategorisert med overvekt (BMI≥25.0 kg/m^2) og fedme (BMI≥25.0 kg/m^2) er i dag anbefalt styrketrening 2-3 ganger i uken (60-80% av 1RM). Styrketrening kan gjennomføres på mange ulike måter og på ulike arenaer, men mange velger å trene på et treningssenter hvor man typisk kan velge mellom styrketreningstime i gruppe, styrke med en personlig trener eller individuell styrketrening. BodyPump er på verdensbasis en populær styrkeøkt i gruppe, og konseptet koreograferes og distribueres av LesMills International. Øktene består av ca. 10 musikklåter, styrkeøvelser for hele kroppen og 800-1000 repetisjoner med lav til moderat belastning (vektstang 1.25 kg, vekter på 0.5 kg, 1.0 kg og 5.0 kg).

Metode og hensikt: Hovedhensikten med denne avhandlingen var å gjennomføre en singel-blindet randomisert kontrollert intervensjonsstudie, for å undersøke ulike effekter av BodyPump og tradisjonell tung styrketrening (lineær periodisering, 8-10, 13-15 og 3-6 repetisjoner) med og uten en personlig trener på overvektige og inaktive kvinner etter 12 uker med trening (3 ganger/uken). Totalt 143 kvinner ble inkludert og randomisert til enten BodyPump (n=37), styrketrening med personlig trener (n=35), individuell styrketrening (n=35) eller inaktiv kontroll (n=36). Hensikten i studie I var å undersøke effekten av muskelstyrke og kroppssammensetning, mens studie II undersøkte selvrapportert muskelsmerte før og etter intervensjonsperioden. Hensikten i studie III var å undersøke endringer og gruppeforskjeller i hvilemetabolisme i en subgruppe av deltakerne (n=18), mens i studie IV ble energiforbruket i løpet av èn BodyPump økt målt og sammenlignet med èn økt tradisjonell tung styrketrening. **Resultat og konklusjon:** Frafallet var 32% i BodyPump gruppen, 17% i personlig trener gruppen, 40% i den individuelle gruppen og 35% i kontrollgruppen. I studie I viste BodyPump gruppen ingen effekt på muskelstyrke eller kroppssammensetning etter 12 uker med trening. Personlig trener gruppen økte signifikant mer i 1RM knebøy sammenlignet med alle de andre gruppene ($p \leq 0.001$), og signifikant mer

enn BodyPump gruppen og kontrollgruppen i benkpress ($p \leq 0.001$). Det var ingen forskjeller mellom noen av gruppene i kroppssammensetning. Studie II viste ingen gruppeforskjeller i selv-rapportert muskelsmerte hverken ved baseline eller post-test. I studie III økte gruppene likt i hvilemetabolisme i løpet av intervensjonsperioden ($p=0.660$), med 8.5% (±10.8) i BodyPump gruppen og 10.5% (±10.4) i styrkegruppen (studie III). I studie IV var energiforbruket likt i de to gruppene ($p=0.69$), med 302 kcal ±67 i BodyPump og 289 kcal ±69 i tradisjonell tung styrketrening.

Summary

Background: Individuals categorized as overweight (BMI ≥25.0 kg/m^2) or obese (BMI ≥30.0 kg/m^2) are currently recommended to perform resistance training 2-3 times a week (60-80% of the 1RM). Although resistance training can be conducted in many different ways and at different venues, many choose to exercise at a health- and fitness club, where you typically can choose between strengthening group sessions, resistance training with a personal trainer and non-supervised resistance training. BodyPump is worldwide a popular group session, pre-choreographed and distributed by LesMills International. The session consists of approximately 10 music tracks, exercises for the whole body and 800-1000 repetitions with low to moderate loads (a 1.25 kg barbell, and weights of 0.5 kg, 1.0 kg and 5.0 kg). **Methods and aims:** The main purpose of this thesis was to conduct an assessor blinded randomized controlled trial, to investigate different effects of BodyPump and traditional heavy load resistance training (linear periodization, 8-10, 13-15 and 3-6 repetitions) with and without a personal trainer on overweight and obese women after 12 weeks of exercise (3 times/week). A total of 143 women were included and randomly assigned to BodyPump (n=37), resistance training with a personal trainer (n=35), non-supervised resistance training (n=35) or non-exercising controls (n=36). In paper I, the effect of resistance training on muscle strength and body composition were assessed, and in paper II the effect on self-reported musculoskeletal pain. In paper III, within- and between group differences in resting metabolic rate in a subgroup of the participants were assessed, while in paper IV energy expenditure during a single session of BodyPump (n=10) was assessed and compared with a single session of heavy load resistance training (n=8). **Results and conclusion:** Losses to follow up were 32%, 17%, 40% and 35% in the BodyPump group, personal trainer group, non-supervised group and control group, respectively. In paper I, the BodyPump group showed no effect on muscle strength or body composition. The personal trainer group increased significantly more in

1RM squat than all the other groups ($p \leq 0.001$), and significantly more than the BodyPump group and controls in bench press ($p \leq 0.001$). There was no between group changes in body composition. In paper II, the results showed no differences in self-reported musculoskeletal pain at baseline or post-test. In paper III, the resting metabolic rate increased similar in the two groups ($p=0.660$); 8.5% (±10.8) in the BodyPump group and 10.5% (± 10.4) in the heavy load group. In paper IV, energy expenditure was similar in the two groups ($p=0.69$); 302 kcal ±67 during BodyPump and 289 kcal ±69 during heavy load resistance training (paper IV).

Introduction

Overweight and obesity

Definition

The World Health Organization (WHO) defines overweight and obesity as "abnormal or excessive fat accumulation that may impair health", and classifies adults with overweight and obesity using body mass index (BMI). BMI is calculated as weight in kilograms divided by height in meters squared (kg/m^2). Based on epidemiological studies WHO have defined cut-off points, based on risk of comorbidities (Branca et al., 2007). Overweight is classified as BMI equal to or greater than 25 kg/m^2, and obesity equal to or greater than 30 kg/m^2 (Table 1). In the present thesis, the focus will be on women categorized as overweight and obese class I, which represents a risk group to develop a higher BMI.

Table 1. The international Classification of obesity in Caucasian adults according to BMI, WHO 2000. Derived and modified from WHO 2000 (WHO Preventing and managing the global epidemic. World Health Organization, 2000).

Classification	BMI cut-off points (kg/m^2)	Risk of comorbidities
Normal weight	18.50-24.99	Average
Overweight	≥25.0 (25.0-29.9)	Increased
Obese	≥30.0	
Obese class I	30.0-34.9	Moderate
Obese class II	35.0-39.9	Severe
Obese class III	≥40.0	Very severe

There are some disadvantages with BMI as it fails to distinguish between the different components of body composition, e.g. fat mass, fat free mass, lean mass and muscle mass, and different locations of adiposity. However, in large population based studies, BMI is a well-recognized method (Berker et al., 2010; Heyward &Wagner 2004). Still, more accurate assessments methods should be used when referring to body composition in clinical trials (Heyward & Wagner 2004, Bray & Gray 1988).

Prevalence of overweight and obesity

Globally, overweight and obesity poses one of the most serious public health challenges (Di Cesare et al., 2016, Ng et al., 2014). According to the "Global Burden of Disease 2015 study", overweight and obesity have been one of the most expanding health risks during the last three decades, in both developed and developing countries (Di Cesare et al., 2016, Ng et al., 2014). Overall, the prevalence rate of overweight and obese adults increased with 27.5% from 1980 (857 million) to 2013 (2.1 billion) (Ng et al., 2014). The BMI has increased more in middle-aged women, compared to men and other ages (Kapoor et al., 2017, DiCesare et al., 2016, Ng et al., 2014, Swinburn et al., 2011). In 1980, 29.8% (95% UI 29.3-30.2) of women worldwide were classified as overweight, compared to 38% (95% UI 37.5-38.5) in 2013 (Ng et al., 2014). Moreover, the prevalence of women classified as obese increased from 6.4% to 14.9% from 1975 to 2014 (Di Cesare et al., 2016). In 2015, overweight and obesity was estimated to cause 4.0 million deaths, which represented 7.1% of all death causes (Afshin et al., 2017). As much as 39% of these deaths, were related to a BMI lower than 30 kg/m^2 (Afshin et al., 2017). In addition, overweight and obesity contributed to 4.9% of disability-adjusted life of years in 2015, with 37% of these related to a BMI lower than 30 kg/m^2 (Afshin et al., 2017).

Causes and etiology

The etiology of overweight and obesity are multifactorial, with numerous individual and environmental causes operating in a complex interrelation (Afshin et al., 2017, Kapoor et al., 2017, Meldrum et al., 2017, Hruby et al., 2016, Roberto et al., 2015, Swinburn et al., 2011). To the end, weight gain is a result of fat accumulation, due to greater calories consumed than calories expended (Mitchell et al., 2011), but each individual`s energy imbalance may be affected by several factors. The genetics are involved in the regulation of energy expenditure, appetite, lipid metabolism, adipogenesis, thermogenesis and the cell differentiation (Leońska-Duniec et al., 2016, Deram & Villares 2009). Additionally, physiological factors, the environment, psychosocial factors and lifestyle-related factors (Afshin et al., 2017, Kapoor et al., 2017, Meldrum et al., 2017, Hruby et al., 2016, Roberto et al., 2015, Swinburn et al., 2011) may all affect the energy imbalance. According to the Lancet Series of Obesity Studies, the two leading causes and explanations why the global BMI have raised so rapidly, are excessed energy intake and less physical activity and/or activity of daily living (ADL) (Afshin et al., 2017, Roberto et al., 2015, Swinburn et al., 2011). Rapidly changes in the environment and food systems, have increased the availability of processed energy-dense foods, and the lesser amount of bodily movement is explained by factors as more urbanization, increased technological development and advances, labor-saving devices at work and in our household, increased motorized transport and more sedentary screen time (Afshin et al., 2017, Hruby et al., 2016, Kohl et al., 2012, Swinburn et al., 2011).

Health consequences

Overweight and obesity are responsible for a large part of the total burden of diseases, and have serious health consequences to the individuals affected and the health care- and welfare systems (Afshin et al., 2017, WHO 2013, Lim et al., 2012, Kulie et al., 2010). The leading

BMI-related health risk is cardiovascular diseases (primarily coronary artery diseases, stroke, heart failure and hypertension) (Afshin et al., 2017, Hruby et al., 2016, Williams et al., 2015, Adedeji et al., 2011, Kulie et al., 2010, Anderssen & Hjermann 2000). In 2015, cardiovascular diseases represented as much as 41% of all BMI-related deaths (Afshin et al., 2017). Further, diabetes mellitus, kidney diseases (Afshin et al., 2017, Hruby et al., 2016, Williams et al., 2015, Singh et al., 2013, Wormser et al., 2011) and some types of cancer (Lauby-Secretan et al., 2016, Courneya & Friedenreich 2011) represents less than 10% of all causes each (Afshin et al., 2017). In addition, excess body weight and BMI are associated with sleep apnea (Senaratna et al., 2017), mental disorders (e.g. anxiety and depression) (Wu & Berry 2018, Pereira-Miranda et al., 2017 , Williams et al., 2015, Kulie et al., 2010, Pedersen & Saltin 2006), urinary incontinence (Milsom et al., 2017) and reduced quality of life (Hruby et al., 2016).

A raised BMI may also negatively affect the musculoskeletal system, and overweight and obese individuals are found more disposed of specific and/or general musculoskeletal pain symptoms, than normal-weighed individuals (Blûmel et al., 2017, Zdziarski et al., 2015, Yoo et al., 2014, Vincent et al., 2013; Jiang et al., 2011, Kulie et al., 2010, Anandacoomarasamy et al., 2008). However, the prevalence of pain among overweight and obese is difficult to establish, due to different definitions of pain, study populations (e.g. healthy vs unhealthy, different diagnosis) and a wide range of assessment methods used (Janke et al., 2007). To exemplify the range, Cimmino et al. (2011) report that musculoskeletal pain affect 14-47% of the general population at any given time, despite of gender, age or BMI. Moreover, Stone & Broderick (2012) showed that overweight and obese individuals reported 20% more daily pain than normal-weighed, while those categorized as obese group I reported 68% more pain

(Stone & Broderick 2012). In addition, pain syndromes have been found more prevalent among the female population, and it seems to increase progressively with a higher BMI (Zdziarski et al., 2015, Stone & Broderick 2012). The mechanisms behind obesity-related pain are complex, but increased mechanical loading on joints and tissues, increased muscular inflammation and psychological factors are all found to contribute (Vincent et al., 2013). The biomechanically stress on the musculoskeletal system increases with excess body weight, which may alter compensatory posture and movement patterns, and increase degeneration in the weight bearing joints (Vincent & Vincent 2012, Vincent et al., 2013). According to Naugle et al. (2012), individuals with a BMI≥30 have eighteen times higher risk of adopting compensatory movement strategies during ADL, than individuals with BMI≤30. Physical activity, and especially resistance training, have been found to prevent or reverse this pain-BMI association, as it may increase muscle strength, muscle mass and physical function (Wasser et al., 2017, Barry et al., 2014, Vincent et al., 2014), help stabilize the joints and improve the mobility and proprioception (Zdziarski et al., 2015, Swinburn et al., 2011, Messier et al., 2004).

Treatment of overweight and obesity

Individuals with a BMI≥25-35 kg/m^2 are primarily recommended to develop skills and behavioral strategies to achieve a healthier lifestyle (Samdal et al., 2017, Williams et al., 2015, Dombrowski et al., 2014, Johns et al., 2014, Laddu et al., 2011, Donnelly et al., 2009, Södlerlund et al., 2009). A healthy lifestyle over time have been found to reduce body weight, prevent further weight gain, reduce the development and severity of risk factors related to overweight and obesity, improve body composition and improve physical fitness (Samdal et al., 2017, Hruby et al., 2016, Williams et al., 2015, Johns et al., 2014, Mastellos et al., 2014, Schwingshackl et al., 2013, Donnelly et al., 2009, Laddu et al., 2011, Södlerlund et al., 2009, Shaw et al., 2006). Consequently, a number of lifestyle-related interventions have been evaluated, and the combination of diets, increased physical activity and behavioral change strategies are found effective (Dombrowski et al., 2014, Johns et al., 2014, Mastellos et al., 2014, Donnelly et al., 2009, Laddu et al., 2011; Södlerlund et al., 2009, Shaw et al., 2006). Interventions with physical activity as a sole intervention have showed only small or modest effects on weight reduction and body composition (Johns et al., 2014, Södlerlund et al., 2009, Shaw et al., 2006). However, physical activity have been found to improve physical fitness and reduce the negative health effects of overweight and obesity, also in individuals who not respond with weight loss or reduced fat mass (Baker et al., 2016, Myette-Cote et al., 2016, Barry et al., 2014, Lombard et al., 2009). In addition, women with a low physical activity level, have been found more exposed to further weight gain, compared to those who increase their activity level (Baker et al., 2016, Hruby et al., 2016). Consequently, physical activity is an important contributor to comprehensive weight loss therapies and prevention strategies in overweight and obese individuals (Baker et al., 2016, Hruby et al., 2016, Donnelly et al., 2009, Södlerlund et al., 2009, Haskell et al., 2007, Hallal et al., 2006, Shaw et al., 2006).

General physical activity recommendations

Currently, the American College of Sports Medicine (ACSM) physical activity recommendations for prevention of weight gain are to accomplish 150-250 minutes of endurance activity with moderate intensity, or 75 minutes of vigorous intensity each week, or combinations. To achieve a meaningful weight loss, overweight and obese individuals are recommended to accomplish 225-420 minutes with moderate intensity. From 2009 the recommendations included whole body resistance training or muscle-strengthening activity 2-3 times a week (60-80% of 1RM, 8-12 repetitions, 2-3 sets). In addition, sedentary habits should be replaced by an approach to increase the energy expenditure, e.g. choosing the stairs instead of the elevators (Donnelly et al., 2009).

On a regular basis, physical activity protects against a number of physical diseases, and produces health benefits and improvements in physical performance (Garber et al., 2011, Haskell et al., 2007, Kruk et al., 2007, Schmitz et al., 2007, Pedersen & Saltin 2006). Overall, physical activity have been found to improve cardiovascular risk factors such as decreased blood pressure and improved blood lipid values, insulin sensitivity and glucose tolerance (Donnelly et al., 2009, Haskell et al., 2007). Physical activity, and especially resistance training, may also increase muscle mass and bone mineral density, improve functional capacity, increase basal metabolic rate and reduce fat mass (Myette-Cote et al., 2016, Shaw et al., 2006, Kelley & Kelley 2000, Pollock et al., 2000, Feigenbaum & Pollock 1999). Despite these well-documented health benefits, withdrawal from physical activity and low exercise adherence are challenging in overweight and obese individuals (Lackinger et al., 2017, Kohl et al., 2012, Arikawa et al., 2011). In Lackinger et al. (2017), exercise adherence in overweight and obese individuals was 62% during the first two months of exercise in a real-life setting, and after six months, only half of the retained participants continued to exercise regularly. Thus, Lackinger et al. (2017) suggest that standardized exercise programs specifically customized overweight and obese potentially would promote more commitment to physical activity (Lackinger et al., 2017). Further, Arikawa et al. (2011) found that overweight and obese women struggled with adherence during non-supervised resistance training (61%), compared to a supervised period (95%).

Resistance training

With sustainable dosage, resistance training have showed several health benefits to overweight and obese individuals (Shiroma et al., 2017, Westcott 2012, Winett & Carpinelli 2001), such as increased muscle strength, improved body composition (increased muscle mass and reduced fat mass), increased basal metabolic rate, improved bone mineral density, improved functional capacity, decreased resting blood pressure, improved blood lipid values, glucose tolerance and insulin sensitivity and improved mental health (Shiroma et al., 2017, Westcott 2011, Strasser & Schobersberger 2011, Pollock et al., 2000).

Resistance training is found to be especially important in long-term weight loss and weight management, as it have the potential to increase fat free mass or muscle mass, which in turn are directly correlated to resting metabolic rate (RMR) (Wolfe et al., 2006). RMR makes up for 60-75% of our total daily energy expenditure, and fat free mass and muscle mass are large contributors to RMR, as this is highly metabolically active tissues (Strasser & Schobersberger 2011, Stiegler & Cunliffe 2006). In Wolfe et al. (2006), as much as 50-70% of the variability in RMR was found to correlate with the amount of muscle mass, and every 10-kg difference in muscle mass was translated to an energy expenditure of approximately 100 kcal/day (Wolfe et al., 2006). Another study found that one kg increase in muscle mass raised RMR with approximately 20 kcal/day (Strasser & Schobersberger 2011). Thus, reduced body fat after a longer resistance training period might be due to raised RMR (Stiegler & Cunliffe 2006, Wolfe et al., 2006. In addition, resistance training may also have an acute effect on fat mass, due to the energy expenditure during each session and the post exercise oxygen consumption (EPOC) after the session, as the remodeling process (normally lasting 24-72 hours post-exercise), require some amount of energy (Strasser & Schobersberger 2011, Wolfe et al., 2006, Borsheim & Bahr 2003).

Effect of resistance training on muscle strength and body composition

The impact and exercise dose from resistance training required to change or improve muscle strength and body composition is not fully established, due to a large variety in the study protocols used (e.g. type of exercises, exercise frequency, volume, duration, intensity and assessment methods) and different study populations (Sanal et al., 2013, Donnelly et al., 2009, Williams et al., 2007, Pollock et al., 2000).

The present studies did only include female participants, and to summarize the most relevant literature on resistance training in overweight and obese women, a computerized search for clinical trials were performed in Pubmed and The Cochrane Controlled Trial Register. The following terms were used: resistance training, resistance exercise, strength training, women, female, overweight, obese, muscle strength, body composition, muscle mass, lean body mass, fat mass. The exact search strategy was: (resistance training OR strength training OR resistance exercise OR resistive training) AND (overweight OR obese OR obesity) AND (women OR female OR females) AND muscle strength AND (body composition OR muscle mass OR lean body mass OR fat mass).

RCT studies including healthy female participants performing resistance training as a separate intervention was included. In addition, an age between 18-65 years and publishing year ≥2000 were set as inclusion criteria's. Studies combining resistance training with other types of exercise (e.g. aerobic training), dietary restrictions or dietary supplementations, included pregnant participants or populations diagnosed with some kind of lifestyle-related diseases, were excluded. A total of seven studies were identified and are presented in Table 2. To rate the methodological quality in the studies, PEDro rating scale (The Physiotherapy Evidence Database), was used (Sherrington et al., 2000). PEDro consider physiotherapy related studies, that include at least two intervention groups (one can be a control group without intervention), and contain a randomized assignment of the groups. In PEDro, relevant studies are being judged by a scale, including the following 11 criteria's; whether eligibility criteria were specified, use of random allocation, use of concealed allocation, baseline comparability/groups similar at baseline, blinded subjects, blinded therapists, blinded assessors, adequate follow-up (≥85%), whether data was analyzed by intention to treat, use of between group comparison/statistical comparison between groups and report point based on estimates and variability. The first criterion, evaluating inclusion- and exclusion criteria's, pertains to external validity, and is not included in the total sum. The highest possible score on PEDro is therefore ten (Moseley et al., 2002). Ideally, participants and therapists/instructors included in RCT studies should be blinded. However, trials including physical activity cannot provide blinding of the participants or those providing the exercises, giving eight as the highest possible score (Moseley et al., 2002). Therefore, exercise studies are categorized with modest methodological quality when they score 4-6 out of 10, and high with score 7-8 out of 10 (Sherrington et al., 2000).

Table 2. Summarize of studies evaluating the effect of resistance training (RT) in overweight and obese women (BMI≥25 kg/m²). Reported outcomes are muscle strength (MS), assessed with one repetition maximum (1RM), or 8 repetition maximum (8RM), and body composition (BC), assessed with Dual-energy X-ray absorptiometry (DXA), skinfold thickness or bioelectric impedance. Outcomes included in body composition are muscle mass (MM), fat mass (FM) and body weight (BW). Methodological quality of the studies are reported with PEDro score.

Reference	n	Intervention	Sessions	Load and volume	Assessment methods	Results muscle strength	Results body composition	PEDro score
Nunes et al., 2016	32 BMI≥25	Low volume RT (LV), n=10 High volume RT (HV), n=11 Control (C), n=11	3/w/16 weeks	LV: 3 sets/exercise HV: 6 sets/exercise Both groups 8 exercises: 70% 1RM C: no intervention	MS: 1RM leg extension BC: skinfold	Pre-post: LV and HV sig↑ (p<0.05) (exact p-value not stated) Between group: no diff.	Pre-post: All groups sig↓ FM% Between group: HV sig↓ compared to LV and C in waist circumference and waist hip circumference (p<0.05)	4/10
Carnero et al.,. 2014	66 BMI≥25	Aerobic training (AT), n=14 RT, n=15 AT+RT, n=16	3/w/5 months	AT: walking treadmill or cycle ergometer 70% HRmax: w 1-6: 30→60 min, w 6-20: 60 min RT: 20 RM x 3 sets (circuit exercise, 10 exercises) AT+RT: 12 min walk treadmill 70% of HRmax + 20 min circuit (8 exercises)	MS: 1RM BC: DXA	Pre-post: RT and AT+RT sig↑ (p<0.01) in 7 diff.exercises AT: no sig. change. Between group: not stated	Pre-post: total FM and FM%: all groups sig↓ (p<0.001) AT: -4.6 ±1.9 kg RT: -3.8 ±2.6 kg AT+RT: -4.7 ±3.0 kg Between group: no diff.	4/10
Figueroa et al., 2013	41 BMI≥25	Low intensity RT, n=14 Diet, n=13 Diet + RT, n=14	3/w/12 weeks	RT program: supervised leg press, leg extension, leg flexion, calf raise 18-22 reps x 2-3 sets	MS: 8RM leg press BC: DXA	Pre-post: RT: sig↑ relative MS (p=0.008) and absolute MS (p=0.001) Diet: No change Diet + RT: sig↑ relative MS (p=0.0001) and absolute MS (p=0.0001) Between group: RT and diet + RT sig↑ (p=0.001) compared to diet alone	Pre-post: RT: no difference in BC Diet and diet+RT: sig↓ (p=0.001) in BW and trunk FM Diet: sig↓ (p=0.02) in lean leg mass Between group: Diet and diet+RT sig↓ in total FM and trunk FM compared to RT.	5/10
Schmitz et al., 2007	133 BMI≥25-35	RT, n=70 Control (C), n=63	2/w/2 years	RT: 16 weeks of supervised RT – circuit training with 8-10 exercises (large muscle groups), 8-10 reps x 2-3 sets C: no intervention except a brochure with aerobic training recommendations	MS: 1RM leg press and bench press BC: DXA	Pre-post: sig↑ in both exercises C: no change Between group: RT sig↑ in both exercises	Pre-post: RT: LBM no change, body fat % and FM (kg) sig↓ C: LBM no change Between group: RT sig↓ in body fat% (p=0.01) and FM (kg) (p=0.07)	5/10

Olson et al., 2007	28 BMI≥25	RT, n=16 Control (C), n=12	2/w/1 year	RT: 5 min warming-up and stretching + 8-10 reps x 3 sets (major muscle groups: quadriceps, hamstrings, gluteus, pectoralis, latissimus dorsi, rhomboids, deltoids, biceps, triceps) C: no intervention, but a brochure "walking for a healthy heart" guide	MS: 1RM leg press and bench press BC: DXA	M.S: Pre-post: bench press sig↑ (p=0.01). C group no diff. Between group: RT group sig↑ (p=0.04) in bench press, leg press no diff.	Pre-post: RT sig↑ (p<0.01) in LBM Between group: no diff. BM and FM, but sig↑ (p<0.05) in LBM	5/10
Fenkci et al., 2006	51 BMI≥30	RT, n=17 AT (aerobic training), n=17 Control (C), n=17	RT: 3/w/3 months AT: month 1/3 days/w, month 2/4 days/w, month 3/5 days/w	RT: six exercises, whole body, 10 reps (75-80% of 1RM x 3) AT: 15 min walking + cycle ergometer (12-15 min month 1, 20-30 min month 2, 30-45 min month 3) C: no intervention	MS: not assessed BC: Bioelectric impedance	Not reported	Pre-post: all groups sig↓ BMI AE: sig↓ FM Between group: AT sig↓ in FM compared to C No other diff.	4/10
Schmitz et al., 2003	60	RT, n=30 Control (C), n=30	2/w/15 weeks Week 16-39: non-supervised	RT: w 1-15: 50 min supervised RT class (9 exercises, 8-10 reps x 3 sets). Between w 16-36: unsupervised RT, same intervention C: no intervention	MS: 1RM leg press and bench press BC: DXA	Pre-post: not reported Between group: RT sig↑ in leg press (p=0.0001) and bench press (p=0.04) after 15 w (supervised), and after 39 w (non-supervised) (leg press p=0.0001, bench press p=0.0001).	Pre-post: RT sig↑ FFM and sig↓ FM kg and FM% w 1-15 – this was maintained to w 39. Between group: RT gained sig↑ FFM p=0.009, sig↓ FM kg p=0.06 and sig↓ FM% p=0.006	5/10

All the seven studies included in Table 2 were categorized with moderate methodological quality (Sherrington et al., 2000). Five of the studies included an inactive control group (Nunes et al., 2016, Olson et al., 2007, Schmitz et al., 2007, Fenkci et al., 2006, Schmitz et al., 2003), while one study compared resistance training with aerobic training and a combination of resistance and aerobic training (Carnero et al., 2014), and one compared resistance training with a diet group and a combination group (Figueroa et al., 2013). Overall, exercise adherence among the studies was high (≥75%). Generally, many of the studies are limited by small sample sizes and low power (n=10-16), and potentially type II errors. Schmitz et al. (2003) and Schmitz et al. (2007) are exceptions, including 30 and 70 participants in their exercise groups, respectively. Furthermore, only three of the studies reported statistical power calculations and included the number of participants required to detect a clinical meaningful difference (Figueroa et al., 2013, Olson et al., 2007, Schmitz et al., 2007).

It is difficult to compare the results or draw any clear conclusion from these seven studies, as the training programs vary. However, all studies included exercises for the whole-body, and loads between 70-85% of 1RM (8-12 repetitions), except of Figueroa et al. (2013), including 18-22 repetitions. The intervention periods varied from 12 to 16 weeks, except for Olson et al. (2007) and Schmitz et al. (2007) with one year and two year’s duration, respectively. All studies that reported within-group changes in muscle strength, found significantly improvements (Nunes et al., 2016, Carnero et al., 2014, Figueroa et al., 2013, Olson et al., 2007, Schmitz et al., 2007). In addition, four studies reported significantly between group differences in muscle strength, three of these compared to inactive controls (Olson et al., 2007, Schmitz et al., 2007, Schmitz et al., 2003), and one compared to a diet group (Figueroa et al., 2013). However, the results on lean mass and/or fat mass were more conflicting. Compared to inactive control groups, three of the studies reported significantly reduced fat mass (Nunes et al., 2016, Schmitz et al., 2007, Schmitz et al., 2003) and two increased lean mass (Olson et al., 2007, Schmitz et al., 2003). Moreover, in Figueroa et al. (2013) the group combining resistance training and diet reduced significantly in total fat mass and trunk fat mass, compared to resistance training separately. In Fenkci et al. (2006) and Carnero et al. (2014), who both compared resistance training to aerobic training, no effects were seen on muscle mass or fat mass. However, in Fencki et al. (2006), the aerobic group reduced significantly in fat mass, compared to controls. According to a meta-analysis (Schwingshackl et al., 2014), the combination of resistance and aerobic training are most effective when the aim is to improve body composition and cardiorespiratory fitness in healthy overweight and obese individuals. And, in correspondence with the findings in Olson et al. (2007) and Schmitz et al. (2003), resistance training are most effective when the aim is to increase muscle mass (Schwingshackl et al., 2014). This meta-analysis did not report on muscle strengths variables.

To summarize, the literature examining the effects of resistance training on overweight and obese women is somewhat inconclusive. Different exercise programs and testing protocols make interpretation and determination of a dose-response relationship difficult. Overall, resistance training seems more effective when it comes to increase in muscle strength, than improvements in body composition. Nevertheless, resistance training is endorsed as an effective means in obesity prevention and treatment, and the recommended loads by ACSM (60-80% of 1RM) (Donnelly et al., 2009) seems sufficient. Hence, few well-designed studies have directly and separately compared the effectiveness of popular exercise modalities available at health- and fitness clubs on an overweight population.

The health- and fitness industry

Worldwide, health- and fitness clubs have become popular and common exercise locations, especially in urban areas (Bakken-Ulseth 2004). The concept “fitness club” and “health club” are used interchangeably, and can be described as “a facility that contains a health and fitness room with resistance training and cardiovascular equipment, open for the general public on either a pay and play or membership basis” (Middelkamp & Steenbergen 2015). The number of commercial clubs, and number of members, have increased considerably during the last two decades, and in 2015, approximately 187 000 clubs served 151 million members worldwide (International Health Raquet and & Sportsclub Association - IHRSA global report 2016). In Norway, the number of adults that reported to exercise at a health- and fitness club increased from 8% in 1987, to 25% in 2007 (Ommundsen & Aadland 2009). Unfortunately, we have not been able to find newer scientific studies with updated numbers, but according to Slater & Tiggermann (2006), one third of all women that exercised regularly, choose to exercise at a health- and fitness club. Moreover, knowledge and data on what type of exercise the members choose are limited. Though, a Dutch trend report from 2012 who included almost 2500 members, reported that about half of the female members incorporated resistance training in their exercise programs. And, 31% of these women reported that they only participated in group classes, while 45% combined individual and group exercise (Hover, Hakkers & Breedvald 2012).

With increased activity in the health- and fitness industry, the provision of premade and commercial group exercise concepts have increased accordingly. However, the evidence-based knowledge of the effect or impact from these exercise concepts are scarce, especially in a risk group as overweight and obese.

BodyPump

In 1997, Phillip Mills from New Zealand established LesMills, which is the largest commercial distributor of premade group exercise concepts worldwide. Currently, LesMills produce and distribute eleven different fitness workout concepts, and according to a Les Mills internal report, they are present at over 14 000 health- and fitness clubs worldwide (LesMills International). BodyPump is their strengthening group session, and was one of the first concepts LesMills established. Today, over 5 million individuals participate in a BodyPump session weekly (LesMills unpublished internal report). In the Nordic countries, 1039 health- and fitness clubs offer BodyPump on their group exercise schedule, 179 of these in Norway (Les Mills International). Health- and fitness clubs offering BodyPump pays a monthly license to LesMills, which includes delivery of updated and detailed pre-choreographed exercise programs and music four times a year. LesMills also require that the instructors participate on LesMills` instructor courses to become certified BodyPump instructors. These courses are led by national trainers, which in turn are trained by international master trainers. Further, the instructors need to follow an ongoing educational program for all new releases (every third month), and regularly be evaluated as instructors by video assessment (Les Mills International).

The BodyPump concept is based on the “REP-effect”, meaning that muscles are being exhausted by using a high number of repetitions with low- to moderate loads. The session is available as 55, 45 or 30 minute sessions, but in the present thesis and papers only the 55 minute session have been examined. All BodyPump releases follow a standardized format and are performed equally by all LesMills instructors. The 55-minute BodyPump session consists of approximately ten music tracks (4-6 minutes each), and for each track specific exercises assigning specific muscle groups, match the music. In total, 10-12 free-weight exercises are included in the program, and the participants exercise using a barbell (1.25 kg), weights (0.5 kg, 1.0 kg, 2.5 kg and 5.0 kg) and a step. Each session includes totally 800-1000 repetitions, and the number of repetitions throughout the session varies between the muscle groups, in the range of 50-100. The repetitions are performed continuously, but some of the tracks includes short inter-session rest periods of typically 16-32 beats (7-14 seconds), with instructions like “shake your legs” or “release your shoulders”, depending on the exercises being performed. Between each track there is approximately one minute of rest, used to change weights and prepare for the next exercises. All sessions start with a warming-up track (containing some of the same exercises as the main part), before multi-joint exercises for the largest muscle groups (legs, chest, back) are exercised in track two, three and four. Then the smaller muscle groups (triceps, biceps, shoulders) are exercised in track five and six, before the program returns to the largest muscle groups in track seven and eight. Finally, there is a cool-down and stretching track, including specific exercises for the abdominals. During the exercises, there might be some small variations in range of motion (ROM), foot placement and speed of the movement. As the participants exercise in a group setting, they follow general verbal instructions from the licensed BodyPump instructor, regarding technique, postural alignment, lifting velocity and loads. However, the exercise intensity and loads are self-selected. According to the internal report, 88% of the BodyPump participants are women, aged between 30-49 years.

According to LesMills`website, BodyPump is a breakthrough in resistance training proven to deliver a total body transformation (LesMills). To quote their website; *"BODYPUMP™ use THE REP EFFECT™ to give you sculpted shoulders, defined biceps and triceps, strong lean legs, firm glutes and a tight core. Choreography in each of these areas is specifically targeted so you’ll burn fat, burn more calories and achieve more meaningful fat loss and muscle* *fatigue to build strength without building bulk. That means a long, lean muscles and a toned, strong physique – fast!"* In addition, they claim that BodyPump gives a sense of good wellbeing, and highlight that each session burn up to 540 calories (Les Mills International).

To date, only few studies have examined acute and long-term effects of BodyPump or similar group-training sessions. Oliveira et al. (2009) described and correlated acute metabolic, cardiovascular and neurological parameters during a single BodyPump session on healthy untrained women (n=15). Oliveira et al. (2009) judged the muscular activation and fatigue state to be sufficient to assume that BodyPump have the potential to improve muscle strength in untrained females, despite physical fitness level. However, the metabolic and cardiovascular stimulus were low and they do not believe that BodyPump have the potential to improve aerobic capacity (Oliveira et al., 2009). Previously, two RCTs have investigated long-term effects of BodyPump, both identifying between group differences in muscle strength (Nicholsson et al., 2011, Greco et al., 2009). In Greco et al. (2011) nine untrained women exercised BodyPump twice weekly in 12 weeks, and showed significantly improvements in maximal muscle strength and muscular endurance in the lower body, compared to inactive controls (n=10). They did not find any differences in endurance capacity or body composition (Greco et al., 2011). In Nicholsson et al. (2014) 32 older adults improved significantly in maximal muscle strength and gait speed, compared to inactive controls (n=36), after 26 weeks of BodyPump (2 times/week). Additionally, two previous studies have examined energy costs during a single BodyPump session, both including moderately trained men and women. In Stanforth et al. (2000), the energy expenditure was estimated to be 265 kcal (±60), and in Bertiaume et al. (2015) 250 kcal (±68). Bertiaume et al. (2015), did also ask the participants to report perceived energy expenditure after the session. Interestingly, all participants overestimated their energy expenditure compared to the physiologically findings, with 50% and 84% among men and women, respectively. Also, 40% of the men reported that BodyPump gave moderate fatigue, compared to 70% of the women. Moreover, 85% of the participants reported that BodyPump gave a high level of pleasure. They did not find any correlation between months of BodyPump experience and energy expenditure, exercise intensity or perceived energy expenditure, and highlight that the results are reliable for individuals both with and without resistance training experience (Bertiaume et al., 2015).

Personal training

The term “personal trainer” is often used to describe a trainer in a health- and fitness club setting, that offer supervised exercise one-to one or in small groups. Personal trainers are commonly certified through commercial educational courses, but this is not a legal health profession (Anderson et al., 2010). Unfortunately, the exact number of personal trainer`s on a national or international level are unknown.

Today, health- and fitness clubs offers personal training to their members, against an extra fee for each session. According to Melton et al. (2010) a personal trainer needs both interpersonal skills and theoretical and technical competence, as they develop exercise programs and follows their clients over a longer time-period. They instruct proper execution and technique, correct the technique, control the intensity and serve as motivators (Melton et al., 2010, Ratamess et al., 2008). To ensure the safety and effectiveness of the exercises, personal trainers spot their clients, which refers to assistance and hands on to complete a repetition if needed, or the trainer’s guidance in lifting technique (Fleck & Kraemer 2014). Furthermore, most health- and fitness clubs offer 1-3 supervised exercise sessions for free when beginners sign their membership, including technique guidance, before they continue non-supervised exercise.

Search on Pubmed and other sport- and health related databases reveal that only a few RCT`s have examined the impact of resistance training with a personal trainer, and they are mostly conducted on men (Storer et al., 2014, Maloof et al., 2001, Mazzetti et al., 2000). Storer et al. (2014) found significant greater improvements in lean-body mass after a 12 week nonlinear periodized program in middle aged men, compared with members doing non-supervised resistance training. They also found significant changes in 1RM in chest press, but no changes in leg press. Mazzetti et al. (2000), included moderately trained men, and found that participants exercising with a personal trainer, lifted heavier weights, compared to a non-supervised group. The participants that exercised with a personal trainer did also show greater improvements in muscle strength, and they choose heavier loads, than to the non-supervised participants (Mazzetti et al., 2000). Maloof et al. (2001) compared six weeks of personal training to non-supervised exercise on several health-related fitness outcomes in adults. No between group differences were found in muscle strength, but the personal trainer group experienced significantly greater improvements on waist circumference, body fat and VO_2 max (Maloof et al., 2001). A cross-sectional study, found that men chose heavier loads and had greater strength gains after a training period with a personal trainer, than a group without the same experience (Ratamess et al., 2008). Thus, these findings indicate that regular exercise with a personal training may positively influence physical fitness and health-related outcomes. Moreover, inactive and overweight women needs information and motivation to overcome their inactive lifestyle, as well as guidance and support to initiate and maintain an exercise program (Madeson et al., 2010). A personal trainer may provide a part of the solution to this issue of overweight and obesity (Madeson et al., 2010). However, no previous studies have examined the effect of a personal trainer on untrained and/or overweight or obese women, representing a population not familiar with the atmosphere and facilities at health- and fitness clubs.

Aims of the thesis

The principal aim of the present PhD-project was to increase the knowledge of popular resistance training modalities available at health- and fitness clubs worldwide, on overweight and obese women. Thus, the thesis includes effect studies of BodyPump and traditional heavy load resistance training with and without a personal trainer (paper 1, II and III), as well as an acute experimental study (paper IV). The specific aims of the four papers in the present thesis were as follows:

Paper I

To evaluate the effects of BodyPump and traditional heavy load resistance training with and without a personal trainer, compared to inactive controls, on muscle strength and body composition in overweight and obese women after 12 weeks of exercise.

Paper II

To evaluate between group effects on musculoskeletal pain after 12 weeks of BodyPump, traditional resistance training with a personal trainer and non-supervised resistance training, compared to inactive controls, in overweight and obese women. In addition, paper II aimed to study whether the results were influenced by exercise adherence.

Paper III

To investigate changes in RMR after 12 weeks of BodyPump (3 times/week) in former untrained women with BMI ≥ 25 kg/m^2, and to compare the results with traditional heavy load resistance training.

Paper IV

To evaluate total exercise workload and energy expenditure from a single BodyPump session in overweight women, and to compare the outcomes to a time-matched session of traditional heavy load resistance training.

Methods

Study design and recruitment paper I and II

Design

Paper I is a four-armed single assessor blinded RCT comparing the effects of 12 weeks of BodyPump, heavy load resistance training with a personal trainer and non-supervised heavy load resistance training, to non-exercising controls. Primary outcome in paper I was maximal muscle strength, and secondary outcomes were strength endurance and body composition. Paper II is a secondary analysis of the RCT, evaluating the effect on musculoskeletal pain (primary outcome), in the same groups.

Power calculations

Power calculations were based on the findings from Greco et al. (2011), whom detected a difference of 11% in muscle strength (1RM) (effect size: 0.7) compared to inactive controls, after 12 weeks of BodyPump. With a standard deviation of 15, alpha = 5%, and a statistical power of 80%, 30 participants were estimated for each group. With an expected attrition rate of 10-20%, a minimum of 35 women were included in each study group.

Participants

Participants were recruited via Facebook and the homepage of Norwegian School of Sport Sciences (NSSS). In total, 195 women contacted the principal investigator by phone or e-mail. After the aims and implications of the study were explained, a check-off health-profile scheme (attachment no.3) including health issues contraindicated for participation was fulfilled (noted in Table 3). If a participant was uncertain regarding one or more of the check-off points in the health-profile scheme, we asked for a health declaration from their physician, before they were considered to the study. Further, eligibility criteria were checked (Table 3), and a sample of 143 women were included.

Table 3. Inclusion and exclusion criteria's.

Inclusion criteria's	Exclusion criteria's
Female with BMI ≥ 25.0 kg/m^2	Vacation/absence from exercise during the intervention period >2 weeks
Age 18-65 years	Pregnancy or planned pregnancy during the intervention period
Not regularly exercising: "not performing regular structured exercise ≥ twice a week the last six months	Diseases/injuries being contraindicated for 1RM strength tests and heavy load resistance training (e.g. sciatica, low back pain, osteoarthritis, osteoporosis, secondary hypertension, history of coronary heart disease, stroke, arrhythmias, type I diabetes and neurological diseases)
	Obesity surgery
	Psychiatric diseases (anxiety and/or depression)

Randomization

The 143 participants included were randomly allocated to one of four groups: BodyPump (BP) (n=37), heavy load resistance training with a personal trainer (PT) (n=35), non-supervised heavy load resistance training (NS) (n=35), inactive control group (C) (n=36) (Fig.1). An independent statistician used computer generated random numbers in blocks of eight. The first 140 included participants were randomized with n=35 in each group. The last three participants included, were randomized from a new eight-person block, giving different n in the four groups. The randomization was done after all the baseline assessments were completed and sealed brown opaque envelopes were used. A person not involved in the exercise interventions or assessment of outcome performed the randomization.

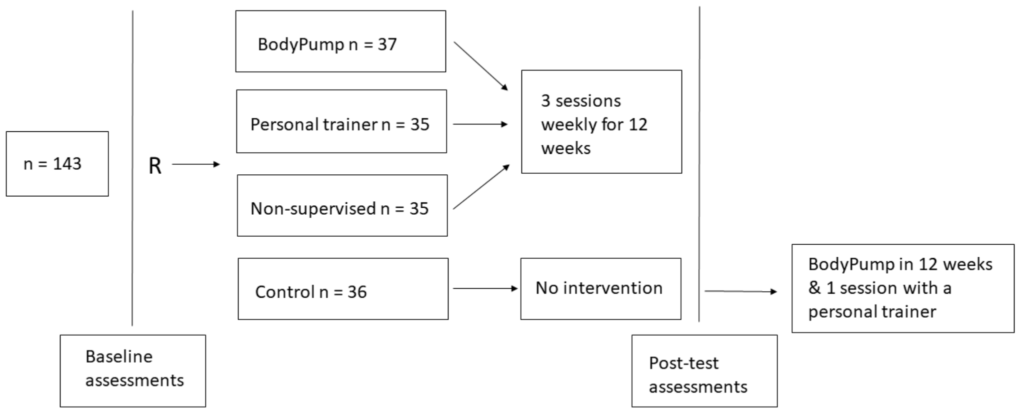

Fig.1. Study overview paper I and II.

Procedures

All participants were asked to exercise three sessions weekly for 12 weeks, based on their intervention group. They all signed a written statement (attachment no.2), and agreed not to take part in any other exercise regimens during the intervention period, change any dietary habits or ADL. Participants in the BodyPump group had free access to all SATS clubs in Oslo and Akershus, and the opportunity to attend a large range of BodyPump sessions close to their working place and/or their home. They entered the classes as an ordinary member of the health club, and all sessions were led by a Les Mills licensed BodyPump instructor. Participants in the personal trainer group exercised with their personal trainer in the health club at the NSSS. Participants in the non-supervised group exercised at the health club at the NSSS. Their first exercise session was an introduction session, supervised by one of the personal trainers. At this session they were introduced to the standardized exercise program and guided in correct lifting technique. After six weeks of non-supervised exercise, they had a follow-up session with the same personal trainer, before they continued with non-supervised exercise the last six weeks. In total, 16 different personal trainers were included in the study, all educated with a bachelor degree in physical activity and health, including a personal trainer certificate from the NSSS. Each personal trainer was responsible for 1-3 participants throughout the whole intervention period.

Intervention programs

BodyPump

In the present thesis, the BodyPump release no.83 are presented (Table 4), as this release was present at all health- and fitness clubs during the intervention period. The session lasted 55 minutes, included nine music tracks and approximately 800 repetitions. The participants followed general guidelines and instructions from the certified instructors. After all sessions, the participants registered exercise load and any potential deviation from the program in a training diary.

Table 4. Exercise program for the BodyPump group (release no.83)

Music no.	Exercise	Volume (reps)
1 Warming-up	Straight leg deadlift, rowing, shoulder press, squat, lounges and biceps curl	88
2 Leg	Squat	95
3 Cheast	Bench press	80
4 Back	Rowing, stiff legged deadlift, clean & press and power press	75
5 Triceps	French press, triceps press, pullover and overhead triceps press	78
6 Biceps	Biceps curl	68
7 Leg	Squat, lounges and squat jump	72+24 jumps
8 Shoulders	Push-up, lateral raise, rowing and shoulder press	76+36 push up
9 Abdominals	Sit-ups, sit-ups to the side and side-plank	51+30 seconds

PT and NS program

The exercise program in the personal trainer and non-supervised groups were designed to resemble the BodyPump program, and included similar free-weights exercises. The program was standardized with nonlinear periodization (Table 5), with repetitions varying between 3-6, 8-10 and 13-15, and number of sets 2-4. All sessions started with a 5-10 minutes light warm-up on a treadmill or cycle ergometer, before the participants performed the exercises in the free-weight area in the gym, using traditional free-weight equipment. Both groups were instructed to perform repetition maximum in each set, and thereby choose appropriate training loads, with proper lifting technique. Participants in the PT group had their personal trainer present at all sessions, but they were not allowed to interfere with the standardized exercise program. The personal trainers were restricted to advise the participants to add appropriate loads and conduct the exercises with proper technique, in addition to spot/secure and/or verbally motivate the participants during the exercises. Exercise load was registered in their training diary.

Table 5. Exercise program (exercises and training volume) in the personal trainer group and non-supervised group.

Exercises	Training volume week 1-4	Training volume week 5-8	Training volume week 9-12
Squat Lounges Deadlift/deadlift with straight legs Bent over rows to chest	*Session 1* Reps: 8-10 Series: 2 Break: 60 sec	*Session 1* Reps: 8-10 Series: 2-3 Break: 60 sec	*Session 1* Reps: 8-10 Series: 3-4 Break: 60 sec
Bench press Dips/kickback Shoulder press/lateral raise Clean and press	*Session 2* Reps: 13-15 Series: 2 Break: 60 sec	*Session 2* Reps: 13-15 Series: 2-3 Break: 60 sec	*Session 2* Reps: 13-15 Series: 3-4 Break: 60 sec
Triceps press Biceps curl Sit ups	*Session 3* Reps: 3-6 Series: 2 Break: 120 sec	*Session 3* Reps: 3-6 Series: 3 Break: 120 sec	*Session 3* Reps: 3-6 Series:4 Break: 120 sec

*Loads were repetition maximum (RM)

Study design and recruitment paper III and IV

Design

Paper III was an experimental study, with pre-post design, conducted with a subgroup of the women allocated to the BP and PT group in the RCT. Primary outcome in paper III was RMR. Paper IV was an acute experimental study from single BP and RT sessions, including the same subgroup of participants as paper III. Outcomes in paper IV were total workload and energy expenditure.

Participants

After baseline assessments and randomization in the RCT, all participants allocated to BodyPump and the personal trainer group were informed about the two experimental studies, and invited to participate (participants from the personal trainer group are named resistance training group (RT) in paper III). Ten women from each group volunteered, but two participants from the resistance training group dropped out because of illness, giving 18 participants in total.

Intervention programs

The interventions are described and shown above (Table 4 and 5).

Procedures paper III

RMR was assessed at baseline, midway through the 12 weeks intervention period and at post-test (Fig.2). Paper III also included data from the assessment of body composition (Inbody) and maximal muscle strength (1RM in squat and bench press), conducted in the RCT study (see above).

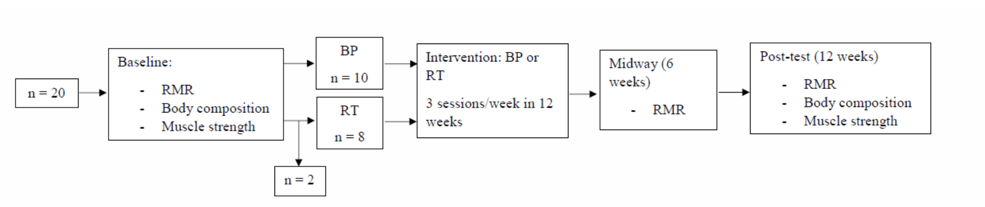

Figure 2. Study overview of the experiment in paper III

Procedures paper IV

In paper IV, total workload and energy expenditure during a single-session of BodyPump were assessed and compared with a single-session of traditional heavy load resistance training. In addition, RMR was assessed at two time-points after the sessions. Assessments were conducted midway in the 12 weeks intervention period (week 5-6), at the same day as the participants completed their midway test in paper III. After assessment of RMR, the participants performed an exercise session at the laboratory, based on their intervention group. Participants in the BodyPump group followed instructions from a BodyPump instructor on DVD (release no.83). Participants in the resistance training group performed session one from week 5-8, including 8RM x 3 sets, and 60 and 45 seconds rest between sets and the exercises, respectively. After the exercise session, RMR was assessed immediately after exercise (0-20 min) and two hours after exercise (120-140 min).

A personal trainer was present during the sessions to ensure proper lifting technique and assist if necessary, but did not interfere with the training. Workload during the session were self-selected, based on their experience from the previous sessions.

Data collection and analysis paper I and II

Outcome measures paper I

Primary outcome: maximal muscle strength

Background characteristics of the participants were collected using a questionnaire (attachment no. 4). Maximal muscle strength was assessed with 1RM test in squats (lower body) and bench press (upper body). All tests were performed in the training center at NSSS, and all participants followed the exact same assessment procedure. They started with a 5-10 minutes light warm-up on a treadmill, before they entered the squat station, and finally the bench press. The test procedure in both exercises included three series with gradually increasing load (40-75-85% of predicted 1RM) and reduction of repetitions (12-7-3). The participants conducted the first attempt with a load around 5% below the expected 1RM. The approved trials increased the demand of 2-5%, until the participants failed. Resting periods between attempts were 3 to 5 minutes. The testing was conducted by master students included in the project, and a personal trainer who took care of spotting.

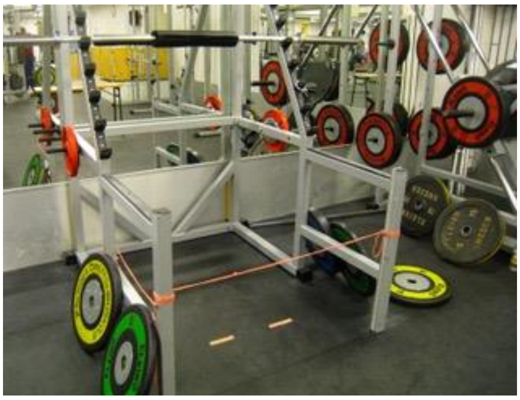

Figure 3: Picture showing the standardization of the equipment during the assessment of squat, regarding foot placement and depth of the squat.

Secondary outcome: Strength endurance

Strength-endurance test was completed in each exercise immediately after the 1RM test. All participants performed the maximal number of repetitions at 70% load, based on the results from 1RM, with correct lifting technique. When reporting strength endurance, the number of repetitions was multiplied with the load lifted.

Secondary outcome: Body Composition

Body composition was assessed with Inbody 720 (Biospace Co., Ltd., Seoul, Korea), which is an eight-polar bioimpedance method, pre-set from the manufacturer. Inbody assess intracellular water and extracellular water by using multiple broadband frequencies in the range of 1-1000 kHz, and estimates total body water and separates adipose tissue and bone mass from other tissues in the body (Sillanpää et al., 2013; Heyward & Wagner 2004). All participants were assessed after 12 hours of fasting, and they arrived at the laboratory at NSSS early in the morning at the test day (between 7-9 pm). The same test-leader was present during all tests, using the same Inbody machine. The participants were assessed in the same room, and they were all assessed in underwear or shorts and a t-shirt, and stood barefoot on the metal electrodes. The handrails with metal grip electrodes were held according to the user manual, fully extended arms and approximately 20 degrees lateral abduction.

Statistics paper I

Analyzes were done with SPSS statistics program, version 21 (IBM Corporation, Route, Somers, NY, USA). Results are presented for completers only. An attrition rate analysis of baseline characteristics between completers and non-completers was made with an independent t-test. Background data is presented as means with standard deviation (SD) or numbers with percentages (%). The individual training load in squat and bench press was estimated as total load (kg) lifted in each exercise throughout the intervention period, divided by the total number of conducted sessions. The individual relative training load (% of 1RM) was calculated by dividing mean training load throughout the intervention by mean of 1RM at pre- and posttest. A normal distribution of the data was assessed with the Shapiro-Wilk test, and differences between groups at baseline were analyzed with ANOVA. A one-way ANOVA and Bonferroni post-hoc comparisons were used to detect between-group differences in the changes over the training period. Data are presented as means with 95% CI. Level of statistical significance was set at $p<0.05$.

Outcomes measures paper II

Primary outcome: musculoskeletal pain

Musculoskeletal pain was registered using the Standardized Nordic Pain Questionnaire (SNQ), developed to measure prevalence of musculoskeletal pain and syndromes in epidemiological studies (18) (attachment no. 4). This frequently used symptom questionnaire, registers whether the participants have experienced musculoskeletal pain in ten different anatomical body parts, during the last 12 months, and the last seven days. It consists of structured, forced, multiple choice questions for each anatomical area in turn, using questions “At any time during the last 12 months/7 days, have you had trouble (ache, pain, discomfort) in the lower back, shoulders, neck, etc.)?” The ten anatomical body parts included in the questionnaire were; head, neck, shoulder, elbow, wrist, low back, upper back, hip, knee and feet. Possible responses in all the questions were yes or no, and those who answered "yes", were categorized as having pain. (Kuorinka et al., 1987). SNQ can be used as a self-administered questionnaire or as an interview. In the present study, the questionnaire was answered before randomization at baseline and at post-test. For the purpose of paper II, responses to the last seven days, were used as the primary outcome. Responses the last 12 months before baseline were used only in the descriptive analysis.

Secondary outcome: Adherence

Adherence to exercise, registered in the participants training diary, was used to analyze whether adherence interfered pain. The participants were classified as having high versus low adherence, as ≥75% attendance to exercise (≥28 sessions of 36 possible) and ≤75% (≤27 sessions of 36 possible), respectively.

Statistics paper II

Analyzes were done with SPSS statistics program, version 21 (IBM Corporation, Route, Somers, NY, USA). Background data are presented as means with standard deviations (SD), and data on self-reported pain is presented as numbers (n) with percentages (%). One-way ANOVA was used to analyze possible differences between the groups in background variables and primary outcome at baseline. An attrition rate analysis of baseline characteristics between completers and non-completers was made with an independent t-test. Results are presented for completers only. McNemar`s test was used to analyze if there was a difference in the proportion of the participants (collapsed together) reporting muscle pain in any of the body parts prior to, versus after the intervention. Chi-square test was used to analyze differences between the groups in self-reported pain (categorical data), as well as the association between pain (yes/no) and high/low adherence. Level of statistical significance was set at $p<0.05$.

Data collection and analysis paper III and IV

Outcomes measures paper III

Primary outcome: Resting metabolic rate

At each of the three assessment days (baseline, midway and post-test), the participants arrived at the laboratory at NSSS between 7.00-9.00 am, in fasting state (Compher et al., 2006, Carter & Jeukendrup 2002). Indirect calorimetry with a ventilated hood (Canopy-option for Oxycon Pro, Jaeger, Hoechberg, Germany) was used to assess RMR and respiratory exchange ratio (RER). The test procedure started with 15 minutes of rest in supine position, before the oxygen uptake was measured each 30 second for 30 minutes. The hood was placed over the head after the first ten minutes of rest, to make sure that each participant was familiar with the equipment before assessment. To ensure high validity, the test lab was located in a quiet area, had dimmed light, the temperature was controlled between 22-24º Celsius and only the last 20 minutes were used for calculating RMR (Compher et al., 2006). The calorie equivalent used to estimate the energy expenditure was derived from each participant's RER (proportion of the different energy substrates used) and ranged from 4.68-5.04 kcal per LO_2 (McArdle, Katch & Katch 2010). Estimated RMR was calculated as RMR = calories each minute x 1440 (total minutes each 24 hour).

Figure 4: Showing one of the participants assessing RMR with indirect calorimetry and a ventilated hood.

Secondary outcome: Heart rate

Heart rate (HR) was registered by a HR monitor (Polar RS800, Kempele, Finland). Maximal HR was estimated using the equation: 211 – 0.64 x age (Nes et al., 2012).

Statistics paper III

In-between group differences were analyzed using a dependent t-test analyzed. A mixed between-within subject's analysis of variance assessed the impact of the two different exercise programs on absolute values in RMR and RER at the three assessment time points. Relative change between the groups (percent from baseline to midway test, and from baseline to post-test) were analyzed with an independent t-test. Correlation analyzes were conducted using Pearson correlation coefficient. Level of significance was set at $p<0.05$, and values are presented as means with standard deviations (±SD). All analyzers were conducted with SPSS version 24 (IBM Corporation, Route, Somers, NY, USA).

Outcome measures paper IV

Total workload

Total workload was calculated by multiplying the amount of weights lifted in each of the exercises (kg x repetitions x sets) (Table 4 and 5). The test leader registered load lifted, repetitions and sets in all the exercises, and ensured that the participants followed the exact protocol. As all participants were overweight or obese, part of the body weight was included when summarizing total workload in exercises involving body weight. In squat and lounges 90% of each participant`s body weight was included, in push-ups 65%, dips 50% and in sit-ups 40%.

Energy expenditure and resting metabolic rate

As described in paper III, the participants arrived at the laboratory early in the morning, in a fasting state. After assessment of RMR (described above), the participants had a standardized breakfast consisting a caloric equivalent of 20% of the individual`s estimated RMR. Then, the exercise sessions were performed. Energy expenditure was registered with the same indirect calorimetry used when assessing RMR. The participants breathed through a Hans Rudolph mask (US) – covering both mouth and nose – attached to a three-meter long non-rebreathing hose. VO_2 was measured from two minutes before exercise, and expired air/gases were continuously sampled each 30 second during the whole exercise sessions. Prior to each test, all analyzers were calibrated after the manufacturers' guidelines. The gross energy expenditure was calculated as O_2 consumption using the formula (LO_2) x 5 kcal (McArdle, Katch & Katch 2010). Immediately after the sessions the participants laid down in supine position, and RMR acute (0-20 min) was assessed. RMR was estimated as change of resting VO_2 during 20 minutes. After lunch the participants rested in a seated position until assessment of RMR 2-hours (120-140 min). In total, the assessment procedures lasted four hours (Fig.6).

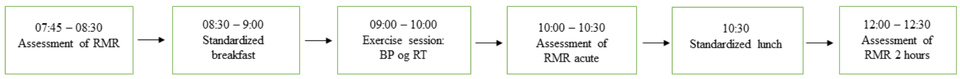

Figure 6. Time-schedule and procedure of the experiment in paper IV, showing assessment time for resting metabolic rate before exercise (RMR), breakfast, the exercise session for the BodyPump group (BP and resistance training group (RT), lunch and RMR after exercise at two time-points.

Heart rate

HR and HR_{max} were registered using the same monitor and formula as described above.

Statistics paper IV

Data are presented as means with standard deviation (±) for all variables, and all measurement points were analyzed in Excel. The data had a normal distribution and an independent t-test was used to compare between-group differences in total workload and energy expenditure during the sessions. A mixed between-within subject's analysis of variance assessed the impact of the two different exercise programs on O_2 ml/kg, RMR (20 min), HR (beats/min) and RER at the three assessment time points. Analyzes were conducted with SPSS Statistical Software version 21 (IBM Corporation, Route, Somers, NY, USA). Level of significance was set at $p \leq 0.05$.

Ethics

The present studies were approved by the Regional Committee for Medical Research Ethics Norway, Oslo (REK 2012/783) (attachment no.1), and all participants signed a written consent statement before entering the study (attachment no.2). The procedures followed the World Medical Association Declaration of Helsinki, and the study is listed in the Clinical Trial.gov Registration System (NCT01993953).

Results

Summary of the paper results.

Paper I

Of the 143 participants included, 96 participants completed primary outcome (1RM squat and/or bench press), and are included in the analysis (mean age 39.6 years ±10.1, BMI 31.1 kg/m^2 ±5.4). Unfortunately, due to a mistake, the total number of participants stated in the manuscript of paper I were 94. However, in all analysis, the results and the flow chart, both in the paper and the thesis, we have been operating with the correct number of participants (n=96). As shown in Fig.7, the exact number of participants that completed each of the outcomes differed. Losses to follow up and discontinued to intervention were 32%, 17%, 40% and 35% in the BodyPump group, personal trainer group, non-supervised group and control group, respectively. At baseline, there were no differences between the four groups in any of the background variables, and the attrition analysis showed no differences between completers and non-completers (data not shown).

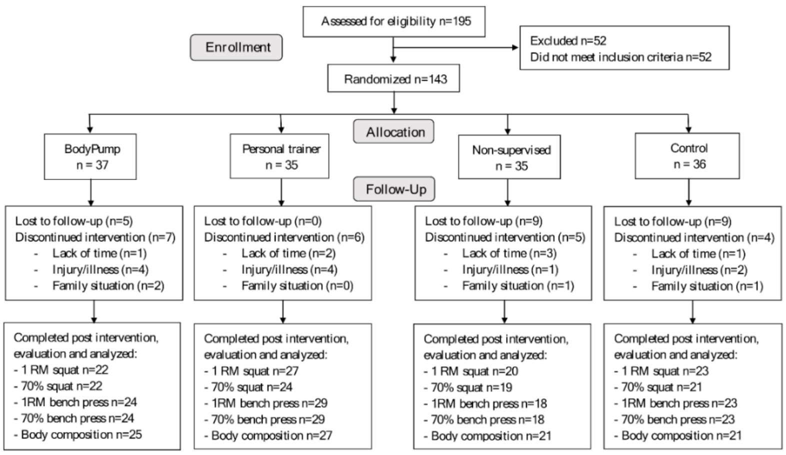

Figure 7. Flow chart of participants throughout the study, including reasons for drop-out.

Adherence to exercise was significantly higher in the personal trainer group (89%), compared to the BodyPump group (58%) ($p \leq 0.001$) and the non-supervised group (74%) ($p=0.017$). Exercise intensity in the BodyPump group was calculated to 12% and 16% of 1RM in squat and bench press, respectively. In the personal trainer group the intensity was calculated to 66% and 69% in squat and bench press, respectively, and the non-supervised group 47% and 63%, respectively.

The BodyPump group did not show any effect in muscle strength. The personal trainer group increased significantly in 1RM squat, compared to the control group ($p \leq 0.001$), the BodyPump group ($p \leq 0.001$) and the non-supervised group ($p \leq 0.001$), with a between group difference of 30%, 20% and 17%, respectively. In 1RM bench press, the personal trainer group increased 16% and significantly compared to controls ($p \leq 0.001$) and 10% and significantly compared to the BodyPump group ($p \leq 0.001$). The non-supervised group increased significantly in 1RM squat compared to the control group ($p=0.020$) with a between group difference of 12%. In bench press the non-supervised group increased significantly compared to controls ($p \leq 0.001$) and the BodyPump group ($p=0.007$) with 16% and 10%, respectively. In strength endurance, the personal trainer group increased significantly compared to controls in squat with 69% ($p=0.017$) and bench press with 35% ($p=0.006$). The non-supervised group increased significantly compared to the controls in squat with 44% ($p=0.027$) and bench press with 49% ($p=0.004$).

There were no between-group changes in any of the variables in body composition (BMI, fat mass or muscle mass).

Paper II

A total of 92 participants fulfilled the SQN questionnaire (mean age 39 years ±10, BMI 31 kg/m^2 ±5), with the following distribution; 65% in the BodyPump group, 80% in the personal trainer group, 54% in the non-supervised group and 58% in the control group. Adherence to exercise were 54% (±20) in the BodyPump group, 83% (±15) in the personal trainer group and 69% (±20) in the non-supervised group.

There were no differences in reported musculoskeletal pain, in any of the ten body parts, at baseline or post-test, nor any within- or between group changes from baseline to post-test. Thus, the participants from all three intervention groups were collapsed, and the prevalence of pain at baseline in the ten body parts were; neck 34%, head 29%, shoulder 27%, lower back 27%, upper back 16%, knee 14%, feet 11%, hip 10%, wrist 8% and elbow 7%. At post-test the prevalence was neck 31%, shoulder 30%, head 23%, knee 23%, lower back 16%, elbow 13%, wrist 11%, feet 11%, upper back 10%, hip 4%.

No statistically significant differences were found in the prevalence of reported pain when the participants were divided into high (n=38) versus low (n=20) exercise adherence.

Paper III

There were no differences between the BodyPump group (n=10) and the resistance training group (n=8) in background variables at baseline (mean age 35 years ±10. and BMI 31 kg/m^2 ±5). At post-test, adherence to exercise was significantly higher in the resistance training group (p=0.003), with 34 (±7) sessions of totally 36 (93%), compared to 22 (±6) (62%) in the BodyPump group.

In the BodyPump group, RMR was unchanged from baseline to the midway test (baseline: 1447±203 kcal; midway test: 1432±205 kcal). From baseline to post-test (1562±231 kcal), RMR increased 8.5% (±10.8) which was statistically significant (p=0.041, 95% CI 6.1 to 223.7 kcal). In the resistance training group, RMR increased 8.1% (±7.6) and significantly from baseline (1431±138 kcal) to the midway test (1546±171 kcal) (p=0.025, 95% CI 18.9 to 209.2 kcal), and 10.5% (±10.4) and significantly from baseline to post-test (1586 ±252 kcal) (p=0.027, 95% CI 23.7 to 285.8). There was a significant interaction between the two exercise programs and assessment periods (Wilks`Lambda = 0.613, F=4.734, p=0.025, partial eta squared = 0.387), and a substantial main effect of the three RMR assessments during the intervention period (Wilks`Lambda = 0.540, F=6.379, p=0.010, partial eta squared = 0.460). No main effect between the groups were found (p=0.660, with partial eta square = 0.012), suggesting no difference in the effectiveness of the two exercise programs on RMR.

Paper IV

Background characteristics of the participants were similar as presented in paper III. The duration of the two exercise sessions was significantly different (p=0.033), with 53.0 min (±0.0) in the resistance training session, and 55.7 min (±2.9) in the BodyPump session. Total workload was significantly higher in the BodyPump group (19 485 kg ±2 258), compared to the resistance training group (15 616 kg ±2 976) (p=0.006). Estimated total energy expenditure was 302 kcal (±67) in the BodyPump group, and 289 kcal (±69) in the resistance training group ($p=0.69$), representing no group differences.

RMR increased 29% from before exercise to immediately after exercise, and 22% from before exercise to 2 hours after exercise in the BodyPump group ($p<0.01$). For the resistance training group changes in RMR were 33% and 15% before to immediately after and before to 2 hours after exercise, respectively ($p<0.01$). There was no significant interaction effect between the groups in RMR. There was a significant effect for time in both groups ($p<0.005$), but the main effect comparing the two groups was not significant.

Discussion

Overall, the present thesis aimed to investigate the effect of BodyPump and heavy load resistance training with and without a personal trainer, on previously inactive overweight women. The papers have evaluated the effect of 12 weeks of these three interventions compared to controls on muscle strength and body composition (paper I), musculoskeletal pain (paper II), and RMR (paper III), in addition to acute energy expenditure during exercise (paper IV). In this section, methodological strengths and limitations will be discussed, in addition to discussion of the main findings and needs for further research.

Methodological strengths and limitations

Paper I and II

Study design

The randomized controlled design with a blinded assessor is an important strength in paper I and II. Appropriate designed, conducted and reported RCT`s provide the highest level of evidence in clinical research, when the aim is to study a causal relationship between intervention and effect (Kabisch et al., 2011, Harbour & Miller 2001). However, the quality among RCT`s varies, depending on the research question, design, assessment methods, statistical analysis and the prevention of systematic errors. Paper I in the present thesis scored 6 out of 10 of the criteria for internal validity (risk of bias) included in PEDro rating scale, giving moderate to high methodological quality. As stated earlier, it is not possible to satisfy the criteria`s regarding blinded participants or therapists/instructors in trials including physical activity. Consequently, our paper scored on blinded assessors only, giving 6 points out of 8 possible. Additionally, our paper did not score on adequate follow-up or intention-to-treat (ITT) analysis. We preferred per protocol analysis of completers only, due to the high number of drop-outs and the low exercise adherence (Kabisch et al., 2011, Herbert et al., 2005). Herbert et al. (2005) stated that more than 85% of the participants should been assessed and obtained in the main outcome, when using ITT analysis, as imputation techniques do not compensate for or exactly reproduce missing data (Herbert et al., 2005). Per protocol analysis may provide the true efficacy of an intervention, but may also potentially overestimate the effect size due to selection bias, as those who follow the exact exercise prescription differ from those who do not. Armijo-Olivo et al. (2009) recommended that ≥80% of the exercise sessions should be attended when using per protocol analysis, which is higher than in our BodyPump and non-supervised group. Hence, we have reduced ability to generalize the results to other study groups and exercise settings. On the other hand, we have done an ITT-analysis, and there were no differences compared to the per protocol analysis with completers only.

A strength in paper I and II is the real-life context, without any interference from the investigators. Hence, we find the ecological validity maintained, as realistic expectations of effects from the exercise program were endorsed and a controlled study situation was avoided (Jones et al., 2005). Additionally, inclusion of previously inactive women not familiar with exercising at health- and fitness clubs, increases external validity to the study sample of interest. Furthermore, based on group allocation, participants in the intervention groups followed a standardized exercise program, and received the same detailed descriptions of warming up, repetitions, sets and time of breaks. Also, to ensure homogeneity, all the personal trainers included had the same educational background, and followed the same instructions regarding progression strategy, motivation and instructions.

Another strength is inclusion of a non-exercising control group. This was ethically approved as they were asked to continue their lifestyle and ADL as usual during the intervention period, and received 12 weeks of BodyPump and one session with a personal trainer after the intervention period. Importantly, in order to detect group differences, our controls underwent exactly the same assessment protocol as participants in the three intervention groups. Furthermore, all participants were allocated to their groups after finishing baseline tests. Some of the controls expressed disappointment of being randomized to the non-exercising group, and we cannot exclude whether some of them increased their activity level during the intervention period. On the other hand, they were asked to register all kind of physical activity in their training diary, and none of the controls reported a higher activity level during the intervention period, than defined in the inclusion criteria.

Study population and sample size

Power calculations was based on the primary outcome in paper I, and the results of Greco et al. (2011). With a possibility to compare all four study arms and an assumed drop-out rate of 10-20%, a minimum of 35 participants were included in each group. Unfortunately, drop-out was higher than assumed. Consequently, with reduced statistical power our ability to draw conclusions in paper I and II are limited, and we cannot eliminate a type II error (Robiner 2005). In addition, with significantly lower exercise adherence in the BodyPump (58%) and non-supervised group (74%), compared to the personal trainer group (89%), the potential for positive outcomes in muscle strength and body composition (paper I) might have been limited. The exercise adherence in paper II was somewhat similar in all three intervention groups as in paper I, and thus, the outcomes may also have been affected in this paper. On the other side, in paper II the participants were divided into high versus low adherence, which did not change the results. Commitment to exercise is a well-known challenge among overweight and obese individuals (Herring et al., 2014, Annesi et al., 2011), especially non-supervised exercise (Arikawa et al., 2011). Similar to our findings, Arikawa et al. (2011) found that exercise adherence in overweight and obese women was significantly higher (95%) during supervised resistance training compared to non-supervised training (61%). Accordingly, even though it is difficult to predict expected exercise adherence, our findings support that inactive and overweight individuals struggle with exercise adherence, and one- to one supervision may be a way to overcome the problem.

As many as 23 of our women dropped-out without reporting any reason, and they did not respond when contacted. Hence, we can only speculate why so many struggled with the exercise commitment. Among the women who actually did report reason for drop-out, lack of time and illnesses/injuries were the most common reasons. However, it has been documented that motivation for the exercise goals and type of exercise are important regarding exercise commitment (Middelkamp et al., 2016). Middelkamp et al. (2016) investigated exercise behavior in different group concepts from LesMills (e.g. BodyPump, Bodybike, Bodycombat, Bodyjam, Bodystep, Bodybalance), and reported 88% drop-out when the participants were offered only one exercise program: virtual cycling session for 12 weeks. In comparison, 48% dropped out when they self-sat their exercise goals and activities, and participated in multiple LesMills live group sessions. However, in clinical trials, standardization of the interventions are essential, which may reduce the opportunity for self-selection of activities and goals. In the present thesis, the participants were limited to perform BodyPump or the exact resistance training program described only, and thus, we cannot exclude that lack of self-determination on activities and goals may have affected adherence or drop-out.

Exercise adherence are found to be associated with factors such as gender, age, education, previously activity level, diets, smoking and social support (Trost et al., 2002, Wier & Jackson 1989, Gale et al., 1984), as well as higher levels of body mass and BMI (Arikawa et al., 2011, Gale et al., 1984). In our study sample, there were no group differences in background characteristics at baseline, and these factors should therefore not be related to the differences in exercise adherence. However, one explanation, especially relevant in the BodyPump group, might be related to the real-life setting. It is possible that the participants experienced low coping sense in the group class setting and did not feel any fidelity to BodyPump, the instructors or the other participants. This assumption is supported by a meta-analysis who stated that exercise in a group with individuals having the same background and interest was superior to standard exercise classes without the same affiliation (Burke et al., 2006). Further, D`Abundo (2007) reported that women attending aerobic classes, and especially beginners and those who did not meet the physical standards, felt uncomfortable with the exercise setting and the atmosphere during exercise. Contrary, Cleland et al. (2013) reported that group-based exercise programs had a more meaningful impact on physical activity behavior in women with disabilities, which could increase the effectiveness of the intervention. Thus, separate BodyPump sessions for our participants, might have increased the exercise commitment. On the other side, we emphasized a study situation representing the real-life concepts of interest, and did not want to interfere with the exercise setting. Importantly, even though one-to one supervision seems positive for the exercise adherence on a group level, exercise sessions in larger groups have the potential to activate more individuals at the same time, and thus be more cost-effective. Hiring a personal trainer is expensive over time, and are probably not an alternative to all individuals.

As we included overweight and obese participants, and changes in body composition as one study outcome, we assume that extrinsic motivation e.g. weight loss or changes in body composition, were present among our participants. Interestingly, it has been shown that individuals primarily exercising for extrinsic reasons, more likely report lower self-esteem and dissatisfaction with exercise (Strelan et al., 2003). Moreover, women exposed to exercise with a weight loss focus, have reported more body shame and appearance-related motivation to exercise, than women exposed to health-related marketing (Aubrey 2010). On the other side, intrinsic motivation factors such as health and well-being, are found to provide more commitment to exercise, and are associated with positively outcomes, e.g. enjoyment and effort during exercise (Brown & Fry 2014, Strelan et al., 2003). One study group did also find that the name and description of a group exercise session influenced women`s reasons for exercising (Brown et al., 2017). The women that chose intrinsically described group sessions were more concerned with health benefits, did more likely enjoy the exercise, had greater effort during exercise and perceived themselves as more competent during exercise, than those who chose sessions focusing on extrinsic factors (Brown et al., 2017). Finally, exercise in front of mirrors has been shown to give sedentary women more negative feelings and prevented them to derive to the session, compared to women exercising in a non-mirrored environment (Martin Ginis et al., 2003). All these aspects might be related to the high drop-out and low exercise adherence in our women. Especially the women exercising BodyPump were exposed to extrinsic factors such as fat-burning and defined muscles, due to the marketing strategies to LesMills and the group exercise setting. Thus, to recruit and appeal to untrained and/or overweight participants, we recommend LesMills to shift to more intrinsic aspects of the exercise concept.

Assessments

Muscle strength

Primary outcome in paper I, maximal muscle strength, was assessed using 1RM in squat and bench press. In addition, strength-endurance tests (70% of 1RM) were included in in the same exercises. 1RM tests in squat and bench press have showed good reliability and validity, and are considered as the best functional tests to assess maximal muscle strength in the upper and lower limbs (Seo et al., 2012, Levinger et al., 2009, Kraemer & Ratamess 2004, McCurdy et al., 2004, Nevill & Atkinson 1997). With a standardized test protocol, the coefficient of variation has been found to be less than 5.4% (Paulsen et al., 2003). Ideally, to maintain the validity and capture physiological changes in muscle strength over time, 2-3 familiarization sessions are recommended before pretest in untrained individuals (Ritti-Dias et al., 2011, Levinger et al., 2009). Thus, a limitation in the present study is that familiarization sessions before pretest were not included. With a total of 143 participants included and a wish to avoid Christmas and summer holidays between pretest and posttest, we did not have time or resources to priority familiarization sessions. However, all participants followed the same standardized test procedure regarding warm-up, rest intervals, progression of loads, positioning and speed (Paulsen et al., 2003). In addition, the same test leader was present during all tests, and gave an oral instruction and demonstration of the exercises. Moreover, all participants performed one testing set, with approximately 10 repetitions. Furthermore, all assessments were conducted with the same equipment in the training facility at NSSS, representing the natural environment of the interventions, which hopefully increased the sensibility of the tests (Abernethy et al., 1995).

Assessment of body composition

The present study followed all recommended procedures regarding energy- and fluid intake, placement of electrodes, temperature in the room and assessment early in the morning after 12 hours of fasting. When standardized procedures are followed, Inbody 720 has been found to be a valid and reliable assessment method to determine body composition in healthy overweight and obese individuals (Faria & Faria 2014, Anderson et al., 2012, Ogawa et al., 2011, Berker et al., 2010). In Faria & Faria (2014) Inbody 720 was compared to dual-energy X-ray absorptiometry (DXA) in obese individuals (89% women), and they found high reliability in both fat mass (kg) (ICC=0.83) and fat free mass (kg) (ICC=0.90). In addition, in Anderson et al. (2010), ICC was found to be 0.88 and 0.98 in lean body mass and fat mass, respectively, when comparing Inbody 720 with DXA in obese women. On the other side, in Vôlgyi et al., (2008), Inbody 720 underestimated fat mass in obese men and women with 2-6%, compared to DXA (variation coefficient DXA=2.2 and Inbody=0.6). Moreover, in Sillanpää et al., (2013) Inbody 720 underestimated fat percent with 6.5% and overestimated lean body mass with 3.2 kg, compared to DXA. Thus, as the sensitivity is higher in DXA, it is considered the gold-standard when assessing body composition (Hangartner et al., 2013, Thibault & Pichard 2012, Pateyjohns et al., 2006). In our study, we were planning to use DXA, but we did not have the opportunity, due to practical and economic reasons.

Assessment of musculoskeletal pain

The SNQ questionnaire used to assess musculoskeletal pain in paper II is easy to administer, have demonstrated acceptable test-retest reliability (0-23% variation) and has been validated against clinical history and diagnosis with a variation of 0-20% (Kuorinka et al., 1987). Descatha et al. (2008) validated SNQ against clinical examination in workers highly exposed to upper-limb work-related musculoskeletal disorders and minor exposed workers. They found the sensitivity (82-100%) and specificity (51-82%) to be similar in the two groups, but agreement between the SNQ and clinical examination differed in the two study groups, with kappa=0.22 and kappa=0.77, among the low and high exposed group, respectively. Thus, Deschata et al. (2008) concluded that the SNQ is a useful tool when investigating upper-limb work-related musculoskeletal disorders, especially together with numerical scales on symptom severity. However, limitations in the SNQ and thus paper II, are that it does not distinguish pain intensity, differentiate types of pain symptoms (e.g. numbness, tingling, shooting pain, confused stiffness, delayed onset muscle soreness (DOMS), fatigue) and/or capture the question of pain duration. Thus, it might be that our participants have interpreted the definition of musculoskeletal pain differently, and additional use of e.g. a visual analog scale for pain, numeric rating scale for pain, McGill pain questionnaire or the short form 36 bodily pain scale (Hawker et al., 2011), could have given more detailed information about our participants. However, as the primary aim in paper II was to investigate between group effects on musculoskeletal pain, we assumed the SNQ as an adequate assessment method.

Paper III and IV

Study design and study population

Some of the strengths regarding study design in paper III are similar to strengths in paper I and II; the randomized controlled design, the blinded allocation procedure and the clear inclusion- and exclusion criteria's. Another strength in paper III is that our values in RMR are in line with other studies, and thus we assume our study group representative to overweight and obese women (McMurray et al., 2014, Geliebter et al., 1997). RMR variability depends on several factors, e.g. gender, age, fat free mass and fat mass (Hirsch et al., 2016, McMurray et al., 2014, Geliebter et al., 1997). A review from 2014 (including almost 400 publications on RMR) concluded that obese women have lower RMR, compared to normal weight individuals and to men (McMurray et al., 2014). They found mean RMR in obese middle-aged women (BMI ≥ 30.0) to be 0.72 kcal/kg/hour, compared to 0.93 kcal/kg/hour in normal-weighed women. In our subgroup of participants, mean BMI was 30.4 (±4.8) and mean RMR at baseline was 0.71 kcal/kg/hour, and thus highly correlating with the values in McMurray et al. (2014). However, a limitation in our study is that we, due to practical reasons and time restraints, did not control the participants' dietary intake or their menstrual cycle. Intra-individual variation in RMR during the menstrual cycle have been found to vary up to 11.8% (CV range 1.7-10.4%), with half of the included women showing small variations (2-4%) and the other half high variations (5-10%) (Henry et al., 2003). Another study, using indirect calorimetry and a ventilated hood, found a day-to day variation of 2-4%, and concluded that a change between 6 and 8% were necessarily to observe a meaningful intervention-related effect within subjects (Roffey et al., 2006). Moreover, we did not include a control group that could control for other factors affecting the RMR, such as seasonal changes (Anthanont et al., 2017, Leonard et al., 2014). Leonard et al. (2014) found a significant increase of 6% during winter in younger individuals, while older individuals showed a decrease of 2%. On the other side, Anthanont et al. (2017) did not find any significantly differences in basal metabolic rate between summer and winter. In the present study, assessments were conducted during fall and early winter (September-December).

A strength in paper IV was that the participants were familiar with the program and exercise intensity at the time energy expenditure was assessed, and our result should be valid for people following BodyPump or a similar training protocol over time. Physiological responses to unaccustomed exercise may not be representative for repeated sessions as it may lead to exercise-induced muscle damage, which secondarily may affect the EPOC values (Paoli et al., 2012, Hackney et al., 2008, LaForgia et al., 2006, Borsheim & Bahr 2003, Schuenke et al., 2002, Thornton & Potteiger 2002, Haltom et al., 1999). According to McHuge et al. (2003) exercise-induced muscle damage will decrease drastically after only one session, and thus, the EPOC assessed after the initial session will overestimate the EPOC in the following exercise sessions. However, as EPOC was still present after our last assessment time point after exercise (120-140 min), a limitation is that we might not have captured the total magnitude from EPOC. Therefore, we describe the results as RMR at the two time points, instead of EPOC. Moreover, RMR may have been affected by the two light meals and time of day per se (Borsheim & Bahr 2003), and not only the exercise sessions. On the other side, Haugen et al. (2003) found that repeated morning and evening assessments of RMR were stable and highly correlated, with only 6% variability, supporting that the about 30% increase in RMR in both our groups, was due to the EPOC.

We did not conduct separate power calculations for paper III and IV, as this were sub-analysis from the RCT study (paper I). However, all participants in the BodyPump group and the personal trainer group in the RCT study, were invited to participate. Furthermore, the number of participants included in our studies are comparable with some of the other studies on BodyPump (Greco et al., 2011, Oliveira et al., 2009).

Assessments paper III and IV

Assessment of total workload

To maintain reliability, the same test leader was present during all tests and registered load lifted in all exercises and controlled the number of repetitions, sets and rest periods, used to calculate total workload. However, to maintain real-life expectations, all participants self-selected exercise loads, based on their experiences from previous sessions noted in their training diary.

Assessment of resting metabolic rate and energy expenditure

Indirect calorimetry is a valid assessment method when estimating energy expenditure (Compher et al., 2006), and the Oxycon Pro is found to be an accurate and valid system to measure respiratory values as VO_2, VCO_2 and RER (Carter et al., 2012, Rietjens et al., 2001). Compared to Douglas bag, Oxycon Pro have shown a coefficient of variation between 4.7-7.0% (Carter et al., 2012), when standard recommendations are followed. In the present study all standardized recommendations were followed, and the same test-leader was present during all assessments. To maintain high validity and reliability, assessments were conducted after 12 hours fasting, and the participants arrived the laboratory by car or public transportation, to ensure as little physical activity as possible before assessment (Compher et al., 2006, Carter &

Jeukendrup 2002). Consequently, the last exercise session at the midway- and post-test, were minimum ≥24 hours before assessment. In addition, we did also conduct a pilot study with three representative participants ahead of the study start, to test the equipment, time schedule and routines.

Discussion of main findings

Paper I and II

The fact that our overweight and obese women exercising BodyPump not improved maximal muscle strength, strength-endurance or body composition, compared to the non-exercising controls, are in contrast to two previous effect studies on BodyPump (Nicholson et al., 2014, Greco et al., 2011). In Greco et al. (2011) nine untrained female university students exercised BodyPump two times a week in 12 weeks, and increased 1RM in squat with 33%, compared to ten inactive controls ($p<0.001$). However, similar with our findings, they did not find any effect on body composition. All exercise sessions in Greco et al. (2011) were performed in a laboratory, which may have increased the adherence and training quality, and thus, may explain some of the discrepancy compared to our results. In Nicholson et al. (2014), 32 middle-aged and older adults exercised BodyPump in a real-life setting two times a week in 26 weeks, and improved significantly in 1RM leg press (13%) and bench press (14%), compared to non-exercising controls (n=36). Different exercise adherence might explain some of the differences to our results. Nicholson et al. (2014) reported 89% adherence, compared to 58% in the present study. Moreover, the intervention period was 14 weeks longer in Nicholson et al. (2014), compared to our study.

The absence of increased muscle strength among our participants in the BodyPump group can also be related to the low exercise intensity with 12% of 1RM and 16% of 1RM in squat and bench press, respectively. In comparison, exercise intensity in the personal trainer group was significantly higher with 66% of 1RM in squat and 69% of 1RM in bench press. The intensity in the non-supervised group was 47% of 1RM in squat and 63% of 1RM in bench press. Importantly, we assume these exercise intensities realistic and representative, since the participants exercised in a real-life setting, without any influence by the investigators. Participants in the BodyPump group followed the intensity instructions from the BodyPump instructors, who were not informed about the study. The personal trainers guided their participants regarding exercise intensity and could spot and secure during the exercises, while forced-repetitions were not allowed. The non-supervised group self-selected their exercise intensity, based on the general recommendations given at the first exercise session. Furthermore, except of the squat in the non-supervised group, the personal trainer group and the non-supervised group exercised with an intensity reflecting the prescribed recommendations aimed to increase muscle strength and muscle mass (60-80% of 1RM) (Garber et al., 2011, Donnelly et al., 2009). Moreover, according to Kraemer et al. (2002), untrained individuals performing resistance training with loads over 60% of 1RM may improve maximal strength with approximately 1% each session, giving 30-40% improvement after 24-36 sessions. These values are in line with the loads and number of sessions in our participants in the heavy load resistance training groups (personal trainer and non-supervised groups). The values also confer with a meta-analysis from 2014, who summarized muscular adaptations between low- and high-load resistance training in untrained normal-weighed men and women (Schoenfeld et al., 2014). Schoenfeld et al. (2014) reported that an exercise intensity ≤60% of 1RM potentially increase muscle strength and muscle mass, but that loads ≥60% are even more effective (Schoenfeld et al., 2014). Moreover, one study compared 20%

versus 80% of 1RM, on muscle strength adaptations and hypertrophy after 12 weeks of resistance training in well-trained men (Lasevicius et al., 2018). Similar with Schoenfeld et al. (2014), Lasevicius et al. (2018) found positive effect with both intensities, but the effect was about 20-25% larger at 80% of 1RM, compared to 20%.

According to LesMills` website, the BodyPump concept is based on an evidence proven formula, called the “REP-effect” (LesMills International). The idea is to exhaust the muscles to provoke a strong motoneuron recruitment using light weights and a high number of repetitions (Burd et al., 2010). Based on this formula, LesMills propose four exercise benefits; “shape and tone the muscles”, “burn up to 540 calories per class”, “improve general fitness and well-being” and “increase bone density”. In addition, one of the most noticeable claimed benefit from BodyPump are muscular definition (LesMills International). However, “shaping and toning your muscles” or improved muscular definition are unclear statements, and we have not been able to find any previously published scientific evidence supporting these benefits on untrained and/or overweight women. However, according to three systematic reviews, traditional resistance training as a sole intervention may give moderate to large effect on muscle strength in overweight individuals, but improvements in body composition or body weight are more difficult to achieve (Swift et al., 2014, Ho et al., 2012, Willis et al., 2012). This correspond with our findings, as the present study did not find any improvements in body composition. However, three outliers in the control group may explain this somewhat unexpected finding when comparing the PT group against non-exercising controls, as the majority in the PT group (21 of 27 participants) increased total muscle mass. Moreover, since we did not include dietary registration, we cannot be sure that the participants maintained diet or other lifestyle related habits that could affect body composition. On the other hand, they were told and agreed not to change their diet or ADL. One explanation why improvements in muscle strength is more commonly found is neural adaptations, including learning and coordination in the early stages of resistance training (Folland & Williams 2007, Gabriel et al., 2006).

Interestingly, one study found that some overweight and obese individuals are considered as low-responders or non-responders, and do not accomplish loss of fat mass after an exercise intervention (Myette-Cote et al., 2015). This inter-individual variability may be explained by genetic factors (Bouchard et al., 1994), adipose tissue characteristics (Tremblay et al., 1984), RMR, energy intake and physical activity levels (Donnelly & Smith 2005). Hence, since physical fitness has been found to have the most important impact on physical capacity and ADL (Hunter et al., 2004), improvements in body composition should not be the only outcome to evaluate from an exercise intervention. A systematic review concluded that behavioral changes and more physical activity, were associated with reduced metabolic risks, morbidity and mortality regardless of change in body weight (Ross & Bradshaw 2009). Myette-Cote et al. (2016) also found that those who were overweight and categorized as non-responders, still improved their physical fitness to the same level as those who improved their body composition after 1 year of aerobic and resistance exercise. These findings support that shifting focus from body weight and changes in body composition after exercise, to the health benefits may be important. Furthermore, future studies should have longer duration and/or long-term follow-up.

Even though BodyPump is classified as a resistance training concept, it contains some practical limitations that may negatively affect long-term effects, compared to traditional heavy load resistance training. First, a resistance training program should involve both concentric and eccentric muscle actions to stimuli the strength adaptions, and especially the eccentric phase is important to achieve neuromuscular stimuli via high mechanical stress (Wernbom et al., 2007, Bird et al., 2005, Kraemer et al., 2002). BodyPump includes both muscle actions, but the loads applied are limited, as the participants are restricted to light weights without racks or spotters. Even though the velocity of the movements in BodyPump varies to some degree, no exercises are conducted with maximal velocity, as in power training (Kawamori & Newton 2006). Thus, increases in rate of force development and high velocity movements are not to be expected by BodyPump training. Furthermore, since most tracks includes superset with exercises involving both larger and smaller groups, the smallest and weakest muscle groups may limit the performance and load lifted. Secondly, according to Kraemer & Ratamess (2004), specific motor unit recruitment patterns stimulate neural- and strength adaptations during heavy load resistance training. The degree of this stimuli is not the same during low load resistance training, despite of muscular fatigue (Kraemer & Ratamess 2004). Therefore, variations and periodization of loading and repetitions, as the exercise program used in our two heavy load groups, are found effective (Garber et al., 2011, Wernbom et al., 2007, Kraemer & Ratamess 2004).

The effect of a personal trainer

Our findings confer with previous studies investigating the effect of resistance training with a personal trainer; one-to one supervision seems to amplify load lifted and facilitate exercise progression, compared to non-supervised resistance training (Ratamess et al., 2008, Mazzetti et al., 2000, Storer et al., 2014). Notably, previously effect studies have mainly included recreationally trained men (Storer et al., 2014, Mazzetti et al., 2000), and to our knowledge, our RCT is the first including untrained and/or overweight women. However, one study interviewed eight women about their experiences with personal training, and what qualifications they emphasized with their trainer (Madeson et al., 2010). The women reported that they hired a personal trainer to ensure that the activities were fun and rewarding and stated that the personal trainer was important for their exercise motivation and to become more physically active (Madeson et al., 2010). Moreover, Melton et al. (2011) reported that women preferred a personal trainer who empathized their struggle with the exercise adherence, helped them to lose weight and generally improve their bodies. Based on these studies, it seems that a personal trainer not only increase the exercise intensity, but positively influence the commitment to exercise. It also correspond with our findings, as drop-out was lower and exercise adherence higher in our personal trainer group, compared to those exercising without one-to one support. However, once again it is important to highlight that hiring a personal trainer is an expensive service, and probably not an alternative to all.

To our knowledge, no previous studies have investigated the effect of high-repetition low load resistance training and heavy load resistance training on musculoskeletal pain in overweight women. Paper II revealed no within- or between-group differences from baseline to post-test, and adherence did not influence the results. During the inclusion process, participants were excluded if they had a history of diseases or injuries being contraindicated for resistance training, but the check-off health-profile scheme did not include musculoskeletal pain. Thus, 29%, 24%, 22% and 22% had experienced pain during the last seven days in the neck, head, shoulders and lower back, respectively. However, there was no group differences in pain at baseline, in any of the body part. Moreover, as stated in the introduction, nearly half of the normal-weighed population are affected of general musculoskeletal pain at any given time (14-47%) (Cimmino et al., 2011), and the prevalence are even higher among overweight and obese individuals (Stone & Broderick 2012). Thus, we assume the prevalence of pain among our participants representative to our study group.

Although we did not find any reduced prevalence of pain after 12 weeks of exercise, no increase in pain was seen among the participants who completed the study. However, we do not know if any of the drop-outs, not reporting reason, did experience musculoskeletal pain. Among those who did report reason for drop-out, nine reported injuries/illness, but unfortunately, we do not know whether this was related to the exercise. Anyhow, with all exercise sessions performed in a real-life setting, our results indicate that risk of pain, not should to be a reason why overweight or obese women would refrain from these types of resistance training. Interestingly, Zdziarski et al. (2015) reported that fear of pain are one of the most important barriers to exercise in overweight and obese women. However, it is important to inform that resistance training may induce immediate exercise induced pain and result in DOMS post-exercise, which is a normal physiological reaction (Dannecker & Koltyn 2014).

Paper III and IV

Changes in RMR during the 12 weeks intervention period did not differ between our participants exercising BodyPump and heavy load resistance training, nor did we find different energy expenditure during the sessions. The fact that both our groups increased RMR from pre- to post-test is comparable with other studies (Westcott 2012). However, previous findings on RMR are inconsistent, due to differences in the exercise program used, diet restrictions, genetic factors and methodological issues. To exemplify, Kirk et al. (2009) reported a 7% increase in RMR, after 24 weeks of low volume resistance training (nine exercises, single set, intensity of 3-6 RM, 3 times a week), in 39 overweight men and women. Contrary, in Geliebter et al. (1997) RMR decreased 7% after eight weeks of resistance training (6-8 repetition, 3 set, 3 times/week) in 20 obese women and men. Different from our study, the energy intake in Geliebter et al. (1997) was restricted (70% of RMR) and the participants lost body weight. In the present study, the participants were instructed not to alter lifestyle or dietary habits, and despite large individual changes, body composition was stable at a group level.

In paper III we showed that RMR in untrained women with BMI ≥ 25 responded to resistance training independently of exercise load (% of 1RM). As described in the introduction, if we assume that changes in muscle mass is relevant for changes in RMR (McMurray et al., 2014, Hambre et al., 2012, Washburn et al., 2012, Potteiger et al., 2008, Speakman & Selman 2003, Byrne & Wilmore 2001), it is interesting to note that both low and high load resistance training may induce equivalent skeletal muscle hypertrophy (Schoenfeld et al., 2014). In the present study, we observed both a correlation between estimated muscle mass and RMR at baseline and after the intervention period, as well as a correlation between changes in estimated muscle mass and changes in RMR. Thus, our findings support the assumption that muscle mass may be a relevant mechanism behind the changes in RMR. However, muscle mass did not increase at the group level, and are probably not the only mechanism.

Not surprisingly, in paper IV we found that the total workload (repetitions x sets x kg) was significantly higher in the BodyPump group, compared to the resistance training group. This was due to the high number of repetitions (approximately 800) and only ten minutes of rest in the BodyPump program, compared to 248 repetitions and 28 minutes of rest in the resistance training program. Nevertheless, energy expenditure was similar between the groups, probably due to lower mechanical work efficiency and higher energy expenditure per kg lifted during heavy load resistance training. Participants in the resistance training group performed all exercises with controlled lifting speed close to concentric failure, and used 4-6 seconds on each repetition. In comparison, in BodyPump the participants have to keep up with the choreography and music, and the lifting pace is higher. Thus, range of motion in the exercises in BodyPump might be smaller, which result in less energy used per repetition. In addition, HR and estimated relative intensities (HR_{max}) were similar between the two groups (76% and 77% in BodyPump and resistance training in the BodyPump group and resistance training group, respectively), demonstrating that the cardiovascular stress was similar. These values correspond with Oliveira et al. (2009), who investigated the physiological profile during a single BodyPump session, and estimated HR_{max} to be 78% and 84%, during the tracks involving the largest muscle groups.

Two previously studies have examined energy expenditure during BodyPump (Berthiaume et al., 2015, Stanforth et al., 2000), both including normal-weighed trained men and women. The energy expenditure in these two studies was lower, compared to our findings. In Stanforth et al. (2000), the total energy expenditure in both genders was reported to be 265 kcal (±60), and in women only 214 kcal (±26). Berthiaume et al. (2015) reported the energy expenditure to be 250 kcal (±68) in both genders, and 202 kcal (±38) in women only. The fact that our participants were overweight might explain some of the differences in the results, as body mass makes up most of the load in exercises involving body weight and thus require more energy used per repetition. Our women were about 23 kg heavier than the women in Stanforth et al. (2000), and BMI was 30.3 kg/m^2 (±4.7) in our women, compared to 22.7 kg/m^2 (±2.2) in Berthiaume et al. (2015). Different assessment methods used and different exercise intensity, may also explain why the energy expenditure was somewhat higher among our participants. In the present study, relative exercise intensity was 76% of HR_{max} (mean 142 beats/min,) compared to 63% of HR_{max} (mean 124 beats/min) in the Stanforth study. In Berthiaume et al. (2015) HR was not reported, but they asked their participants of perceived energy expenditure after the session, and both genders overestimated the assessed energy expenditure (men by 50% and women 84%). To summarize, no known studies on BodyPump have been able to reach the distributors claimed energy expenditure of 540 kcal. Furthermore, it is difficult to predict the size of expected energy expenditure from an exercise as several factors may affect the results, e.g. age, fat mass, muscle mass, physical fitness level, mechanical efficiency and environmental conditions under were the exercise are being performed (Ainsworth et al., 2011). However, the Compendium of Physical Activities can be used to quantify the energy expenditure of a variety of physical activities (Ainsworth et al., 2011), using the equation metabolic equivalent (MET) x body weight in kg x times of the exercise. When multiplying mean body weight in our study group with 55 minutes of exercise, resistance training (8-15 repetitions) with multiple exercises (5.0 MET) would give an energy expenditure of approximately 400 kcal. In comparison, fast walking (4.3 MET) would give an energy expenditure of approximately 340 kcal, and running (6 miles/h, 9.6 km/h) (9.8 MET) would results in 750-800 kcal. Compared to these activities, our findings of approximately 300 kcal must consequently be considered rather low. In light of this rather low energy expenditure per exercise session, it is not surprising that our women did not reduce fat mass. On the other hand, BodyPump and heavy load resistance training seems to give almost the same energy expenditure as fast walking, which is a common and recommended activity in overweight individuals.

The main part of the energy expenditure occurs during exercise, but increased RMR after exercise may also contribute to a higher daily energy expenditure (Borsheim & Bahr 2003). In paper IV, both groups had elevated RMR immediately after exercise (0-20 min) and 2 hours after (120-140 min). However, the changes were similar between our groups, and the values were comparable with other studies (Borsheim & Bahr 2003, La Forgia 2006). Since total workload was different in our two groups, we suggest that the elevated RMR, or the EPOC, was more related to the cardiovascular stress and muscular energy turnover than the mechanical loading. In addition, the magnitude and duration of EPOC after exercise have previously been found to be highly correlated to cardiovascular intensity, expressed as % of HR_{max} or % of VO_{2max} (Paoli et al., 2012, La Forgia et al., 2006, Borsheim & Bahr 2003, Schuenke et al., 2002, Haltom et al., 1999). Bertiaume et al. (2015) and Stanforth et al. (2000) did not include assessment of RMR or EPOC after BodyPump. However, Thornton & Potteiger (2002) compared high-load resistance training (85% of 8RM) with low-load resistance training (45% of 8RM), and found similar acute energy expenditure, but greater EPOC in the high-load group. They did also report higher cardiovascular stress and muscular energy turnover rates in the high-load group, judged by HR and blood lactate, which may explain the higher EPOC (Thornton & Potteiger 2002). In our study, the BodyPump group compensated for lower loads with more repetitions and shorter inter-set rest periods, which might be one explanation why they had similar cardiovascular and muscular stress as the heavy load resistance training group.

Conclusions

Overall, the results presented in this thesis support previous literature; resistance training at 60-80% of 1RM seems to positively affect muscle strength in overweight and obese individuals, but resistance training as a sole intervention seems not to have a meaningful impact on body composition.

More specifically the conclusions from this thesis are:

I. Twelve weeks of BodyPump was insufficient to improve maximal muscle strength, strength endurance and body composition in previously untrained overweight and obese women. In contrast, individual heavy load resistance training effectively improved maximal muscle strength and strength endurance, and a personal trainer amplified the effects on maximal muscle strength in the lower body, and improved exercise adherence. There were no effects on body composition.

II. Self-reported musculoskeletal pain did not change after 12 weeks of exercise in any of the groups, nor when controlling for exercise adherence.

III. Twelve weeks of BodyPump and heavy load resistance training showed similar increases in RMR/EPOC.

IV. A single session of BodyPump resulted in higher total workloads than heavy load resistance training, but this difference was not reflected in energy expenditure, which was approximately 300 kcal consumed in both groups.

Further research

The main aim of this thesis was to provide new knowledge about one of the most popular resistance training modalities available in the health- and fitness industry. Today, a wide range of individuals choose to exercise at a health- and fitness club; men and women of all ages, with different physical fitness levels, disabilities and BMI classes. Hence, there is need for more research on exercise behaviors in different study groups, and the effect of different exercise regimens. Also, further studies should focus on positive and negative health variables with the "concepts" or exercises, as well as exercise barriers and strategies on how to best implement the exercises to different risk groups. Increased knowledge on all these aspects is also important in terms of education of the instructors, personal trainers and therapists working in the industry.

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ELSEVIER

ORIGINAL ARTICLE

Effects of BodyPump and resistance training with and without a personal trainer on muscle strength and body composition in overweight and obese women—A randomised controlled trial

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Summary
Objectives: Overweight and obese individuals are recommended to perform regular resistance training, and the health- and fitness industry offer several exercise programs with purpose to improve muscle strength and body composition. This randomised controlled trial aimed to compare 12 weeks (45—60 min, 3 sessions/weeks) of popular exercise programs, available at health- and fitness centers worldwide.
Methods: Previous untrained women with BMI $\geq$ 25 were allocated to either BodyPump (a high-repetition group session) (n = 25), individual resistance training with a personal trainer (n = 25), non-supervised individual resistance training (n = 21) and non-exercising control group (n = 21). Primary outcome was one repetition maximum (1RM) in squat and bench press, and secondary outcome was body composition (Inbody720).
Results: The BodyPump group did not improve muscle strength, compared to any of the other groups. In 1RM squat, the personal trainer group increased 17% (95% CI 5.1—23.0), 20% (95% CI 7.5—24.8) and 30% (95% CI 15.8—33.0 kg) more than the non-supervised group, BodyPump and controls, respectively. In bench press the personal

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trainer group increased 10% (95% CI 1.5—7.2) and 16% (95% CI 3.5—9.3 kg) more compared to BodyPump and controls. No difference was found compared to the non-supervised group in bench press. There were no between-group differences in body composition.
Conclusion: Twelve weeks of BodyPump did not improve muscle strength in overweight women, but a personal trainer amplified the effects of individual resistance training on maximal strength in squat. None of the intervention groups showed effect in body composition.

Introduction

Increased body mass index (BMI) is associated with several health challenges, both to the individual and to the public [1,2]. In 2010, a high BMI was estimated to cause 3.4 million deaths [1]. The worldwide prevalence of women classified as overweight (BMI $\geq$ 25.0 kg/m^2) increased from 29.8% to 38.0% between 1980 and 2013 [3], and the prevalence classified with obesity (BMI $\geq$ 30.0 kg/m^2) increased from 6.4% to 14.9% between 1975 and 2014 [4]. Today overweight and obese individuals are recommended to perform resistance training 2—3 times a week, in combination with endurance training and dietary restrictions [5—7]. Regular resistance training is found to maintain or increase muscle strength and lean body mass, but may be insufficient in weight loss or decrease in fat mass [6,8]. However, Shiroma et al. [9] followed almost 36,000 healthy women and found that women exercising regular resistance training significantly reduced the risk of diabetes type-2 and cardiovascular diseases, compared to endurance training only. This support the importance of including resistance training in the physical activity recommendations for overweight individuals.

The health- and fitness industry offers a large variation in resistance training programs; in groups and individual. BodyPump, distributed from Les Mills International, is a pre-choreographed group resistance program, with over 5 million participants every week [10]. This is a full-body workout session, with a high number of repetitions (approximately 800 repetitions in total), including low-to-moderate loads. According to Les Mills, regular BodyPump exercise improves muscle strength, increases lean body mass and decrease fat mass [10]. To our knowledge, only two studies have examined the effects of BodyPump over time [11,12]. Greco et al. [11] found positive changes in maximal muscle strength in sedentary young students, but body composition did not change significantly in response to BodyPump. Nicholsson et al. [12] included elderly women and found positive changes in maximal muscle strength, but did not investigate the effect on body composition.

Individual heavy load resistance training with a personal trainer is another popular alternative in the health- and fitness industry. Today more than six million Americans employee a personal trainer (The International Health, Racquet and Sportsclub Association, 2015), however; search on Pubmed and other Sport related journals, did not reveal any studies on the amplitude of a personal trainer on muscle strength and changes in body composition in overweight and obese women.

The purpose of the present study was to evaluate the effects of BodyPump and traditional heavy load resistance training with and without a personal trainer on muscle strength and body composition in overweight and obese women. We hypothesized that BodyPump would improve muscle strength and body composition, compared to an inactive control group and that resistance training with a personal trainer would emphasize the effect on muscle strength and body composition, compared to non-supervised exercise.

Material and methods

Study design

This is a four armed assessor blinded randomised controlled trial (RCT) comparing the effects of 12 weeks of BodyPump, individual heavy load resistance training with a personal trainer, individual non-supervised resistance training and a non-exercising control group. All exercise sessions in the study were performed in a health- and fitness club setting. Primary outcome was maximal muscle strength (one repetition maximum [1RM]). Secondary outcomes were strength-endurance (maximal repetitions with 70% of 1RM) and body composition.

Subjects

Recruitment of participations was made via various social media channels and the homepage of the Norwegian School of Sport Sciences (NSSS). In total, 195 overweight or obese women contacted the principal investigator by phone or email. After aims and implications of the study were explained, eligibility criteria checked and a check-off health-profile scheme including health issues contraindicated for participation was fulfilled, a final sample of 143 participants were included. If a participant was uncertain regarding one or more of the check-off points in the health-profile scheme, we asked for a health declaration from their physician, to be able to enter the study. The included participants were allocated to either BodyPump ($n = 37$), heavy load resistance training with a personal trainer ($n = 35$), non-supervised heavy load resistance training ($n = 35$) or a non-exercising control group ($n = 36$). The statistician performed block randomization, using a computer generated random numbers and an 8-persons block size, meaning that for every eight randomized person each block had two participants with the same intervention. The first 140 included participants were randomized with $n = 35$ in each group. Then, three more participants were included, randomized from a new 8-person block, giving different n in the four groups.

Inclusion criteria were $BMI \geq 25.0$, age 18–65 and not regularly exercising defined as ''not performing regular structured exercise $\geq$ twice a week ''the last six months''. Exclusion criteria were diseases or injuries being contraindicated for maximal strength tests and heavy load resistance training (e.g. ischia's, low back pain, osteoarthritis, osteoporosis, secondary hypertension, history of coronary heart disease, stroke, arrhythmias, diabetes type 1 and neurological diseases), vacation or absence from exercise during the intervention period (>2 weeks), pregnancy, obesity surgery or psychiatric diseases (anxiety and depression). The participants were asked not to take part in any other exercise regimens during the intervention period, change any dietary habits or activity of daily living (ADL).

Power calculations were based on the findings from Greco et al. [11], whom detected a difference of 11% (effect size: 0.7) in muscle strength (1RM) compared to inactive controls, after 12 weeks of BodyPump. With a standard deviation of 15, alpha = 5%, and a statistical power of 80%, 30 subjects were needed in each group. With an expected attrition rate of 10-20%, a minimum of 35 women were included in each study group.

The study was approved by the National Committee for Medical Research Ethics Norway, Oslo (REK 2012/783), and all participants gave written consent to participate. The procedures followed the World Medical Association Declaration of Helsinki, and the study is registered in the Clinical Trial.gov Protocol Registration System (NCT01993953).

Procedures and interventions

All intervention groups were prescribed three exercise sessions weekly, for a period of 12 weeks. The duration of each BodyPump session was 60 min. The exercise program in the personal trainer and non-supervised group included linear periodization and varied between 45 and 60 min, due to small variations in the number of repetitions, sets and rest periods. All participants were told not to use less than 45 min or more than 60 min. Participants in the BodyPump group had free access to several local health- and fitness club centers offering BodyPump classes. The personal trainer group exercised with their personal trainer in the health- and fitness club at NSSS. The non-supervised group received instructions about the exercise program, lifting technique, intensity and progression from an instructor at their first exercise session, and a follow-up session after six weeks of the intervention period. All of the other exercise sessions were performed on their own in the health- and fitness club at NSSS. Sixteen personal trainers, educated with a bachelor degree in physical activity and health, including a personal trainer certificate from the NSSS, trained the women. All participants used a training diary to register adherence, training mode, repetitions and sets.

BodyPump is a pre-choreographed full-body workout session including 9–12 free-weight exercises. Table 1 shows an overview of the BodyPump program. The participants exercised with a weight bar (1.25 kg), plates (1, 2.5 or 5 kg) and a step. A typical one-hour BodyPump session includes approximately 800 repetitions, and number of repetitions throughout the session varies between muscle groups, in the range of 50–100. Each music track (4–6 min each) contains exercises for a particular muscle group. Between each music track, there is a short rest period (approximately one minute), primarily used to change weights and pre-

Table 1 Exercise program BodyPump.

Music nr.	Exercise	Volum (reps)
1 Warming-up	Straight leg deadlift, rowing, shoulder press, squat, lounges and bicepscurl	88
2 Leg	Squat	95
3 Cheast	Bench press	80
4 Back	Rowing, stiff legged deadlift, clean & press and power press	75
5 Triceps	French press, tricepspress, pullover and overhead tricepspress	78
6 Biceps	Bicepscurl	68
7 Leg	Squat, lounges and squat jump	72 + 24 jumps
8 Shoulders	Push up, lateral raise, rowing and shoulderpress	76 + 36 push up
9 Stomach	Sit-ups, sit-ups to the side and side-plank	51 + 30 seconds

pare to the next exercises. Some of the tracks also includes short inter-session rest periods (5—10 s), preferably used to "shake the legs". The session starts with a warm up track, containing different resistance exercises for the whole body. This is followed by exercises for the largest muscle groups (legs, chest, back), before smaller groups (arms, shoulders, core), and finally a cool-down including stretching. The participants selected their own training loads, but were encouraged to achieve muscular fatigue in each music track, with proper lifting technique. During a BodyPump session the instructor's gives verbal technique guidance ahead of each exercise. In addition, they repeat the most important technique components throughout each track, and gives individual instructions if necessarily.

The exercise program in the personal trainer and non-supervised groups were designed to resemble the BodyPump program, and included similar free-weights exercises (squat, lounges, deadlift, bent over rows to chest, bench press, dips or kickback, shoulderpress, modified clean and press, triceps press, bicepscurl and sit-ups). However, all exercises were performed in the free-weight area in the gym, with traditional free-weight equipment. The programs were standardized with nonlinear periodization. Session 1 included 8—10 repetitions, 2 sets and 60 s inter-set breaks. Session 2 included 13—15 repetitions, 2—4 sets and 60 s inter-set breaks, while session 3 included 3—6 repetitions, 2—4 sets and 120 s inter-set breaks. In week 1—4 the participants performed 2 sets in all exercises, while they increased to 3 sets in week 5—8 and 4 sets in week 9—12. The exercise program did not include any form of aerobic endurance training, except of 5—10 min light warm-up on a treadmill or cycle ergometer, and one warm-up set in each exercise. Both groups were instructed to perform repetition maximum in each set, and thereby choose their own appropriate training loads, with proper lifting technique. The participants in the personal trainer group exercised with the same personal trainer during the whole intervention period. The personal trainers were not allowed to interfere with the standardized training program (sets, reps, rest periods etc.) and were restricted to advise the participants to add appropriate loads and conduct the exercises with proper technique. The personal trainers could spot/secure and verbally motivate the participants during the weightlifting exercises, while forced-repetitions were prohibited. Totally, sixteen personal trainers took part in the study, all educated with a bachelor degree in physical activity and health, including a personal trainer certificate from the NSSS (including 33 h theory and 27 h practical teaching). All exercise sessions were performed in the health- and fitness club at NSSS.

The non-supervised group received instructions about the exercise program, lifting technique, intensity and progression from one of the personal trainers at their first exercise session, and a follow-up session with the same personal trainer after six weeks of the intervention period. All of the other exercise sessions were performed on their own in the health- and fitness club at NSSS. All participants used a training diary to register adherence, training mode, repetitions and sets.

Participants in the non-exercising control group were instructed to continue their lifestyle and ADL as usual. If they performed any exercise or activities, this was reported in a training diary. After the intervention period, they were offered BodyPump classes for 12 weeks, and one session of resistance training guided by a personal trainer.

Measurements

All participants included in the study conducted the baseline assessments directly ahead of the intervention. The randomization procedure and allocation to the different intervention groups was done after the baseline assessments, and delivered via opaque sealed envelopes. Immediately after the intervention period, the participants who completed the study conducted the same test procedure. All investigators involved in the assessments conducted the same tests at baseline and post-test, and the participants were instructed not to change their diet and activity of daily living during the intervention period.

Primary outcome

Maximal muscle strength was assessed with 1RM in squats and bench press. The participants came in groups of three, and they started with 5—10 min of light warm-up on a treadmill. Firstly, the squat was assessed, followed by the bench press. The participants received an oral instruction and practical demonstration of the exercises and were allowed to practice the technique with light weights (~20 kg), before initiating the test procedure. There was no other familiarization sessions ahead. The test procedure in both exercises included three series with gradually increasing load (40—75—85% of predicted 1RM) and reciprocally reduced numbers of repetitions (12-7-3). The participants conducted the first 1RM with a load about 5% below the expected 1RM. After each approved lift, the load increased with 2—5%, until failure. Resting periods between attempts were 3—5 min. High intraclass-correlation (ICC = 0.91) is found in both squat and bench press 1RM tests, and is considered the gold standard when assessing maximal muscle strength in non-laboratory situations [13].

Secondary outcomes

Strength-endurance tests were completed immediately after the 1RM test, in both squat and bench press. All participants performed the maximal number of repetitions at 70% load of their 1RM, with correct lifting technique. Qualified sport master students conducted all tests, and experienced spotters were present during all lifts.

Body composition was assessed with direct segmental multifrequency bioelectrical impedance Inbody720 (Body Composition Analyzer, Biospace Co., Ltd., Seoul, Korea). To obtain reliable measurements the assessment followed a standardized procedure, including overnight fasting [14]. All participants arrived to the laboratory at NSSS between 7 and 9 am on test day. The eight-polar Inbody separates adipose tissue and bone mass from other tissues in the body, leaving ''lean body mass'' (LBM) [15]. The ICC for Inbody720 is also found to be high in both fat mass (kg) and fat-free mass (kg) when comparing Inbody720 with Dual-energy X-ray absorptiometry (DXA) with ICC = 0.832 and ICC = 0.899 respectively [16]. The Inbody was calibrated based on the manufacturer specifications. The participant's body weight analyzed with Inbody was registered to the closest 0.1 kg, and height was measured to the closest 0.5 cm. BMI was then calculated as body weight (kg) divided by squared height (m).

Statistical analyzes

Analyzes were done with SPSS statistics program, version 21 (IBM Corporation, Route, Somers, NY, USA). Results are presented for completers only. An attrition rate analysis of baseline characteristics between completers and non-completers was made with an independent t-test. Background data is presented as means with standard deviation (SD) or numbers with percentages (%). The individual training load in squat and bench press was estimated as total load (kg) lifted in each exercise throughout the intervention period, divided by the total number of conducted sessions. The individual relative training load (% of 1RM) was calculated by dividing mean training load throughout the intervention by mean of 1RM at pre- and posttest. A normal distribution of the data was assessed with the Shapiro-Wilk test, and differences between groups at baseline were analyzed with ANOVA. A one-way ANOVA and Bonferroni post-hoc comparisons were used to detect between-group differences in the changes over the training period. Data are presented as means with 95% CI. Level of statistical significance was set at $p < 0.05$.

Results

Fig. 1 shows the flow-chart of the study including reasons for discontinuation. Ninty-four participants completed the study (mean age 39.6, SD 10.1 and BMI 31.1, SD 5.4). Loss to follow-up and discontinued to intervention were 32%, 17%, 40% and 36% in BodyPump, personal trainer, non-supervised and control group, respectively. Of 36 exercise sessions prescribed, mean adherence in the BodyPump group (n = 18) was 21.1 (SD 7.8, 58%), in the personal trainer (n = 27) 32.2 (SD 5.6, 89%) and in the non-supervised group (n = 19) 26.9 (SD 7.6, 74%). The personal trainer group had significantly higher adherence compared to both the BodyPump ($p \leq 0.001$) and the non-supervised group ($p = 0.017$).

Table 2 shows the background characteristics of the participants. There were no significant differences between the groups at baseline, or when analyzing baseline characteristics of the completers and non-completers (data not shown).

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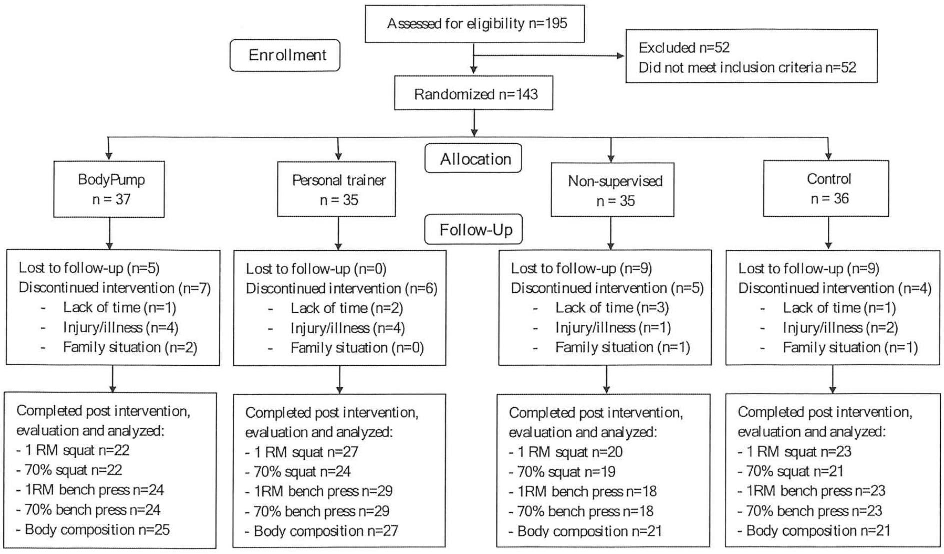

Figure 1 Flow chart of participants throughout the study period.

Table 2 Characteristics of the study population at baseline in Body Pump (BP), personal trainer (PT), non-supervised (NS) and control (C) group. Values presented as mean (SD) or numbers (%).

	BP	PT	NS	C	p-Value
Age (years)	39 (10)	38 (9)	42 (11)	40 (10)	0.369
Weight (kg)	84.4 (14.3)	93.3 (21.1)	86.2 (14.1)	86.4 (14.5)	0.229
BMI (kg/m^2)	30.2 (5.4)	32.3 (6.1)	30.8 (4.9)	30.8 (5.0)	0.545
Muscle mass (kg)	28.3 (2.8)	30.0 (4.4)	29.1 (3.3)	27.9 (2.9)	0.168
Fat mass (kg)	33.4 (11.2)	39.3 (14.6)	33.8 (10.8)	36.0 (11.2)	0.286
Fat mass (%)	38.7 (6.3)	41.1 (6.2)	38.4 (6.5)	20.8 (6.1)	0.340
1RM squat (kg)	79.3 (14.2)	80.8 (20.1)	82.6 (18.2)	80.4 (16.4)	0.945
1RM bench press (kg)	37.4 (5.5)	38.6 (6.0)	37.9 (5.8)	38.1 (6.1)	0.909
Daily smoker (yes)	2 (11%) (n = 18)	1 (5%) (n = 22)	0 (0%) (n = 14)	1 (6%) (n = 10)	0.691
Children (yes)	11 (61%) (n = 18)	7 (32%) (n = 22)	10 (71%) (n = 14)	7 (58%) (n = 12)	0.090
Education level (university <4 yr)	9 (50%)	7 (32%)	6 (43%)	6 (50%)	0.329

Maximal muscle strength

Descriptive data is presented in Table 3.The personal trainer group increased significantly in 1RM squat compared to the non-supervised group (Table 4) ($p \leq 0.001$), representing a between group difference of 17%, and the BodyPump group with a difference of 20% ($p \leq 0.001$). Both the personal trainer and non-supervised group increased significantly in 1RM squat compared to control group ($p \leq 0.001$ and $p = 0.020$), with a between group difference of 30% and 12%, respectively. In 1RM bench press, there were significant differences between the personal trainer group and the BodyPump group with 10% ($p \leq 0.001$) and controls with 16% ($p \leq 0.001$). The non-supervised group improved significantly in bench press compared to controls with 16% ($p \leq 0.001$) and to BodyPump with 10% ($p = 0.007$).

Strength-endurance

In strength-endurance, number of repetitions have been multiplied with the load lifted. The personal trainer group increased significantly compared to non-exercising controls in squat with 69% ($p = 0.017$) and bench press (35%) ($p = 0.006$) (Table 4). The non-supervised group increased significantly com-

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Table 3 Within group changes from pre- to posttest, in BodyPump (BP), personal trainer (PT), non-supervised (NS) and control group (C). Presented as n and mean (SD).

Outcome variable	Group	n	Mean (SD)
BMI (kg/m^2)	BP	24	−0.3 (0.6)
	PT	27	−0.2 (0.8)
	NS	20	−0.3 (0.8)
	C	21	−0.4 (0.7)
Muscle mass (kg)	BP	25	0.1 (0.8)
	PT	27	0.9 (0.2)
	NS	21	0.3 (0.8)
	C	21	0.1 (0.8)
Fat mass (kg)	BP	25	−1.0 (1.4)
	PT	27	−1.5 (2.0)
	NS	21	−1.2 (2.4)
	C	21	−1.1 (1.8)
Fat mass (%)	BP	25	−0.8 (1.5)
	PT	27	−1.5 (1.7)
	NS	21	−1.1 (2.2)
	C	21	−0.8 (1.5)
1 RM squat (kg)	BP	22	12.3 (12.0)
	PT	27	28.4 (11.5)
	NS	20	14.4 (10.8)
	C	23	4.0 (10.6)
Strength-endurance 70% squat (kg × reps)	BP	22	149.0 (342.2)
	PT	24	338.2 (609.8)
	NS	19	340.6 (493.3)
	C	21	−71.3 (211.4)
1 RM bench press (kg)	BP	24	3.8 (2.6)
	PT	29	8.1 (4.6)
	NS	18	7.8 (3.3)
	C	23	1.7 (4.2)
Strength-endurance 70% bench press (kg × reps)	BP	24	64.0 (134.3)
	PT	29	93.3 (124.4)
	NS	18	112.8 (139.1)
	C	23	−27.5 (111.4)

pared to the non-exercising control group in squat with 44% ($p = 0.027$) and bench press with 49% ($p = 0.004$).

Body composition

There were no significant differences between any of the groups in body composition or muscle mass (Table 5). A mean change boxplot of muscle mass showed four outliers (three in control group and one in the non-supervised group), and when excluding these from the analysis, ANOVA and Bonferroni post-hoc test revealed that the personal trainer group increased significantly in muscle mass, compared to controls ($p = 0.047$, 95% CI 0.0–1.2 kg).

Training load

Based on the training diaries and the mean results from the maximal muscle strength tests at baseline and posttest, mean training load in the BodyPump group was calculated to 12% of 1RM in squat and 16% in bench press. In the personal trainer group mean load in squat was 66% of 1RM and bench press 69%, while the non-supervised group trained with 47% of 1RM in squat and 63% in bench press. The personal trainer group exercised with significantly higher load in squat than the non-supervised group (19.8 kg (SD 3.3), $p \geq 0.001$, 95% CI 11.7–27.9). No differences were seen between the two groups in bench press. Both the personal trainer and non-supervised group had significantly higher training load than the BodyPump group.

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Table 4 Differences between BodyPump (BP), personal trainer (PT), non-supervised group (NS) and control group (C) in all variables in muscle strength, analyzed with ANOVA and Bonferroni post-hoc test. Presented with 95% CI and p-value.

Outcome variable	ANOVA (between group mean difference)	Comparison group	Mean difference (SD)	95% CI	Post-hoc p-value
1RM squat (kg)	$p \leq 0.001$	BP vs C	8.3 (3.3)	−0.8 to 17.3	0.092
		PT vs C	24.4 (3.2)	15.8–33.0	≤0.001*
		NS vs C	10.4 (3.4)	1.1–19.6	0.020*
		PT vs NS	14.1 (3.3)	5.1–23.0	≤0.001*
		PT vs BP	16.2 (3.2)	7.5–24.8	≤0.001
		NS vs BP	2.1 (3.5)	−7.4 to 11.4	1.000
Strength endurance 70% squat (kg x reps)	$p = 0.009$	BP vs C	220.4 (136.0)	−147.3 to 588.0	0.654
		PT vs C	409.5 (133.2)	49.4–769.5	0.017*
		NS vs C	411.9 (141.1)	30.3–793.4	0.027*
		PT vs NS	-2.4 (136.9)	−372.5 to 367.6	1.000
		PT vs BP	189.12 (131.6)	−166.6 to 544.8	0.926
		NS vs BP	191.5 (139.6)	−185.9 to 568.9	1.000
1RM bench press (kg)	$p \leq 0.001$	BP vs C	2.1 (1.2)	−0.9 to 5.1	0.370
		PT vs C	6.4 (1.1)	3.5–9.3	≤0.001*
		NS vs C	6.1 (1.2)	2.9–9.4	≤0.001*
		PT vs NS	0.3 (1.2)	−2.8 to 3.4	1.000
		PT vs BP	4.3 (1.1)	1.5–7.2	≤0.001*
		NS vs BP	4.0 (1.2)	0.8–7.2	0.007
Strength endurance 70% bench press (kg x reps)	$p = 0.002$	BP vs C	91.4 (37.0)	−8.5 to 191.3	0.093
		PT vs C	120.7 (35.4)	25.1–216.3	0.006*
		NS vs C	140.2 (40.9)	32.5–248.0	0.004*
		PT vs NS	−19.5 (38.1)	−122.2 to 83.3	1.000
		PT vs BP	29.3 (35.0)	−65.2 to 123.8	1.000
		NS vs BP	48.8 (39.6)	58.0–155.6	1.000

* Indicates a significant mean difference with $p < 0.05$.

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Table 5 Differences between BodyPump (BP), personal trainer (PT), non-supervised group (NS) and control group (C) in all variables in body composition, analyzed with ANOVA and Bonferroni post-hoc test. Presented with 95% CI and p-value.

Outcome variable	ANOVA (between group mean difference)	Comparison group	Mean difference (SD)	95% CI	Post-hoc p-value
BMI (kg/m^2)	p = 0.848	BP vs C	1.0 (0.2)	−0.6 to 0.7	1.000
		PT vs C	0.2 (0.2)	−0.4 to 0.8	1.000
		NS vs C	0.1 (0.2)	−0.6 to 0.7	1.000
		PT vs NS	0.1 (0.2)	−0.5 to 0.7	1.000
		PT vs BP	0.1 (0.2)	−0.4 to 0.7	1.000
		NS vs BP	0.0 (0.2)	−0.6 to 0.6	1.000
Muscle mass (kg)	p = 0.102	BP vs C	0.1 (0.2)	−0.6 to 0.7	1.000
		PT vs C	0.5 (0.2)	−0.1 to 1.2	0.180
		NS vs C	0.2 (0.3)	−0.5 to 0.9	1.000
		PT vs NS	0.3 (0.2)	−0.3 to 1.0	1.000
		PT vs BP	0.5 (0.2)	−0.1 to 1.0	0.229
		NS vs BP	0.2 (0.2)	−0.3 to 1.0	1.000
Fat mass (kg)	p = 0.769	BP vs C	0.0 (0.6)	−1.5 to 1.6	1.000
		PT vs C	-0.5 (0.6)	−2.0 to 1.0	1.000
		NS vs C	-0.2 (0.6)	−1.8 to 1.4	1.000
		PT vs NS	-0.3 (0.6)	−1.8 to 1.2	1.000
		PT vs BP	-0.5 (0.5)	−1.9 to 0.9	1.000
		NS vs BP	-0.2 (0.6)	−1.7 to 1.3	1.000
Fat mass (%)	p = 0.486	PT vs NS	-0.1 (0.5)	−1.5 to 1.3	1.000
		PT vs BP	-0.7 (0.5)	−2.1 to 0.7	1.000
		NS vs BP	-0.3 (0.5)	−1.8 to 1.1	1.000
		BP vs C	-0.3 (0.6)	−1.8 to 1.2	1.000
		PT vs C	-0.5 (0.5)	−1.9 to 0.9	1.000
		NS vs C	-0.2 (0.6)	−1.7 to 1.3	1.000

Discussion

To our knowledge, this is the first study to investigate the effect of popular resistance training programs available in the health- and fitness industry, on muscle strength and body composition in overweight and obese women. The main findings were that twelve weeks of BodyPump neither changed maximal muscle strength, strength-endurance nor body composition, compared to non-exercising controls. Resistance training with a personal trainer was more effective to improve maximal strength in the lower body, compared to non-supervised resistance exercise, but no differences were found in strength-endurance nor body composition.

BodyPump failed to enhance both maximal muscle strength and strength-endurance, which indicates that the participants selected too low loads and/or did not reach muscular fatigue during the workouts (estimated training intensity was 12% of 1RM in squat and 16% in bench press). Since our participants trained under real-life settings, the workload was self-selected, and, thus, not influenced by the investigators. The participants followed general instructions from licensed BodyPump instructors, not involved or informed about the study. Both the personal trainer and non-supervised group had significantly higher training intensity than the BodyPump group. However, the BodyPump program is based on the ''rep-effect'' [10]. The idea is to exhaust the muscles while using light weights by performing a high number of repetitions and thereby provoke a strong motoneuron recruitement—as during heavy load resistance training [17]. A meta-analysis from 2014 [18] summarizes the evidence when comparing muscular adaptations between low- and high-load resistance training programs in untrained individuals. They conclude that a load ≤60% of 1RM increased muscle strength and hypertrophy, although less than heavier load. In addition, neither significant improvement in lean body mass nor decrease in fat mass was found in BodyPump, compared to non-exercising controls. This may also be due to the low training intensity, but also an unfortunate low adherence in the BodyPump group.

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Corresponding with the present study, Arikawa et al. [19] found highest adherence to resistance training (95.4%) in overweight individuals with one to one supervision. This suggests that supervised exercise may be especially beneficial and necessarily for adherence to exercise in overweight women [19]. Nevertheless, participation in a RCT is time-consuming, and three exercise sessions per week, may have been overwhelming for some of the participants. However, ACSM recommends traditional resistance training (60—80% of 1RM) 2—3 times a week [20], and Les Mills encourage members to practice BodyPump 2—3 times a week [10]. Orsatti et al. [21] have reported that one session weekly can increase muscle strength and muscle mass in overweight women, similar with two or three times a week. In the present study, 17 participants in the BodyPump group exercised at least one session a week, compared to 28 in the personal trainer group and 18 in the non-supervised group. Low adherence, as found in the BodyPump and non-supervised group, may still have limited the potential for successful outcomes.

Our findings in the BodyPump group is in contrast to Greco et al. in muscle strength, but confers with their findings in body composition [11]. Greco et al. investigated the effect of 12 weeks of BodyPump in 19 untrained female university students and found significant improvements (33%) in maximal strength in squat, compared to a non-exercising control group. However, in Greco et al. all exercise sessions were performed in a laboratory, which might have increased the adherence and training quality. Our findings are also in contrast to Nicholson et al. [12] who found significant improvements in 1RM leg press (13%) and bench press (14%), compared to controls, after 26 weeks of BodyPump in middle-aged and older adults. However, adherence in Nicholson et al. was 89%, compared to 58% in the present study, which may explain some of the differences in results. Nicholson et al. did not assess body composition. None of these studies included endurance training or had compared BodyPump in combination with endurance training, which might be necessarily to change body composition. Previous studies investigating the effect of 3 month of endurance training separately (cycle ergometer), compared to endurance training in combination with endurance strength training in obese women, found that the combination group significantly improved both body composition, physical capacity, as well as liver function [22,23].

Only a few studies have previously investigated the effects of resistance training with a personal trainer, but our result correspond with those reports: direct one to one supervision is beneficial for improving muscle strength [24—26]. Mazzetti et al. [24] compared linear periodized resistance training with and without a personal trainer for 12 weeks in recreationally trained men. They found that the personal trainer group had greater progression in the load lifted during training and improvements in 1RM. Storer et al. [25] investigated 12 weeks of non-linear resistance training on middle-aged men, and found that resistance with a personal trainer was beneficial to improve lean body mass and maximal muscle strength in the upper body. In a cross-sectional study, a group of women with personal trainer experience selected significantly higher training loads, compared to controls [26]. Greater progression of loads and better control over the lifting techniques might be important factors [24], and explain the benefits of supervised resistance training. Our findings support that higher training-loads results in larger improvements in 1RM, since the personal trainer group exercised with significantly higher loads in squat, compared to the non-supervised group (19.8 kg (SD 3.3), $p \geq 0.001$, 95% CI 11.7—27.9). No differences in training load or 1RM were seen between the groups in bench press. Based on our findings, we suggest that the personal trainer effects was a consequence of applying higher training loads during training.

In our study, the personal trainer group did not increase significantly in muscle mass compared to controls. Three outliers in the control group may explain this somewhat unexpected finding, as the majority in the personal trainer group (21 of 27 participants) increased total muscle mass assessed by Inbody. On the other hand, our results is in line with other studies, confirming that resistance training may give moderate to large effects on muscle strength in overweight and obese individuals, while changes in body composition seem more difficult to achieve [8,27,28].

There are strength and limitations of the present study that needs to be highlighted: use of a randomized controlled design, blinded assessments and strictly controlled inclusion and exclusion criteria's can be considered strengths. In addition, ecological validity was maintained because the interventions were performed in the context of a health- and fitness club, which represent the real world of the concepts of interest. All possible variables were standardized, and all participants in the personal trainer and non-supervised group followed the same standardized exercise program, based on the exercises in the BodyPump program. All personal trainers had the same background, and followed the same instructions regarding progression strategy, motivation and instructions. In addition, the partic-

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ipants were encouraged to continue their usual ADL and energy intake, and the study was conducted outside holiday periods.

A limitation in the present study is that we did not include familiarization session ahead of the 1RM test. To increase the validity and capture physiological changes in muscle strength over time, untrained individuals are recommended to perform 2–3 familiarization sessions before pretest [29,30]. However, all participants in the present study were given an oral instruction, demonstration and a test before pretest. Also, the study may have reduced power and increased risk of type 2 error [31] because of an unfortunate high loss to follow-up, which may have reduced our ability to detect statistically significant improvements in the BodyPump group. On the other hand, positive effects were found in the two other intervention groups on muscle strength and the attrition analysis showed no differences in any of the variables between completers and non-completers. Moreover, there were no differences between the groups at baseline. Finally, the study did not control for diet and activities of daily living, although participants were told not to change any lifestyle habits.

Conclusion

After 12 weeks of exercise in a health- and fitness setting, overweight and obese women exercising BodyPump did not improve muscle strength. Individual heavy load resistance training with and without a personal trainer effectively improved muscle strength, and a personal trainer amplified the effects on maximal muscle strength in squat. None of the groups changed body composition.

Disclosure

The study declare no conflict of interest, and no competing financial interests exist.

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Paper II

Is there any effect of BodyPump and heavy load resistance training on prevalence of musculoskeletal pain in overweight and obese women? A randomized controlled trial.

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Introduction

Overweight (Body mass index (BMI) ≥ 25.0 kg/m^2) and obesity (BMI ≥ 30.0 kg/m^2) are common contributors to pain and disability in the musculoskeletal system (1-7). The association between pain and BMI seems more widespread in the female population (3) and with 40% of women worldwide classified as overweight (8) and 15% as obese (9), this association may evolve as an increasing challenge for the health care system (4).

The association between pain and BMI is primarily explained by increased mechanical load on joints and tissues, muscular inflammations and psychological issues (6,10-11). Consequently, this relationship may lead to reduced physical ability and challenges in activity of daily living (ADL), as well as impaired quality of life (12). Overweight and obese women report fear of pain or injuries during exercise as a major barrier for a more active lifestyle, as well as an important deterrent for adherence to exercise (6). On the other hand, physical activity, and especially resistance training (RT), may prevent or reverse pain symptoms by increasing muscle mass, muscle strength and physical function (12-14), help stabilizing the joints, improve mobility and improve proprioception (4).

RT can be practiced in many different ways, e.g. with a large range in repetitions and loads, and in different settings (individually and in groups). Today, overweight and obese individuals are recommended to perform RT 2-3 times/week, with an intensity between 60-80% of maximal muscle strength (15). However, high-repetition low-load RT sessions in groups, e.g. BodyPump (BP), are popular exercise programs for women (16). Worldwide, over 5 million individuals participate in BP weekly, distributed in approximately 14 000 health- and fitness centers (16). We have previously reported (17) that 12 weeks of BP was ineffective in improving muscle strength and body composition in overweight and obese women, compared to an inactive control group. However, exercise adherence was low (58%) and drop-out was high (32%). At the same time, we found that traditional heavy-load RT, in accordance with the ACSM recommendations, with a personal trainer effectively improved muscle strength, and provided significantly higher exercise adherence (89%), compared to the other intervention groups (17).

We have not been able to find studies examining whether different popular RT modalities, available in health- and fitness centers, affect the prevalence of self-reported pain in overweight or obese women. Hence, the aim of the present study was to investigate the effect of three different RT modalities, compared to controls, on musculoskeletal pain, in overweight and obese women. Furthermore, we aimed to study whether the results were influenced by adherence to exercise.

Material and methods

Study design

This is secondary analysis of a four armed assessor blinded randomized controlled trial (RCT) (17). Primary outcome of the present study was to examine between group differences in musculoskeletal pain in former untrained, but healthy women with BMI $\geq$ 25.0, allocated to 12 weeks of either BP, heavy load RT with a personal trainer, non-supervised heavy load RT or no exercise. Secondarily, we examined the association between musculoskeletal pain and adherence to exercise.

Participants

Totally 143 women were included in the RCT and allocated to either BP (n=37), heavy load RT with a personal trainer (PT) (n=35), non-supervised heavy load RT (NS) (n=35) or a non-exercising control group (C) (n=36). Eligibility criteria`s included BMI ≥ 25.0, ages between 18 and 65 years and not regularly exercising defined as “not performing regular structured exercise ≥ twice a week the last six months". Using a inclusion screening scheme, participants were excluded if they had a history of diseases or injuries being contraindicated for the assessments or intervention (e.g. low back pain with radiation or osteoarthritis during the last six months, osteoporosis, secondary hypertension, history of coronary heart disease, stroke, arrhythmias, diabetes type 1 and neurological diseases). In addition, planned vacation or absence from exercise during the intervention period for >2 weeks, pregnancy, obesity surgery or psychiatric diseases were exclusion criteria`s. Additional details about the recruitment and randomization procedure have been previously reported (17).

Procedures and interventions

The participants were prescribed three exercise sessions weekly for 12 weeks and the exercises were performed in a real life setting. Participants in the BP group had free access to several health- and fitness centers offering BP during the intervention period, while participants in the PT and NS group exercised at the health- and fitness center at the Norwegian School of Sport Sciences (NSSS). Sixteen personal trainers took part in the study, all educated with a bachelor degree in physical activity and health, including a personal trainer certificate from the NSSS.

BP is a pre-choreographed, strengthening workout session, guided by a LesMills certified instructor. Every third month Les Mills ‘releases a new program, but they are all based on the same principles and have the same structure (16). During the intervention period, BP release no.83 was present at all centers. Detailed description of the BP program has been previously published (17). A BP session consists of ten music tracks, 4-6 minutes each, including strengthening exercises targeting specific muscle groups. The participants exercise with a weight bar (1.25 kg), plates (1, 2.5 or 5 kg) and a step. Each one-hour session includes between 800-1000 repetitions (50-100 in each muscle group). There are 1-2 minute rest periods between each track, used to change weights and prepare for the next exercises. Training loads were self-selected, based on technique and intensity guidance from the instructor, as well as experiences from previous exercise sessions (16).

The PT- and NS group followed a standardized nonlinear periodization program, including similar exercises as the BP program. Details of the program have been previously reported (17). Repetitions varied between 3-6, 8-10 and 13-15, and number of sets between 2-4. Before the exercises, the participants performed a 5-10 minutes low intensity warm-up on a treadmill or cycle ergometer. The participants were instructed to perform repetition maximum (RM) in each set, with proper lifting technique. Participants in the PT group exercised together with their personal trainer in all sessions, and received continuously advice on appropriate training loads and lifting technique, as well as support and motivation. Participants in the NS group exercised on their own, except of one introduction session with a personal trainer who introduced them to the exercise program (proper lifting technique, training loads and progression), and a follow-up session after six weeks of exercise.

Participants in the C-group were asked to continue their usual lifestyle and ADL. If they performed any exercise or physical activity, they were asked to report this in a similar training diary as the intervention groups. After post-test, all controls were offered BP classes for 12 weeks, and one RT session with a personal trainer.

Assessments

Musculoskeletal pain

Musculoskeletal pain was registered using the Standardized Nordic Pain Questionnaire (SNQ), developed to measure the prevalence of musculoskeletal pain and syndromes in epidemiological studies (18). The questionnaire registers whether the participants have experienced musculoskeletal pain in ten different anatomical body parts, during the last 12 months, and the last seven days. The participants answered the questionnaire at baseline (before randomization) and post-test. For the purpose of the present study, responses to the last seven days were used as the primary outcome. In addition, responses the last 12 months were used in the descriptive analysis at baseline. The ten anatomical body parts included in the questionnaire were; head, neck, shoulder, elbow, wrist, low back, upper back, hip, knee and feet. All questions were formulated as e.g. "Have you ever during the last 12 months/ 7 days experienced pain in the…?”. Possible responses were yes or no, and those who answered "yes", were categorized as having pain. The SNQ questionnaire have demonstrated adequate test-retest reliability (0-23% variation), and has been validated against clinical history with a variation between 0-20% (18).

Adherence

The participants registered adherence to exercise in a training diary. For the purpose of this study, high adherence was defined as ≥75% attendance to exercise (≥28 sessions of 36 possible), and low as <75% (≤27 sessions of 36 possible).

Statistical analysis

Analyzes were done with SPSS statistics program, version 21 (IBM Corporation, Route, Somers, NY, USA). Background data are presented as means with standard deviations (SD), and data on self-reported pain is presented as numbers (n) with percentages (%). One-way ANOVA was used to analyze possible differences between the groups in background variables and primary outcome at baseline. An attrition rate analysis of baseline characteristics between completers and non-completers was made with an independent t-test. Results are presented for completers only. McNemar`s test was used to analyze if there was a difference in the proportion of the participants (the three intervention groups collapsed together) reporting muscle pain in any of the body parts prior to, versus after the intervention. Chi-square test was used to analyze differences between the groups in self-reported pain (categorical data), as well as the association between pain (yes/no) and high/low adherence. Level of statistical significance was set at $p<0.05$.

Results

Of 143 women randomised, 92 completed the study (mean age 39 years ±10, BMI 31 ±5 kg/m^2), with the following distribution: BP (n=24, 65%), PT (n=28, 80%), NS (n=19, 54%)

and C (n=21, 58%) group (Fig.1). No statistically significant differences were found between the four groups in background data or musculoskeletal pain at baseline (Table 1), nor in the attrition rate analysis between completers and non-completers. Adherence to exercise were 54% (±20) in the BP group, 83% (±15) in the PT group and 69% (±20) in the NS group.

There were no differences in musculoskeletal pain between the groups at baseline or post-test (Table 2). Table 3 shows the prevalence of pain with the three intervention groups collapsed. No statistical significant changes in reported pain were found from baseline to post-test. The neck, head, shoulder and lower back were the body parts with the highest reported pain at baseline, compared to the neck, shoulder, head and knees at post-test (Table 3).

Sub analyses of participants divided in high (n=38) and low (n=20) exercise adherence and report of musculoskeletal pain, is presented in Table 4. Irrespective of group allocation, there were no statistically significant difference in prevalence of bodily pain between those with high versus low adherence to exercise.

Discussion

The present study investigated the effect of musculoskeletal pain in healthy untrained women with BMI ≥ 25.0, after twelve weeks of either high-repetition low load RT in groups (BP), heavy load RT with a personal trainer or non-supervised heavy load RT. None of the exercise modalities had effect on musculoskeletal pain, compared to inactive controls, and no changes were found when controlling for exercise adherence.

The present study included healthy women, and participants with a history of diseases or injuries contraindicated for RT were excluded. As such, we assumed a low to moderate prevalence of musculoskeletal pain at baseline. However, 57 of the 143 participants reported pain in the SQN at baseline, in one or more body parts, with the head, neck, shoulder and lower back being the most affected body parts. One reason for this, may be that the inclusion screening scheme contained specific diagnoses only (such as low back pain with radiation, osteoarthritis, osteoporosis, secondary hypertension, history of coronary heart disease, stroke, arrhythmias, diabetes type 1 and neurological diseases). Thus, pain reported in the SQN at baseline, was probably to too trivial to qualify as a contraindication for RT. Still, we cannot exclude that some of the participants might have under-reported pain in the inclusion-screening scheme, as they were afraid of being excluded from the study. However, there were no group differences in self-reported pain in the SQN at baseline, in any of the body parts. The number of participants reporting pain in the present study are comparable with prevalence of musculoskeletal pain in the general adult population, as 14-47% of the population are affected of pain (19). Moreover, Stone & Broderick (20) showed that overweight and obese individuals reported 20% more daily pain than normal-weighed (20). In addition, the most affected body parts in our study group have all previously been reported with high risk of pain in overweight and obese individuals (21-24). Comparison of pain between studies is however difficult, due to differences in the definition used, study population and measurement methods (25).

The overweight-pain association is related to a sedentary lifestyle, reduced physical function and low muscle strength (26,2,4). These factors may all exacerbate the pain symptoms, and contribute to a vicious circle, which RT may reverse or improve (1,2,5,6). In particular, studies have showed that RT may be effective to reverse low-back pain in overweight and obese individuals (2,13-14). In the present study, pain in the lower back was non-significantly reduced with 6%, compared to baseline values. Possible explanations why our reduction was somewhat smaller than in previous studies might be lack of power, low responsiveness of the questionnaire and the fact that low-back pain with radiation was an exclusion criteria.

The present study had unfortunately a high drop-out rate, and adherence to exercise was low in the BP and NS group, which may have affected the outcomes. Nevertheless, comparing participants with high and low adherence did not change the results. In total, seven participants from the three intervention groups dropped out because of illness/injury (Fig.1). We do not know whether these were exercise-induced injuries, as most of the participants did not give any reason for drop-out. In addition, 20 participants were lost to follow-up without reporting reason, the majority of these from the NS group. Low exercise adherence and high drop-out from exercise, is a known challenge in overweight and obese individuals (2, 6). Zdziarski et al (2) have emphasized that exercise modifications, as low load as an alternative of high load RT, could reduce acute exercise induced pain, and possibly increase exercise adherence (2). This was not observed in the present study, as the BP group, representing low load RT, had significantly lower adherence, compared to the heavy load groups (PT and NS). However, the fact that the PT group had higher adherence, compared to the NS group, corresponds with previous findings (6). Arikawa et al (6) compared supervised (month 1-4) and non-supervised (month 5-24) RT in untrained overweight and obese middle-aged women, and found significantly higher adherence during the supervised period (6). Thus, support and motivation from certified personal trainers might be a key-factor to avoid drop-out and increase exercise adherence (6).

Stidsen et al (27) used the same questionnaire as the present study (SQN), and found that 56% of 500 new fitness club members reported musculoskeletal pain in one or more body parts, and 77% of these reported pain as one of the reasons for their membership. These findings raise the importance of investigating the effect of pain during and after popular exercise modalities, especially in a risk group. Therefore, even though none of the three exercise modalities in the present study significantly reduced self-reported pain after 12 weeks of exercise, we would also want to highlight that no adverse effect was seen. Hence, the RT modalities in the present study may all be appropriate for women with a BMI ≥ 25. Still, it is important to emphasize that RT may induce immediate exercise induced pain and give delayed onset muscle soreness (DOMS) (28). Therefore, exercise instructors should teach the participants to differentiate between immediate and transient pain, and long-lasting pain.

Strengths of the present study were use of a randomized controlled design, blinded investigator and use of a validated questionnaire. The study had a high ecological validity, as the exercise training was performed in a real-life setting. In addition, all participants followed the same standardized exercise programs, and the personal trainers followed the same standardized instructions. A limitation in the study may be that SNQ do not distinguish between grade and type of pain. Therefore, the participants may have interpreted the definition of musculoskeletal pain differently, and confused stiffness, DOMS, fatigue and functional limitations. Questionnaires including pain intensity e.g. the visual analog scale for pain, numeric rating scale for pain, McGill pain questionnaire or the short form 36 bodily pain scale (29), could have given more detailed information.

To conclude, our study showed no between- or within group changes in self-reported musculoskeletal pain after twelve weeks of either high-repetition low load RT (BP) in groups, heavy load RT with a personal trainer or non-supervised heavy load RT.

Ethical approval

The study was approved by the Regional Committee for Medical Research Ethics Norway, Oslo (REK 2012/783), and all participants gave written consent to participate. The procedures followed the World Medical Association Declaration of Helsinki, and the study is registered in the Clinical Trial.gov Protocol Registration System (NCT01993953).

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Conflicts of interest statement

The authors have no conflicts of interest relevant to this article.

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Figure 1: Flow chart of participants throughout the study

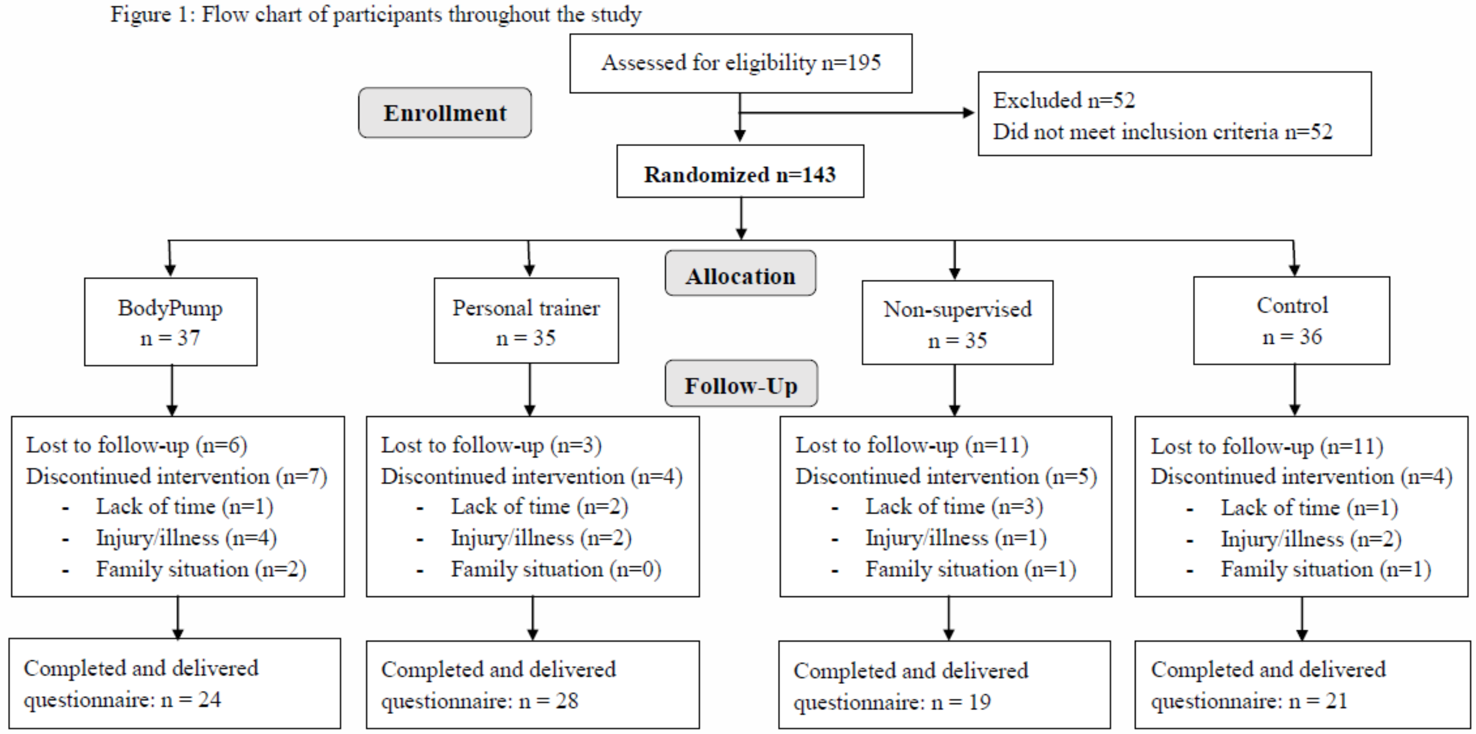

Table 1: Demographic data of the participants in the BodyPump group (BP), personal trainer group (PT), non-supervised group (NS) and control group (C). Presented as mean with standard deviation (±) and differences between groups with p-value.

Variable	BP (n = 24)	PT (n = 28)	NS (n = 19)	C (n = 21)	p-value
Age (year)	38 (11)	37 (9)	42 (12)	40 (12)	0.430
Weight (kg)	83 (11)	94 (21)	85 (14)	87 (15)	0.112
Height (cm)	168 (6)	169 (6)	168 (6)	167 (4)	0.811
BMI (kg/m²)	30 (4)	33 (6)	30 (5)	31 (5)	0.219
Children (yes)	21	15	18	20	0.519
Daily smoker	9	2	4	4	0.212

Table 2: Self-reported musculoskeletal pain at baseline and post-test in the BodyPump group (BP), personal trainer group (PT), non-supervised group (NS) and control group (C). Differences between the groups analyzed with chi-square test, presented with p-value. Presented as numbers reporting pain (n)/of the total number of participants (n) in each group, and as percent (%).

	Baseline					Post-test				
Body part	BP	PT	NS	C		BP	PT	NS	C	
	n (%)	n (%)	n (%)	n (%)	p-value	n (%)	n (%)	n (%)	n (%)	p-value
Head	8/31 (26%)	10/32 (31%)	8/25 (32%)	8/31 (26%)	0.921	8/24 (33%)	7/28 (25%)	1/19 (5%)	8/21 (38%)	0.089
Neck	10/31 (32%)	8/32 (25%)	13/27 (48%)	12/31 (39%)	0.295	11/24 (46%)	6/28 (21%)	5/19 (26%)	4/21 (19%)	0.157
Shoulder	8/31 (26%)	9/32 (28%)	7/28 (27%)	11/31 (35%)	0.838	6/24 (25%)	9/28 (32%)	6/19 (32%)	4/21 (19%)	0.731
Elbow	1/31 (3%)	1/32 (3%)	4/25 (16%)	2/30 (7%)	0.199	0/24 (0%)	4/28 (14%)	5/19 (26%)	2/21 (10%)	0.065
Wrist	2/30 (7%)	3/32 (9%)	2/25 (8%)	3/30 (10%)	0.968	4/24 (17%)	4/28 (14%)	0/19 (0%)	2/21 (10%)	0.317
Upper back	4/30 (13%)	6/32 (19%)	4/25 (16%)	4/30 (13%)	0.923	0/24 (0%)	5/28 (18%)	2/19 (11%)	2/21 (10%)	0.196
Lower back	8/31 (26%)	7/32 (22%)	9/27 (33%)	10/30 (33%)	0.962	2/24 (8%)	5/28 (18%)	4/19 (21%)	3/21 (14%)	0.671
Hip	5/31 (16%)	2/32 (6%)	2/25 (8%)	3/30 (10%)	0.599	0/24 (0%)	3/28 (11%)	0/19 (0%)	1/21 (5%)	0.196
Knee	2/34 (6%)	5/32 (16%)	6/25 (24%)	2/30 (7%)	0.130	3/24 (13%)	8/28 (29%)	5/19 (26%)	2/21 (10%)	0.251
Feet	2/32 (6%)	5/32 (16%)	3/25 (12%)	5/30 (17%)	0.594	2/24 (8%)	4/27 (15%)	2/19 (11%)	4/21 (19%)	0.728

Table 3: The number of participants that reported musculoskeletal pain in the different body parts at baseline and post-test, with the three intervention groups collapsed. Reported as number participants reporting pain (n)/total number of participants (n), and percent (%). Differences from baseline to post-test, analyzed with McNemar`s test are presented with p-value.

Body part	Baseline n/n total (%)	Post-test n/n total (%)	p-value
Head	26/88 (29%)	16/71 (23%)	1.000
Neck	31/90 (34%)	22/71 (31%)	1.000
Shoulder	24/89 (27%)	21/71 (30%)	0.664
Elbow	6/88 (7%)	9/71 (13%)	0.063
Wrist	7/87 (8%)	8/71 (11%)	1.000
Upper back	14/87 (16%)	7/71 (10%)	0.227
Lower back	24/90 (27%)	11/71 (16%)	0.180
Hip	9/88 (10%)	3/71 (4%)	1.000
Knee	13/91 (14%)	16/71 (23%)	0.092
Feet	10/89 (11%)	8/70 (11%)	1.000

Table 4: Association between self-reported muscle pain (yes/no) and high (≥75%) versus low (<75%) adherence to exercise in all intervention groups analyzed together. Analyzed with chi-square test.

Body part	Yes/No	Low adherence n (%)	High adherence n (%)	p-value
Head	Yes	6 (23%)	6 (19%)	0.686
	No	20 (77%)	26 (81%)	
Neck	Yes	8 (31%)	9 (28%)	0.826
	No	18 (69%)	23 (72%)	
Shoulder	Yes	9 (35%)	10 (31%)	0.786
	No	17 (65%)	22 (69%)	
Elbow	Yes	3 (12%)	5 (16%)	0.654
	No	23 (88%)	27 (85%)	
Wrist	Yes	2 (8%)	5 (16%)	0.356
	No	24 (92%)	27 (84%)	
Upper back	Yes	1 (4%)	6 (19%)	0.083
	No	25 (06%)	26 (81%)	
Lower back	Yes	4 (15%)	5 (16%)	0.980
	No	22 (45%)	27 (84%)	
Hip	Yes	0 (0%)	2 (6%)	0.195
	No	26 (100%)	30 (94%)	
Knee	Yes	3 (12%)	9 (28%)	0.121
	No	23 (88%)	23 (72%)	
Feet	Yes	2 (8%)	3 (10%)	0.792
	No	24 (92%)	28 (90%)	

Paper III

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BodyPump versus traditional heavy load resistance training on changes in resting metabolic rate in overweight untrained women

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Title: BodyPump versus traditional heavy load resistance training on changes in resting metabolic rate in overweight untrained women

Running title: BodyPump and resting metabolic rate

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Key words: resting energy expenditure, respiratory exchange ratio, EPOC, group exercise, females

Abstract

BACKGROUND: Moderate to heavy load resistance training (RT) is advocated for overweight and obese individuals. One of the beneficial effects of RT is increased resting metabolic rate (RMR), which typically makes up the majority of the total daily energy expenditure. It is, however, unclear if low to moderate load RT affects RMR. Hence, the present study aimed to examine the effects of twelve weeks of BodyPump, on RMR in previous untrained women with BMI ≥25.0, and to compare the results with individual heavy load RT.

METHODS: Eighteen overweight women participated in the study (mean age 35.4 years ±10.2, BMI 30.4 kg/m^2 ±4.8), ten allocated to BodyPump (high-repetition, low to moderate load RT) and eight to heavy load RT (linear periodization with 3-6, 8-10 and 13-15 repetitions, 2-4 series) Both groups exercised 3 times/week for 12 weeks. RMR was assessed with indirect calorimetry at baseline, midway (after six weeks) and at post-test.

RESULTS: Adherence to exercise were 62% and 93% in the BodyPump and heavy load RT group, respectively (p=0.003). RMR in the BodyPump increased with 8.5% (±10.8) from baseline to post-test (p=0.041). The heavy load RT group increased 10.5% (±10.4) from baseline to post-test (p=0.025). There was no significant group difference in RMR from baseline to post-test (p=0.593).

CONCLUSIONS: BodyPump and heavy load RT resulted in a similar increase in RMR after 12 weeks of training. Assuming that elevation of RMR is important for combating overweight and obesity, BodyPump appears to have the same potential as heavy load RT.

Introduction

Worldwide almost 40% of women are classified as overweight (BMI ≤ 25.0) (1), and 15% as obese (BMI ≥ 30.0) (2). Dietary restrictions and physical activity are recommended in the prevention and treatment of overweight or obesity (3,4,5), but there are several long-term challenges in weight management. Loss of fat-free mass (FFM) and muscle mass is one common consequence during weight loss, which is correlated to decreased resting metabolic rate (RMR) (6). RMR is defined as the energy consumption required for maintaining normal physiological processes during rest, and makes up for 60-75% of our total daily energy expenditure (TDEE) (7,8). RMR varies between subgroups and individuals, based on e.g. physiological and genetic factors, gender, age, BMI and body composition (9). Thus, as much as 50-70% of the variability in RMR is found to correlate with the amount of muscle mass, highlighting the importance of regular resistance training (RT) in long-term prevention and treatment of obesity (7,8,10,11,12).

Today overweight and obese individuals are recommended to participate in whole body RT 2-3 times a week, with an intensity between 60-80% of one repetition maximum (1RM) (8-12 repetitions x 2-3 sets) (4). However, strengthening exercise sessions in groups, available in health- and fitness clubs, are popular RT options. BodyPump (BP) is worldwide the most exposed and high-visited group-training concept, with over 5 million participants weekly (13). This is a high-repetition RT session (800-1000 repetitions each one-hour session), with low- to moderate loads, guided by a LesMills certified instructor. According to the distributor regular BP exercise have several health benefits, e.g. increased muscle strength, muscular endurance and increased muscle mass (13). To our knowledge, only two previous studies have investigated long-term physiological benefits from BP (14,15), but none of these examined changes in RMR and/or included untrained and overweight or obese participants. In addition, we have not been able to find published studies comparing changes in RMR after BP or other strengthening group sessions, to traditional heavy load RT. Hence, the present study aimed to investigate changes in RMR after 12 weeks of BP (3 times/week) in former untrained women with BMI ≥ 25 kg/m^2, and to compare the results with traditional heavy load RT.

METHODS

Study design

This was subgroup-analysis from a four-armed randomized controlled trial (RCT) (16) investigating whether 12 weeks of BP can alter RMR in overweight women, compared to traditional heavy load RT. RMR was assessed before (baseline), midway and after the training intervention period (post-test).

Study population

A subgroup of twenty untrained, but healthy women (age 18-65) with BMI ≥ 25.0, participating in a RCT, were included in the present study. In total, 143 women were included in the RCT, and allocated to either a BP group, heavy load RT with a personal trainer, non-supervised heavy load RT or a non-exercising control group. A statistician performed block randomization, with an 8-persons block size in the RCT. All women allocated to the BP group and heavy load RT with a personal trainer received additional information about the present study, and were invited to participate. Ten women from each group volunteered, but two participants from the heavy load RT group dropped out because of illness, giving 18 participants in total (mean age 36.4 years (± 10.1), weight 83.6 (± 14.1), height 167.5 (± 6.2) and BMI 29.8 kg/m² (± 4.6). The present study included similar inclusion and exclusion criteria`s as the RCT study, see Rustaden et al 2017 (16) for more information. The study is registered in the Clinical Trial.gov Protocol Registration System (NCT01993953) and was approved by the National Commitee for Medical Research Ethics Norway, Oslo (REK 2012/783, approved 01.06.2012 by chairperson Stein A. Evensen). The procedures followed the World Medical Association Declaration of Helsinki, and all participants signed a written consent statement before entering the study.

Assessment procedures

RMR was assessed at baseline, after 6 weeks (midway through the intervention period) and at posttest (Fig. 1). All assessments were conducted in the laboratory at our university. The participants arrived at the laboratory between 7.00-9.00 am, after 12 hours fasting. At the midway- and posttest they had minimum ≥ 24 hours of rest following the last exercise session. All participants arrived the laboratory by car or public transportation, and were instructed to do as little physical activity as possible before the assessment. The same test-leader performed all assessments. A pilot study with three participants was performed ahead of the RMR assessment at baseline.

Fig. 1 about here.

Resting metabolic rate

RMR and respiratory exchange ratio (RER) was estimated by indirect calorimetry with a ventilated hood (Canopy-option for Oxycon Pro, Jaeger, Hoechberg, Germany). The test procedure started with 15 minutes of rest in supine position, before the oxygen uptake was measured each 30 second for 30 minutes. The hood was placed over the head after the first ten minutes of rest, to make sure that each participant was familiar with the equipment before assessment. The test lab was located in a quiet area, had dimmed light and the temperature was controlled between 22-24º Celsius. To ensure high validity, only the last 20 minutes were used for calculating RMR (17). The calorie equivalent used to estimate the energy expenditure was derived from each participant's RER (proportion of the different energy substrates used) and ranged from 4.68-5.04 kcal per LO_2 (18). Estimated RMR was calculated as RMR = calories each minute x 1440 (total minutes each 24 hour).

Heart rate

Resting heart rate (HR) was registered by a HR monitor (Polar RS800, Kempele, Finland). Mean HR was measured during the 15 minutes of rest in supine position prior to the RMR registration. Maximal HR was estimated using the following equation: 211 – 0.64 x age (19).

Body composition (muscle mass)

Body composition was assessed at baseline and posttest, using direct segmental multifrequency bioelectrical impedance Inbody720 (Body Composition Analyzer, Biospace Co., Ltd., Seoul, Korea). To obtain reliable measurements the assessment followed a standardized procedure, including overnight fasting (20). All participants arrived to the laboratory at NSSS between 7 and 9 am on test day. Body composition and RMR was assessed on separate days, but no more than three days between. The eight-polar Inbody separates adipose tissue and bone mass from other tissues in the body, leaving "lean body mass"(LBM) (20).

Maximal muscle strength

One-repetition maximum (1RM) was assessed in squat and bench press exercises at baseline and post-test. For a detailed description of the 1RM test protocol, see Rustaden et al 2017 (16).

Intervention

The participants were prescribed three exercise sessions (45-60 minutes) each week for 12 weeks, following their intervention group. The training sessions included similar exercises for both groups, but number of repetitions and duration of inter-sets rest periods differed (Table 1 and 2).

BodyPump

BP is a strengthening group fitness session, available in about 14 000 health- and fitness clubs worldwide (13). LesMills International distributes and pre-choreographs all BP sessions, and a new release comes out every third month. The concept is similar in all releases, but music and some details in the program varies. The session last in 55-60 minutes, and includes nine music tracks, each representing free-weight exercises for a particular muscle group or body part. The session includes about 800 repetitions in total, and is a full-body workout. The participants exercise with a step, a bar (1.25 kilos) and plates (1, 2.5 or 5 kilos) they can put together on the bar. Between each music track, there are a short rest period (approximately one minute), used to change the weights and/or prepare for the next track. A Les Mills certified instructor teach correct lifting technique throughout the session, and motivates the participants. They also give general recommendations of exercise intensity, but loads are primary self-selected. In the present study, participants in the BP group had free access to several local health- and fitness centers offering BP. During the intervention period release no.83 was present at all clubs worldwide (Table 1). The participants used a training diary to register exercise loads and training volume.

Table 1 about here.

Resistance training

The participants followed a standardized non-linear periodization program, with repetitions varying between 3-6, 8-10 and 13-15, series between 2-4 and inter-sets rest periods of 60-120 seconds (Table 2). The loads were RM. The participants exercised with their personal trainer in the gym at our university, and the same personal trainer was present during the whole intervention period. The personal trainers could not interfere with the training program (sets, reps, rest periods etc.) and were restricted to advise the participants to add appropriate loads and conduct the exercises with proper technique. They could also secure and verbally motivate the participants during the weightlifting exercises, while forced-repetitions were prohibited. The participants used a training diary to register the training volume. All personal trainers involved in the study was educated with a bachelor degree in physical activity and health, including a personal trainer certificate from the Norwegian School of Sports Sciences.

Table 2 about here.

Statistical analyzes

The study contains two independent variables: the two groups (between-subject variable) and the three different time-points (within-subject variable). Dependent variables are RMR and RER. First, a mixed between-within subject's analysis of variance was conducted and the interaction between the two variables was tested. If not found significant each factor was tested for significance in a two-way mixed model without interaction term. If the interaction was found to be significant, time effects were tested within each group variable with a pared-samples t-test, and group effects tested at each time points with an independent samples t-test. Effect size was calculated by partial eta-squared (0.01 = small effect, 0.06 = moderate effect and 0.14 = large effect) (21). A paired-samples t-test was conducted to analyze within group changes in muscle strength and body composition, since these two variables were analyzed at only two time-points (baseline and post-test). Relative changes between the groups in all variables (baseline to midway test and/or baseline to post-test) were analyzed with an independent t-test. Correlation analyzes were conducted using Pearson correlation coefficient. Level of significance was set at $p < 0.05$, and values are presented as means with standard deviations (±SD). All analyzers were conducted with SPSS version 24 (IBM Corporation, Route, Somers, NY, USA).

Results

Background characteristics

There were no group differences in anthropometric variables at baseline (Table 3). After six weeks of intervention and 18 possible exercise sessions, the RT group had significantly higher adherence (p=0.005) with 14 (±3) sessions, compared to 9 sessions (±3) in the BP group. Of totally 36 exercise sessions at post-test, adherence in RT was 34 (±7) (93%) and 22 (±6) (62%) in BP, respectively (p=0.003). Mean exercise intensity in the BP group was 12% (±4) of 1RM in squat and 17% (±7) in bench press, compared to 69% (±7) and 68% (±6) in the RT group, respectively.

Table 3 about here.

RMR

The mixed between-within subject ANOVA analyzed the impact of the two different exercise programs on the participants RMR across three time-points (baseline, midway and post-test). There was a significant interaction between the exercise programs and time (p=0.025) (eta-squared=0.39). In the BP group, RMR was unchanged from baseline to the midway test (-15.1 kcal, 95% CI -72.8 to 42.5, p=0.567). From baseline to post-test the group increased 8.5%, representing 114.9 kcal (95% CI 6.1 to 223.6, p=0.041). In the RT group, RMR increased 8.1% from baseline to the midway test with 114.0 kcal (95% CI 18.9 to 209.2, p=0.025) and 10.5% from baseline to the post-test with 154.7 kcal (95% CI 23.7 to 285.8, p=0.027). The independent samples t-test revealed significant group difference in changes from baseline to the midway test with 129.2 kcal (95% CI -45.8 to 129.2, p=0.012), but not from baseline to post-test (39.9 kcal, 95% CI 115.1 to 194.9, p=0.593). Figure 2 illustrates the individual variations in RMR during the intervention period in both groups.

Table 4 about here.

Figure 2 about here.

RER

The mixed between-within subject ANOVA found no significant interaction between the exercise programs and the three time-points (p=0.084) (eta-squared=0.28). There was a significant within-subject effect for time (p<0.005) (eta squared 0.64), with both groups showing increased RER across the three time-points (Table 5). The main effect for RER between the two groups was not significant (p=0.171) (eta squared=0.114).

RER in the BP group was unchanged from baseline to the midway test (0.004, 95% CI -0.045 to 0.053, p=0.859). From baseline to post-test the group decreased 11% (-0.100, 95% CI -0.160 to -0.040, p=0.005). In the RT group RER decreased 7% from baseline to the midway test (-0.063, 95% CI -0.105 to -0.012, p=0.010), and 7% from baseline to post-test (-0.055, 95% CI -0.095 to -0.015, p=0.014).

Table 5 about here.

HR

Mean HR (beats/min) was 64 (±7) and 63 (±6) at baseline, 66 (±8) and 66 (±9) at the midway test and 65 (±8) and 64 (±9) at post-test in the BP and RT groups, respectively. HR showed no significant within-subject effect for time (p=0.538) (eta squared 0.09), nor main effect between the two groups (p=0.862) (eta squared=0.00).

Body composition (muscle mass)

In the BP group estimated muscle mass was unchanged from baseline (28.8 kg ±3.2) to post-test (28.8 kg ±3.4) (0.01 kg, 95% CI -0.66 to 0.68, p=0.974). Similarly, the RT group demonstrated no changes: 30.4 kg (±3.6) at baseline and 30.8 kg (±4.0) at post-test (-0.44 kg, 95% CI -1.35 to 0.46, p=0.276). There was no differences in the relative changes from baseline to post-test between the two groups (-1.43 kg, 95% CI -4.69 to 1.84, p=0.367).

Maximal muscle strength

In 1RM bench press the BP group increased 4.9 kg (11%), from 38.9 kg (±6.5) at baseline to 42.8 kg (±6.8) at post-test (95% CI 2.1 to 5.8, p=0.001). In squat the group increased 16.5 kg (21%), from 82.5 kg (±12.7) to 99.0 kg (±15.2) (95% CI 9.0 to 24.0, p=0.001). The RT group increased 8.3 kg (20%) in bench press, from 41.1 kg (±6.0) to 49.3 kg (±8.3) (95% CI 4.6 to 11.9, p=0.001), and 34.7 kg (41%) in squat, from 86.6 kg (±15.5) to 121.3 kg (±23.1) (95% CI 20.5 to 48.8, p=0.001). The relative change between the groups was significant in both bench press (-9.5%, 95% CI -18.2 to -0.9, p=0.033) and squat (-20.4%, 95% CI -37.6 to -3.2, p=0.023).

Correlation

When analyzing all participants together, there was a positive correlation between RMR and estimated muscle mass at baseline (r=0.64, p=0.005; n=18) and at post-test (r=0.70, p=0.001; n=18). There was also a correlation between relative changes in RMR and changes muscle mass from baseline to post-tests (r=0.50, p=0.039; n=18).

Discussion

In the present study, we hypothesized that heavy load RT would result in larger increases in RMR than low/moderate load BP training. Contrary to our hypothesis, BP induced similar effects on RMR (8.5%) as heavy load RT (10.5%), during the 12-week intervention period.

RMR varies between individuals and is influenced by several factors, especially by age, sex and body composition (9). A recent review, including almost 400 publications, concluded that obese women have lower RMR values than normal weight women (9). They reported RMR in normal weighed middle-aged women to be 0.93 kcal/kg/hour (95% CI 0.91-0.95), while in obese women the values were 0.72 kcal/kg/hour (95% CI 0.68-0.76). In line with this, we assessed RMR at baseline to be 0.71 kcal/kg/hour. After the intervention period, the values were increased to 0.77 kcal/kg/hour. Thus, our female participants demonstrated RMR levels in the expected range.

The increased RMR in both our groups is in accordance with previous studies. A review from 2012 (22) concluded that inactive adults achieved about 7% increase in RMR after ten weeks of regular RT. Still, previous findings are inconsistent, probably due to factors such as exercise programs, diet restrictions, genetic factors and methodological issues. To exemplify, Kirk et al (23) reported a 7% increase in RMR, after six months of RT in 39 overweight men and women. The participants in Kirk et al performed low volume RT sessions that encompassed single sets of nine different exercises with an intensity of 3-6 RM, 3 times a week. In contrast, Geliebter et al (24) found a 7% decrease in RMR after eight weeks of RT (6-8 repetition, 3 set, 3 times/week) in 20 obese women (92 kg, 43% body fat) and men (114 kg, 38% body fat). However, in Geliebter et al the energy intake was restricted (70% of RMR) and the participants lost body weight (about 9 kg). In the present study, the participants were asked not to alter lifestyle or dietary habits, but we cannot rule out the possibility that some participants changed their energy intake or activity levels in addition to the training intervention. Indeed, at the group level, the body composition was stable, but large individual changes were found.

A meta-analysis from 2014 (25) compared muscular adaptations in low versus high load RT (≤60% vs ≥60% of 1RM) in untrained individuals, and concluded that both high and low intensity increased muscle strength and hypertrophy. In the present study, both groups showed significant within-group increase in maximal muscle strength, despite large differences in exercise load in our two groups. However, the RT group increased significantly more in both exercises compared to BP. In addition, in our mother study (16), changes in muscle strength compared to an inactive control group was the primary outcome, and only the RT group exercising with a personal trainer increased muscle strength. Interestingly, the similar response in RMR between our groups suggests that RMR in untrained women with BMI ≥ 25 respond to RT independently of exercise load (% of 1RM). If we assume that changes in muscle mass is relevant for changes in RMR (7,8,9,10,11,12), it is intriguing to note that both low and high load RT may induce equivalent skeletal muscle hypertrophy (25). In fact, we observed both a correlation between estimated muscle mass and RMR at baseline and after the intervention period, as well as a correlation between changes in estimated muscle mass and changes in RMR. This indicate that muscle mass is a relevant mechanism behind the changes in RMR. Still, changes in muscle mass was probably not the sole mechanism, as muscle mass did not increase at the group level, as did RMR. Furthermore, only the RT group increased RMR from baseline to the midway test. This could probably be explained by higher adherence to the training regime in the RT group, compared to the BP group. Thus, considering that the RT group increased RMR in only six weeks but not further during the next six weeks, it appears that the initial increase in RMR requires a certain numbers of RT sessions and then stabilizes. Such a time course of RMR changes also questions that increases in muscle mass is the only mechanism involved. Although controversial (9), increases in RMR could also be explained by hormonal changes (26), and a colder climate (27,28) and increases in brown adipose fat mass (9).

RER changed with the same time course as RMR, i.e. only the RT group decreased RER from baseline to the midway-test. However, both groups demonstrated a similar decrease in RER from baseline to posttest, indicating improved fat oxidation after both exercise modalities. This is consistent with previous literature (26,29). A RER close to 1.0 is associated with greater carbohydrate oxidation at rest, and potentially a higher risk in developing metabolic diseases, while a lower RER (close to 0.70) is associated with higher fat oxidation and lower risk to develop metabolic diseases (18).

The present study have limitations that needs addressing. Firstly, we did not control the participants' dietary intake or menstrual cycle during the intervention period. Secondly, we did not include a control group, and can therefore not control for other factors affecting the RMR, such as seasonal changes (27,28). Thirdly, the participants rested for a minimum of 24 hours from the last exercise session to assessing RMR after the intervention period. That might be too short to totally rule out the possibility of an influence of post-exercise oxygen consumption (EPOC) on the RMR and RER measurements (6,30). On the positive side, the present study reflected a real-life setting, with all exercise sessions performed at health- and fitness clubs, without any interference from the investigators. This gives our study high ecological validity (31). Moreover, our results are quite clear in that both low and high load RT may work well in increasing RMR, which could have an important effect over time in overweight and obese individuals.

In conclusion, 12 weeks of BP and heavy load RT in untrained overweight women resulted in 8.5% and 10.5% increase in RMR, respectively. With no group differences, low load BP seems to have the same potential to increase RMR and lower RER as heavy load RT. In that respect, both exercise modalities seems to be a viable alternative for overweight and obese untrained women.

Conflicts of interest statement

The authors have no conflicts of interest relevant to this article.

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Table 1: Exercise program BodyPump

Music nr.	Exercise	Volume (Reps)
1 Warming-up	Straight leg deadlift, rowing, shoulder press, squat, lounges and bicepscurl	88
2 Leg	Squat	95
3 Cheast	Bench press	80
4 Back	Rowing, stiff legged deadlift, clean & press and power press	75
5 Triceps	French press, tricepspress, pullover and overhead tricepspress	78
6 Biceps	Bicepscurl	68
7 Leg	Squat, lounges and squat jump	72+24 jumps
8 Shoulders	Push up, lateral raise, rowing and shoulderpress	76+36 push up
9 Stomach	Sit-ups, sit-ups to the side and side-plank	51+30 seconds

Table 2: Exercise program (exercises and training volume) resistance training.

Exercises	Training volume week 1-4	Training volume week 5-8	Training volume week 9-12
Squat	**Session 1**	**Session 1**	**Session 1**
Lounges	Reps: 8-10	Reps: 8-10	Reps: 8-10
Deadlift/deadlift with straight legs	Series: 2	Series: 2-3	Series: 3-4
	Break: 60 sec	Break: 60 sec	Break: 60 sec
Bent ower rows to chest			
	Session 2	**Session 2**	**Session 2**
Bench press			
	Reps: 13-15	Reps: 13-15	Reps: 13-15
Dips/kickback			
	Series: 2	Series: 2-3	Series: 3-4
Shoulder press/lateral raise	Break: 60 sec	Break: 60 sec	Break: 60 sec
Clean and press			
Triceps press	**Session 3**	**Session 3**	**Session 3**
Bicepscurl	Reps: 3-6	Reps: 3-6	Reps: 3-6
Sit ups	Series: 2	Series: 3	Series:4
	Break: 120 sec	Break: 120 sec	Break: 120 sec

*Loads were repetition maximum (RM)

Table 3: Background characteristics for all participants in the BodyPump (BP) group and the resistance training (RT) group. Differences between groups are presented with p-value.

Variable	BP	RT	p-value
Age (years)	36 ±10	34 ±11	0.655
Height (cm)	167 ±7	169 ±7	0.562
Body weight (kg)	85 ±14	87 ±16	0.744
BMI (kg/m^2)	30 ±5	30 ±5	0.967
Fat mass (%)	38 ±7	39 ±5	0.880
Fat free mass (kg)	52 ±5	53 ±6	0.640
Muscle mass (kg)	29 ±3	30 ±4	0.354
1RM squat (kg)	83 ±13	87 ±16	0.550
1RM bench press (kg)	39 ±7	41 ±6	0.469

Table 4: Resting metabolic rate (RMR) in the BodyPump (BP) group and resistance training (RT) group at baseline, midway and at 12 weeks post-test.

Assessment time-point	BP (n=10)	RT (n=8)
Baseline (kcal)	1447.3 (±203.3)	1431.6 (±137.7)
Midway (kcal)	1432.2 (±204.8)	1545.6 (±170.8)*
Post-test (kcal)	1562.2 (±231.4)*	1586.3 (±251.6)*

*Significant (p≥0.005) compared to baseline

Table 5: Respiratory exchange ratio (RER) in the BodyPump (BP) group and resistance training (RT) group at baseline, midway and at 12 weeks post-test.

Assements time-point	BP (n=10)	RT (n=8)
Baseline	0.86 (±0.74)	0.83 (±0.57)
Midway	0.87 (±0.13)	0.77 (±0.33)*
Posttest	0.76 (±0.45)*	0.78 (±0.49)*

*Significant ($p \geq 0.005$) compared to baseline

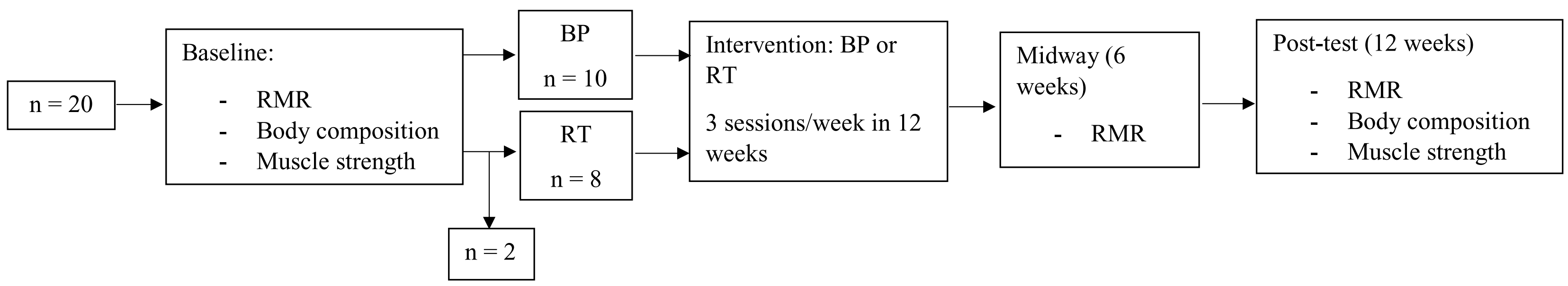
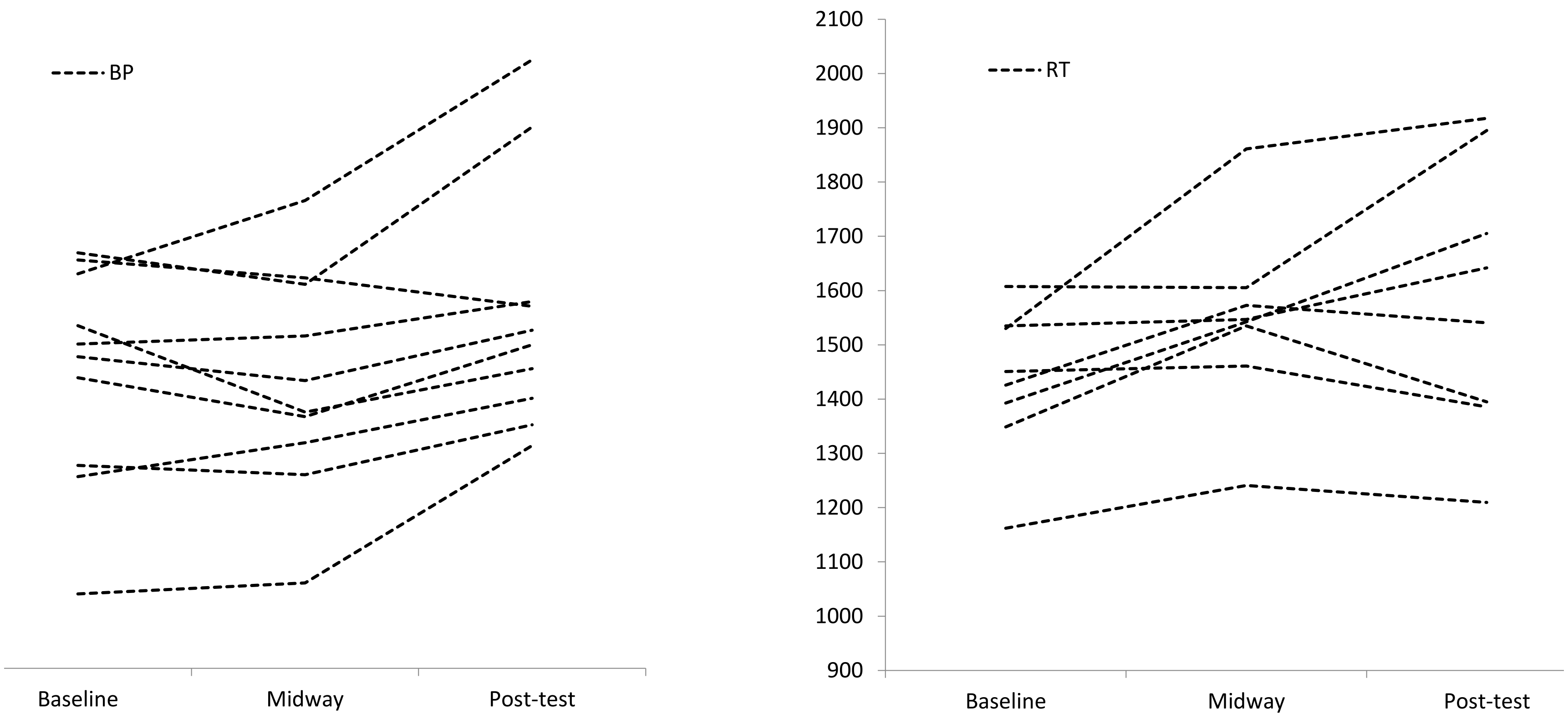


Figure 1: Study overview for the BodyPump (BP) group and the resistance training (RT) group.



igure 2: RMR (kcal) at baseline, midway in the intervention period (6 weeks) and at post-test (12 weeks) in the BodyPump (BP) and resistance training (RT) roup. Each dashed line indicate each participant.

Paper IV

Total workload and energy expenditure during BodyPump versus heavy load resistance training in overweight women.

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Key words: resting metabolic rate, RMR, EPOC, group exercise

Abstract

Purpose: High-repetition, low-load resistance training conducted in a group class setting has gained popularity in recent years, with BodyPump as a primary example. A major aim for this exercise mode is to “burn calories”, and the purpose with the present study was to estimate total exercise workloads and energy expenditure during a single BodyPump session in overweight women (BMI≥25.0). Moreover, we compared these outcomes with a time-matched session of heavy load resistance training.

Method: Eighteen women participated in the study (mean age 35.4 years ±10.2, BMI 30.4 kg/m^2 ±4.8), ten exercising BodyPump (50-100 repetitions each muscle group) and eight heavy load resistance training (8 repetition maximum x 3 sets). Exercise workloads were estimated by multiplying repetitions x sets x load (kg) in all exercises, and energy expenditure during the sessions was assessed with indirect calorimetry. Resting metabolic rate (RMR) was estimated before and twice after the sessions (0-20 and 120-140 min).

Results: The BodyPump group lifted significantly more loads than the heavy load group (19485 kg ±2258 vs 15616 kg ±2976, p=0.006), while energy expenditure was similar with 302 kcal ±67 and 289 kcal ±69 in BodyPump and heavy load group, respectively (p=0.69). With no group differences, RMR after exercise (120-140 min) increased 22% compared to before exercise after BodyPump, and 15% after heavy load resistance training.

Conslusion: A single BodyPump session resulted in higher total workloads compared to heavy load resistance training. With no group differences, energy expenditure during the exercise modalities was approximately 300 kcal.

Introduction

During the last three decades the worldwide prevalence of overweight (BMI ≥ 25.0 kg/m^2) and obese (BMI ≥ 30.0 kg/m^2) individuals have increased almost 30%, and in 2013 nearly 40% of all women were classified as overweight (Ng., 2013). Today, resistance training is part of the physical activity recommendations in overweight and obese individuals (2-3 times/week, 60-80% of one repetition maximum [1RM], 2-3 sets), together with endurance exercise (225-420 min/week with moderate intensity to achieve weight loss and 150-250 min/week with an energy expenditure of 1200-2000 kcal/week to prevent weight gain) (Donnelly et al., 2009). In general, resistance training is found insufficient to promote a clinically significant weight reduction as a sole exercise mode (Donnelly et al., 2009). However, resistance training can be conducted in several ways, and in the health- and fitness industry, many strengthening group concepts are claimed to be especially effective in altering body composition and reduce body weight, e.g. BodyPump (see below). Thus, in order to increase our knowledge of prevention strategies and treatments of overweight and obesity, we need to investigate popular resistance training modalities with scientific methods.

Health- and fitness clubs offer different strengthening group concepts, and BodyPump is the most recognized group-training concept worldwide (distributed from Les Mills International). Globally, almost 15 000 health- and fitness clubs offers BodyPump, and weekly over 5 million participants take part in a session (Les Mills International). BodyPump is based on the "rep-effect", meaning that muscles are being exhausted by a high number of repetitions with low-loads, and thereby provoke a strong motoneuron recruitment in the fatigued state (Burd, Mitchell & Churchward-Venne, 2012). Thus, each one-hour session includes 800-1000 repetitions, with low- to moderate loads, involving free-weights exercises for the whole body.

According to LesMills, BodyPump is for anyone who wants to "get leaned, toned and fit – fast", and each session intend to burn up to 540 kcal (LesMills International).

To establish total energy expenditure or thermal effects from exercise, both energy expenditure during exercise and the elevated oxygen expenditure at rest after exercise (EPOC) needs to be considered (Binzen, Swan & Manore, 2001; Sedlock, Fissinger, Melby, 1989). In two previous studies investigating energy expenditure during a session of BP (Berthiaume, Lalande-Gauthier & Chrone, 2015; Stanforth, Stanforth & Hoemeke, 2000), EPOC or resting metabolic rate (RMR) after exercise were not assessed, and both studies included normal weighed and trained men and women. None of these studies found energy expenditure close to the claimed benefits from LesMills, with 265 kcal (±60) in Stanforth et al (Stanforth et al., 2000) and 250 kcal (±68) kcal in Berthiaume et al (Berthiaume et al., 2015).

As BodyPump is such a high-visited group session, with high energy expenditure as one of the highlighted benefits, the present experimental study aimed to evaluate total exercise workload and energy expenditure, from a single BodyPump session in overweight women. In addition, the study aimed to compare the outcomes to a time-matched session of traditional heavy load resistance training in accordance with the recommendations (Donnelly et al., 2009). Based on the high number of repetitions during a BodyPump session, we hypothesized that both total workload and energy expenditure would be higher in BodyPump, compared to heavy load resistance training.

Methods

Study design and participants

In this independent experimental study, participants were recruited from an on-going randomized controlled trial (RCT) (Rustaden, Haakstad & Paulsen, 2017). The RCT study aimed to investigate the effect on muscle strength and body composition after 12 weeks of BodyPump, heavy load resistance training with a personal trainer and non-supervised heavy load resistance training, in overweight and obese women. Based on power calculations in the RCT study (see Rustaden et al., 2017), 37 and 35 women were allocated to the BodyPump group and heavy load resistance training group (RT), respectively. All these women were informed about the present study, and invited to participate. Totally ten women from each study group volunteered, and were included. Because of illness, two participants from the RT group dropped out, giving 18 participants in total (mean age 36.4 years ±10.1, weight 83.6 kg ±14.1, height 167.5 cm ±6.2 and BMI 29.8 kg/m² ±4.6). Inclusion criteria`s were BMI ≥ 25.0, age 18-65 and being untrained defined as "not performing regular structured exercise ≥ twice a week" before entering the RCT study. Participants were excluded if they had diseases or injuries being contraindicated for strength tests and resistance training, pregnancy, obesity surgery or psychiatric diseases (see Rustaden et al 2017 for more details). The study was approved by the Regional Committee for Medical Research Ethics Norway, Oslo (REK 2012/783). All participants signed a written consent statement before entering the study, and the procedures followed the World Medical Association Declaration of Helsinki.

Measures

An indirect calorimetry (Oxycon Pro, Jaeger, Hoechberg, Germany) was used to assess energy expenditure during the sessions and RMR before and twice after the sessions (0-20 min and 120-140 min). At the testing day, participants arrived to the laboratory early in the morning, after 12 hours fasting. To ensure high reliability, intake of caffeine and nicotine the hours before testing was prohibited, the participants were instructed to use car or public transportations to the laboratory and physical activity or exercise was prohibited 48 hours before the test day. The test procedure started with assessment of resting metabolic rate (RMR) between 07.45 - 8.30 am, followed by a standard breakfast with a caloric content equivalent to 20% of the individual`s estimated RMR. The exercise sessions took part between 9.00 and 10.00 am. Immediately after the exercise session the participants laid down in supine position and acute RMR (0-20 min) was assessed. RMR was estimated as change of resting VO_2 during 20 minutes. Finally, the women were given a standardized lunch (10.30 am), and then rested in a seated position until assessment of 2-hour RMR (120-140 min) (12.00-12.30). In total, the testing procedure lasted approximately four hours. A pilot study with three representative individuals was performed before commencing the study, to ensure the time schedule.

Total workload

The workload was calculated by multiplying the amount of weights lifted in each exercise (kg) x repetitions x sets in the current exercise programs. The test leader registered load in all of the exercises, and controlled the number of repetitions and sets. Since all participants were overweight or obese, part of the body weight were included when summarizing total workload in exercises involving body weight. In squat and lounges 90% of each participant`s body weight were included, in push-ups 65%, dips 50% and in sit-ups 40%.

Resting metabolic rate (RMR)

RMR was estimated by indirect calorimetry with a ventilated hood (Canopy-option for Oxycon Pro). All participants started with 15 minutes of rest in supine position followed by a 30 minutes measurement of oxygen uptake (VO_2) and expired carbon oxide (VCO_2). The test lab was quiet, had dimmed light and the temperature was controlled between 22-24º Celsius. To ensure valid measurements, the last 20 minutes were used for calculating RMR (Compher, Frankenfield & Keim., 2006). The calorie equivalent used to estimate energy expenditure was derived from each participant's respiratory exchange ratio (RER) and ranged from 4.68-5.04 kcal per liter oxygen (LO_2) (McArdle, Katch & Katch, 2010). The energy expenditure was calculated as calories each minute = VO_2 ($Lmin^{-1}$) x kcal per LO_2. Estimated RMR was calculated as RMR = calories each minute x 1440 (total minutes each 24 hour).

Energy expenditure

Energy expenditure during the workouts were registered with the same indirect calorimetry. The participants breathed through a Hans Rudolph mask (US) – covering both mouth and nose – attached to a three-meter long non-rebreathing hose. VO_2 was measured from two minutes before exercise, and expired air/gases were continuously sampled each 30 second during the whole exercise sessions. After the training session, the participants rested for five minutes, with the equipment in place. Prior to each test, all analyzers were calibrated after the manufacturers' guidelines. The gross energy expenditure was calculated as O_2 consumption using the formula (LO_2) x 5 kcal (McArdle et al., 2010).

Indirect calorimetry is a valid assessment method when estimating energy expenditure (Compher et al., 2006), and the Oxycon Pro is found to be an accurate and valid system to assess respiratory values as VO_2, VCO_2 and RER (Carter & Jeukendrup, 2012; Rietjens, Kuipers & Kester, 2001). Compared to Douglas bag, Oxycon Pro have shown a coefficient of variation between 4.7-7.0% (Carter et al., 2012), when standard recommendations are followed.

Heart rate

Heart rate (HR) was registered by using a HR monitor (Polar RS800, Kempele, Finland) during the exercise sessions. Maximal HR was estimated: 211 – 0.64 x age (Nes, Janszky & Wisloff, 2013).

Exercise protocols

The participants conducted either a session of BodyPump (Table 1) or heavy load resistance training (Table 2), based on their intervention group in the RCT study. A personal trainer was present during all sessions to ensure proper lifting technique and assist if necessary, but did not interfere with the training.

BodyPump

BodyPump is a high-repetition low-to moderate group session, prechoreographed and distributed by LesMills International. Every third month LesMills releases a new BodyPump program, all based on the same concept (LesMills International). During the intervention period in the RCT study, BodyPump release no. 83 was present at all health- and fitness clubs, including nine music tracks (4-7 minutes), each exercising specific body parts. Each session include approximately 800 repetitions in total, and 50-100 repetitions in each muscle group. The participants exercise with a step and free-weights (1, 2.5 or 5 kg), which they put together on a 1.25 kg bar. Between each track, there is a short rest period of approximately one minute, used to change weights and prepare to the next exercises. Some of the tracks includes short inter-session rest periods (typically 16-32 beats and 7-14 seconds) (LesMills International). In the present study, participants were instructed from a LesMills DVD during assessment of energy expenditure. They were all familiar with the exercise program, as assessments were conducted midway into the RCT study. Workloads were specified based on the instructions, and their experience from the first six weeks of exercise. The DVD-instructor encouraged the participants to achieve muscular fatigue in each track, with proper lifting technique.

Resistance training

In the present study the RT group performed session one from week 5-8 in the RCT (Rustaden et al., 2017), including 8RM x 2-4 sets, and 60 and 45 seconds rest between sets and the exercises, respectively (Table 2). The participants selected workload based on their experience from the previous sessions in the RCT, noted in their training diary.

Statistical analysis

Data are presented as means with standard deviation (±) for all variables, and all measurement points were analyzed in Excel. The data had a normal distribution and an independent t-test was used to compare between-group differences in total workload and energy expenditure during the sessions. A mixed between-within subject's analysis of variance assessed the impact of the two different exercise programs on O_2 ml/kg, RMR (20 min), HR (beats/min) and RER at the three assessment time points. Analyzes were conducted with SPSS Statistical Software version 21 (IBM Corporation, Route, Somers, NY, USA). Level of significance was set at $p \leq 0.05$.

Results

There were no significant differences in demographic variables between the two experimental groups (Table 3). Mean duration of the BodyPump and RT session was 53.0 min (±0.0) and 55.7 min (±2.9), respectively (p=0.033).

Including both external loads and part of the body mass, the BodyPump group lifted significantly more loads (19 485 kg ±2 258) than the RT group (15 616 kg ±2 976) (p=0.006). Load lifted per minute was also significantly higher in BodyPump than RT (p=0.001), with 368 kg (±43) and 280 kg (±50), respectively. Based on the participants 1RM tests at baseline in the RCT study (Rustaden et al., 2017), the relative loads (% of 1RM) in the BodyPump group were estimated to 14% (±2.8) and 18% (±2.6) in squat and bench press, respectively. The relative loads in the RT group were 77% (±16.5) in squat and 80% (±8.0) in bench press, which were significantly higher than the BodyPump group (both $p \leq 0.001$).

The estimated total energy expenditure during exercise was not significant different between the groups (p=0.69) with 302 kcal (±67) during BodyPump and 289 kcal (±69) during RT (Table 4). The individual range was 170-378 kcal in BodyPump and 169-347 kcal in RT.

There were no statistically significant differences between the exercise modalities in RMR 0-20 min or 120-140 min after exercise (Table 5). Oxygen uptake (O_2 ml/min), RER, RMR and HR were assessed at supine rest for 20 min before exercise, immediately after (0-20 min) and 120-140 min after exercise. The mixed between-within subject's analysis of variance revealed no significant interaction effect between the groups. In both groups, there was a significant effect for time ($p<0.005$), but the main effect comparing the two groups was not significant (Table 5). RMR increased 29% from before exercise to immediately after exercise, and 22% from before exercise to 2 hours after exercise in the BodyPump group ($p<0.01$). For the RT group changes in RMR were 33% and 15% before to immediately after and before to 2 hours after exercise, respectively ($p<0.01$).

Discussion

To our knowledge, this is the first study to compare total workloads and energy expenditure from a single session of BodyPump, with traditional heavy load RT in overweight women. The BodyPump participants lifted significantly more loads (kg) than the RT group. Nevertheless, energy expenditure during the workouts were about 300 kcal and similar in the two exercise modalities. Compared to before exercise, the RMR values 2 hours after exercise were increased by 22% in the BodyPump group and 15% in the RT group.

The higher total workload in BodyPump, compared to the RT group, was due to the high number of repetitions and fewer and shorter rest periods. The BodyPump program included approximately 800 repetitions, and totally ten minutes of rest. In comparison, the RT program included 248 repetitions, and approximately 28 minutes of rest. Thus, the similar energy expenditure might be due to lower mechanical work efficiency (higher energy expenditure per kg lifted) and/or larger range of motions in RT. The BodyPump participants had to keep up with the choreography and music, which means a faster lifting pace than in traditional resistance training. This might have resulted in smaller range of motions, and consequently, less energy used per repetition. In comparison, the RT group performed all exercises with controlled lifting speed close to concentric failure (4-6 seconds each repetition). In correspondence with the VO_2-measurements, mean HR was similar between the two exercise modalities (142 beats/min in BodyPump and 146 beats/min in RT). The estimated relative intensities (HR_{max}) were 76% and 77% in BodyPump and RT, respectively, which indicate a similar cardiovascular stress. This also correspond with Oliveira et al (Oliveira et al., 2009), who investigated the physiological profile during a BodyPump session, and found HR_{max} to be 78% and 84%, during the tracks involving the largest muscle groups. Rixon et al (Rixon, Rehor & Bemben, 2006) investigated energy expenditure in normal weighed women during four different aerobic concepts, and found that 60 minutes of bodycombat, step-aerobics, indoor-cycling and aerobic pump with resistance exercises resulted in 8-10 kcal/min and moderate to high intensity (55-89% of HR_{max}). Compared to Rixon et al (Rixon et al., 2006), our participants - in both the BodyPump group (4.7 kcal/min ±1.2) and RT group (4.0 kcal/min ±1.0) - exercised with approximately half of the energy expenditure per unit time. Furthermore, according to the ACSM position stand (Donnelly et al., 2009), physical activity with moderate intensity, resulting in energy costs between 1200-2000 kcal/week is recommended to prevent weight gain or give a moderate weight loss al (Donnelly et al., 2009). Based on observations in the current study, three weekly sessions of BodyPump, would at best contribute to merely half of this recommendations. Indeed, in our RCT study, body composition was unchanged after 12 weeks of BodyPump in the same study population (Rustaden et al., 2017).

Total energy expenditure during BodyPump was somewhat higher in the present study, compared to previous findings. Stanforth et al (Stanforth et al., 2000) and Berthiaume et al (Berthiaume et al., 2015) investigated physiological responses during a BodyPump sessions in 30 and 40 trained men and women, respectively. Total energy expenditure in Stanforth et al was 265 kcal (±60), and women only 214 kcal (±26). Berthiaume et al reported 250 kcal (±68) in both genders, and 202 kcal (±38) in the female participants (assessed with SenseWear armband), not O_2 uptake. Higher body mass in our participants could explain the discrepancy in energy expenditure, compared to these two studies. Since body mass makes up most of the load in exercises such as squats and lounges, our overweight participants probably used more energy per repetition as they were about 23 kg heavier than the normal weight women in the Stanforth study. Berthiaume et al did not report the participants body weight, but mean BMI in their female participants were 22.7 kg/m^2 (±2.2), compared to 30.3 kg/m^2 (±4.7) in our women exercising BodyPump. In addition, the assumption is further supported by differences in exercise intensity. Our women exercised with a relative intensity of 76% of HR max (mean 142 beats/min,) compared to 63% of HR max (mean 124 beats/min) in the Stanforth study. HR was not reported in Berthiaume et al. Different assessment methods may also explain some of the differences in exercise intensity. Anyhow, the findings of the previous and present studies together indicate that, the energy expenditure is well below the energy costs (540 kcal) claimed by LesMills (LesMills International). Interestingly, Bertiaume et al asked their participants of perceived energy expenditure after the session, and both men and women overestimated the measured energy expenditure by 50% and 84%, respectively (Berthiaume et al., 2015). This emphasizes the importance of informing the public about realistic expectations to energy expenditure during exercise modes as BodyPump.

Even if the bulk of energy expenditure occurs while exercising, an increased RMR after exercise may contribute to a higher daily energy expenditure, and is therefore assumed relevant for weight management (Borsheim & Bahr 2003). The present results indicate elevated RMR due to EPOC after both BodyPump and RT (0-20 min and 120-140 min after exercise), with values in line with similar studies (Borsheim & Bahr 2003; LaForgia, Withers & Gore 2006). Based on similar changes in BodyPump and RT, we suggest that the EPOC was more related to the cardiovascular stress and muscular energy turnover than the mechanical loading (i.e., differences in exercise load). Indeed, as concluded by several authors, the magnitude and duration of EPOC after exercise seem highly correlated to cardiovascular intensity, expressed as % of HR_{max} or % of VO_{2max} (Borsheim & Bahr 2003; Haltom, Kraemer & Sloan, 1999; LaForgia et al., 2006; Paoli et al., 2012; Schuenke, Mikat & McBride, 2002). In contrast to our findings, Thornton & Potteiger (Thornton & Potteiger 2002) found similar acute energy expenditure, but greater EPOC in a high-load resistance training group (85% of 8RM) than a low-load resistance training group (45% of 8RM). Interestingly, Thornton & Potteiger reported higher cardiovascular stress and muscular energy turnover rates in the high-load group, as judged by HR and blood lactate, respectively (Thornton & Potteiger 2002). Thus, this could explain the higher EPOC in the high-load group. In our study, BodyPump (low load) compensated for lower loads with more repetitions and shorter inter-set rest periods, and thereby eliciting similar cardiovascular and muscular stress as RT (high load). Of note, our participants were all accustomed to the training sessions before assessment in this study. This is in contrast to most other studies on EPOC, where the participants conducted the exercise session for the first time. Unaccustomed resistance training may lead to some exercise-induced muscle damage, which again may affect the EPOC values (Borsheim & Bahr 2003; Hackney, Engels & Gretebech, 2008; Haltom et al., 1999; LaForgia et al., 2006; Paoli et al., 2012; Schuenke et al., 2002; Thornton & Potteiger 2002). This is a weakness in many other studies as exercise-induced muscle damage will decrease drastically after only one session (McHuge, 2003), thus, the EPOC assessed after the initial session will overestimate the EPOC in following exercise sessions.

EPOC was still present during our last assessment period (120-140 min after exercise), meaning that we did not capture the total magnitude from EPOC. We can therefore not be sure there were no group differences at later time-points. Furthermore, we did not include a control day without exercise. Thus, we cannot claim that the EPOC assessed was only due to the exercise sessions. The RMR after exercise may have been affected by two light meals and time of day per se (Borsheim & Bahr 2003). However, Haugen, Melanson & Tran (2003) found that repeated morning and evening assessments of RMR were stable and highly correlated with only 6% variability. Thus, these design weakness should not interfere with the main purpose with the present study, to compare BodyPump against heavy load resistance training.

Conclusions

A single BodyPump session resulted in higher total workload, compared to a time matched session of heavy load resistance training in overweight women. However, both exercise modalities resulted in an energy expenditure of approximately 300 kcal, representing no group difference.

What does this article add?

This article suggests that overweight women can expect similar energy expenditure from resistance training, despite of total workload and number of repetitions during the session. In addition, our findings complement previous published studies; expected energy expenditure during resistance training is somewhat low.

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Conflicts of interest statement

The authors have no conflicts of interest relevant to this article.

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department of Sports Medicine, Oslo, Norway.

Ethics

The study is approved by the Regional Committee for Medical Research Ethics Norway, Oslo (REK 2012/783).

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Table 1: Exercise program for the BodyPump group.

Music no.	Exercise	Volume (reps)
1 Warming-up	Straight leg deadlift, rowing, shoulder press, squat, lounges and biceps curl	88
2 Leg	Squat	95
3 Cheast	Bench press	80
4 Back	Rowing, stiff legged deadlift, clean & press and power press	75
5 Triceps	French press, triceps press, pullover and overhead triceps press	78
6 Biceps	Biceps curl	68
7 Leg	Squat, lounges and squat jump	72+24 jumps
8 Shoulders	Push-up, lateral raise, rowing and shoulder press	76+36 push up
9 Abdominals	Sit-ups, sit-ups to the side and side-plank	51+30 seconds

Table 2: Exercise program for the resistance training group.

Exercise	Volume (sets x reps)
Squat	3 x 8
Lounges	4 x 8
Stiff-legged deadlift	3 x 8
Forward rowing	3 x 8
Bench press	3 x 8
Dips	2 x 8
Shoulder press	2 x 8
Lateral raise	2 x 8
Clean & press	2 x 8
Triceps press overhead	2 x 8
Biceps curl	2 x 8
Sit-ups	3 x 8

Table 3: Demographic data of all participants in the BodyPump group (BP) and the resistance training group (RT). Presented as mean with standard deviation (±) and differences between groups with p-value.

Variable	BodyPump (n = 10)	RT (n = 8)	p-value
Age (year)	36.4 ±9.9	34.1 ±11.0	0.651
Weight (kg)	84.7 ±13.5	87.1 ±16.4	0.744
Height (cm)	167.1 ±6.6	168.9 ±6.7	0.562
BMI (kg/m²)	30.3 ±4.7	30.5 ±5.3	0.967
Fat mass (%)	38.1 ±7.4	38.6 ±5.2	0.275
Muscle mass (kg)	28.8 ±3.2	30.4 ±3.6±	0.270

Table 4: Details from the exercise sessions. Presented as mean with standard deviation (±) and p-value showing differences between the BodyPump and resistance training (RT) group.

Variable	BodyPump (n=10)	RT (n = 8)	p-value
O_2 (ml/min/kg)	12.3 ±2.7	12 ±2.0	0.779
RER	0.96 ±0.0	0.94 ±0.0	0.373
Heart rate (beats/min)	142 ±16	146 ±13	0.592
Kcal/min	4.7 ±1.2	4.0 ±1.0	0.200
Total energy expenditure (kcal)	302 ±67	289 ±69	0.696

Table 5: Variables from RMR before exercise, after exercise acute (0-20 min) and after exercise 2 hours (120-140 min) in the BodyPump and resistance training (RT) group. Presented with mean values and standard deviation (±). Interaction between the groups, substantial main effect for time in the two groups and main effect comparing the two groups are shown with p-value and partial eta squared (pes).

Variable	Before exercise		After exercise 0-20 min		After exercise 120-140 min		Interaction	Time	Between groups
	BodyPump	RT	BodyPump	RT	BodyPump	RT	p-value (pes)	p-value (pes)	p-value (pes)
O_2 ml/kg	2.3 ±0.4	2.6 ±0.4	3.0 ±0.5	3.4 ±0.5	3.0 ±0.4	3.0 ±0.7	0.240 (0.17)	<0.0005 (0.75)	0.336 (0.06)
RER	0.87 ±0.13	0.77 ±0.03	0.78 ±0.04	0.75 ±0.04	0.84 ±0.05	0.81 ±0.07	0.473 (0.11)	<0.0005 (0.70)	0.076 (0.21)
RMR kcal	19 ±4	21 ±2	25 ±4	29 ±4	24 ±4	25 ±5	0.194 (0.20)	<0.0005 (0.78)	0.181 (0.11)
HR (beats/min)	65 ±8	66 ±9	89 ±10	93 ±8	72 ±10	72 ±11	0.474 (0.10)	<0.0005 (0.96)	0.751 (0.01)

Appendix 1

Approval letter from the from the Regional Committees for Medical Research Ethics

REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK sør-øst	Gjøril Bergva	22845529	01.06.2012	2012/783/REK sør-øst D
			Deres dato:	**Deres referanse:**
			24.04.2012	

Vår referanse må oppgis ved alle henvendelser

Til Anne Mette Rustaden

2012/783 BodyPump og Personlig Trening

Vi viser til søknad om forhåndsgodkjenning av ovennevnte forskningsprosjekt. Søknaden ble behandlet av Regional komité for medisinsk og helsefaglig forskningsetikk (REK sør-øst) i møtet 10.05.2012. Vurderingen er gjort med hjemmel i helseforskningsloven § 10, jf. forskningsetikklovens § 4.

Prosjektleder: Anne Mette Rustaden
Forskningsansvarlig: Norges Idrettshøgskole

Prosjektomtale
Treningssenterbransjen har økt betraktelig både internasjonalt og nasjonalt de siste 20 årene, og med denne utviklingen har det kommet mange gruppetreningskonsepter, som blant annet BodyPump. BodyPump er styrketreningskonsept i sal med instruktør og musikk. Formålet med prosjektet er å undersøke styrkeeffekt og endring i kroppssammensetning for inaktive kvinner mellom 18-65 år med en BMI over 25 etter 14 ukers trening med BodyPump, sammenlignet med en inaktiv kontrollgruppe. Studien vil også måle energiforbruket under én økt med BodyPump. Samtidig vil prosjektet undersøke styrkeeffekt og endring i kroppssammensetning hos en gruppe som trener med, respektive uten, personlig trener.

Det skal inkluderes 140 inaktive kvinner i aldersgruppen 18-65 år med BMI over 25. Deltagerne randomiseres til til èn av fire grupper: 1) Styrketrening i sal med instruktør (BodyPump), 2) Styrketrening med personlig trener (PT) tilstede ved hver økt, 3) Styrketreningsprogram av veileder, men må trene på egenhånd, 4) Inaktiv kontrollgruppe.

Data omfatter blodprøver, styrketester og måling av kroppssammensetning (måles ved Dual-energy X-ray absorptiometry som gir en beskjeden stråledose), spørreskjema (demografiske variabler, subjektivt opplevd helse, motivasjon for fysisk aktivitet, røyk/alkoholforbruk, ryggsmerter osv). Blodprøvene vil analyseres innen 3 måneder og deretter destrueres. Samtykke innhentes for alle data.

Vurdering
Komiteen har vurdert søknaden, og har ingen innvendinger mot at prosjektet gjennomføres.

Spørreskjemaet som skal benyttes er ikke vedlagt, og det oppgis i søknaden at skjemaet vil sendes inn for godkjenning ved neste frist. Komiteen gjør oppmerksom på at spørreskjemaet skal godkjennes av komiteens leder før studien igangsettes.

I informasjonsskrivet står det at blodprøver skal oppbevares i en forskningbiobank ved NIH. I e-post av 07.05.2012 presiserer prosjektleder at blodprøvene skal analyseres innen tre måneder og deretter destrueres. Det vil derfor ikke være aktuelt med oppbevaring i forskningsbiobank, og informasjonsskrivet må revideres i henhold til dette.

På bakgrunn av dette setter komiteen følgende vilkår for prosjektet:
- Spørreskjema skal ettersendes og godkjennes av komiteens leder før studien settes i gang.
- Informasjon om oppbevaring av blodprøver i forskningsbiobank må tas ut av informasjonsskrivet.

Vedtak
Prosjektet godkjennes under forutsetning av at ovennevnte vilkår oppfylles.

I tillegg til vilkår som fremgår av dette vedtaket, er godkjenningen gitt under forutsetning av at prosjektet gjennomføres slik det er beskrevet i søknad og protokoll, og de bestemmelser som følger av helseforskningsloven med forskrifter.

Tillatelsen gjelder til 31.12. 2015. Opplysningene skal deretter slettes eller anonymiseres, senest innen et halvt år fra denne dato.

Forskningsfilen skal lagres avidentifisert, det vil si adskilt i en nøkkel- og en opplysningsfil.

Forskningsprosjektets data skal oppbevares forsvarlig, se personopplysningsforskriften kapittel 2, og Helsedirektoratets veileder for «Personvern og informasjonssikkerhet i forskningsprosjekter innenfor helse og omsorgssektoren».

Dersom det skal gjøres vesentlige endringer i prosjektet i forhold til de opplysninger som er gitt i søknaden, må prosjektleder sende endringsmelding til REK.

Prosjektet skal sende sluttmelding på eget skjema, senest et halvt år etter prosjektslutt.

Komiteens vedtak kan påklages til Den nasjonale forskningsetiske komité for medisin og helsefag, jfr. Helseforskningsloven § 10, 3 ledd og forvaltningsloven § 28. En eventuell klage sendes til REK sør-øst D. Klagefristen er tre uker fra mottak av dette brevet.

Vi ber om at alle henvendelser sendes inn via vår saksportal: http://helseforskning.etikkom.no eller på e-post til: post@helseforskning.etikkom.no.

Vennligst oppgi vårt referansenummer i korrespondansen.

Med vennlig hilsen

Stein A. Evensen
Professor dr. med.
leder

Gjøril Bergva
Rådgiver

Kopi til: turid.sjostedt@nih.no; postmottak@nih.no

Hei

Viser til henvendelse og vedlagt spørreskjema, mottatt 19.06.2012, i forbindelse med ovennevnte prosjekt. Spørreskjemaet er godkjent av komiteens leder, Stein A Evensen. Studien kan nå igangsettes.

Med vennlig hilsen

Gøril Bergva

Komitesekretær
REK sør-øst
Tlf: 22 84 55 29

-------Original melding--------

Emne: Spørreskjema
Fra: a.m.rustaden@nih.no<mailto:a.m.rustaden@nih.no>
Dato: 19.06.2012 11:09
Til: post@helseforskning.etikkom.no<mailto:post@helseforskning.etikkom.no>
Kopi:

Hei! Vedlagt finner dere spørreskjema til forskningsprosjekt ved NIH (ref 2012/783), som skulle ettersendes og vurderes.

MVH Anne Mette Rustaden Stipendiat/Fysioterapeut Seksjons for idrettsmedisinske fag, Norges idrettshøgskole

Appendix 2

Informed written consent statement

Forespørsel om deltakelse i forskningsprosjektet

" BodyPump og personlig trening – endringer i muskelstyrke og kroppssammensetning"

Bakgrunn og hensikt

Dette er et spørsmål til deg om å delta i et forskningsprosjekt ved Norges idrettshøgskole hvor man skal undersøke tre former for styrketrening for ikke regelmessig trenende kvinner med BMI over 25, over en periode på 12 uker. Med ikke regelmessig trenende mener vi at man ikke er regelmessig fysisk aktiv mer enn 1 gang per 14.dag, men ønsker å bli det. Deltakerne vil bli tilfeldig fordelt til èn av fire grupper. Èn gruppe får styrketrening i sal med instruktør (BodyPump), èn gruppe får styrketrening med personlig trener tilstede ved hver økt, èn gruppe får styrketreningsprogram av veileder, men må trene på egenhånd, og èn siste gruppe blir inaktiv kontrollgruppe. Kontrollgruppen vil få tilbud om gruppetrening med instruktør i etterkant av studien, uten kostnad.

Hva innebærer studien?

For å kunne vurdere effekt av treningen bes du om å gjennomføre noen målinger og tester før og etter treningsperioden, samt svare på et spørreskjema. Vi vil måle din kroppssammensetning, samt kartlegge muskelstyrken din med standardiserte styrketester. Gjennomføring av tester og deltakelse i intervensjonen er uten kostnader for deg som deltaker. Kostnader som transport til og fra trening, samt treningstøy må dekkes av deg. Selve treningen vil foregå på Norges idrettshøgskole for to av treningsgruppene, mens gruppen som skal trene BodyPump vil få tilbud om ulike tidspunkter på t utvalgte SATS treningssentre sentralt i Oslo (Majorstuen og Nydalen).

Mulige ulemper

Alle testene benyttes hyppig innen forskning og idrettsmedisin, og det er generelt liten risiko for skader eller ubehag. Testene vil følge standardprosedyre, og erfarne testledere vil ha ansvar for gjennomføringen.
Kroppssammensetningen måles ved DXA (Dual-energy X-ray absorptiometry) som gir en beskjeden stråledose.
Testing av maksimal styrke følger standard prosedyrer ved Norges idrettshøgskole, men kan medføre en viss risiko for skader, dersom belastningen blir for tung. Testpersonellet vil tilrettelegge for å unngå at skader skal oppstå.

Veneprøver («blodprøve») kan oppleves som ubehagelig, men utføres av erfarent helsepersonell. Det er svært lav risiko for infeksjoner

Mulige fordeler

Alle treningsformene antas å virke positivt på din fysiske form, og de som kommer i den inaktive kontrollgruppen får mulighet til å trene etter studieperioden.

Hva skjer med prøvene og informasjonen om deg?

Prøvene tatt av deg og informasjonen som registreres om deg skal kun brukes slik som beskrevet i hensikten med studien. Alle opplysningene og prøvene vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennende opplysninger. En kode knytter deg til dine opplysninger og prøver gjennom en navneliste.

Det er kun autorisert personell knyttet til prosjektet som har adgang til navnelisten og som kan finne tilbake til deg. Dataene som innhentes vil lagres i manuelle arkiv med personidentifikasjon som låses inn, og du har til enhver tid full innsynsrett i dataene. Dataene avidentifiseres ved elektronisk lagring på PC for statistiske analyser (lagres kun med nummer). Ingen av dataene sammenholdes med elektroniske registre. Lagringen av data vil foregå i henhold til personsopplysningsloven. Etisk komité har godkjent at prosjektet gjennomføres og prosjektet er meldt Norsk samfunnsvitenskapelige datatjeneste AS.

Det vil ikke være mulig å identifisere deg i resultatene av studien når disse publiseres.

Frivillig deltakelse

Det er frivillig å delta i studien. Du kan når som helst og uten å oppgi grunn trekke ditt samtykke til å delta i studien. Dette vil ikke få konsekvenser for din videre behandling. Dersom du ønsker å delta, undertegner du samtykkeerklæringen på siste side. Dersom du senere ønsker å trekke deg eller har spørsmål til studien, kan du kontakte Anne Mette Rustaden på telefon 48 10 06 44.

Ytterligere informasjon om studien finnes i kapittel *A* – *utdypende forklaring av hva studien innebærer.*

Ytterligere informasjon om biobank, personvern og forsikring finnes i kapittel B – *Personvern, biobank, økonomi og forsikring.*

Samtykkeerklæring følger etter kapittel B.

Kapittel A- utdypende forklaring av hva studien innebærer

Kriterier for deltakelse

Det er ønskelig å rekruttere ikke regelmessig trenende kvinner mellom 18-65 år, med en BMI over 25,0 (tabell 1). Ikke regelmessig trenende defineres i denne studien som "ikke regelmessig fysisk aktiv mer enn en gang per 14.dag, men ønsker å bli det"

Bakgrunnsinformasjon om studien

Rundt 500 000 nordmenn trener i dag på treningssenter. Med denne utviklingen har det kommet mange gruppetreningskonsepter, som blant annet BodyPump. BodyPump er styrketreningskonsept i sal med instruktør og musikk, og det tilbys over hele verden. Mange kjøper seg også tjenester som personlig trener, uten at det per i dag finnes mye forskning på dette feltet. Hovedhensikten med dette prosjektet er å gjennomføre en randomisert kontrollert studie for å se på styrkeeffekt og endring i kroppssammensetning for inaktive kvinner mellom 18-65 år med en BMI over 25,0 etter 12 ukers trening med BodyPump, sammenlignet med en inaktiv kontrollgruppe. Studien vil også måle energiforbruket under én økt med BodyPump. Samtidig vil prosjektet undersøke styrkeeffekt og endring i kroppssammensetning hos en gruppe som trener med, respektive uten, personlig trener.

- **Undersøkelser, blodprøver og annet den inkluderte må gjennom**

Forsøkspersonene må gjennomføre følgende tester:

- 1RM test i knebøy (underkropp) og benkpress (overkropp).
- Styrketester med 60 % belastning av 1RM (knebøy og benkpress).
- Endring i kroppssammensetning (fettmasse og muskelmasse) og beinmineraltetthet vil bli målt med DXA
- Energiomsetningen før (hvileverdier) under og etter én treningsøkt med BodyPump blir registrert med indirekte kalorimetri (oksygenopptak), og denne testen vil omfatte kun ti forsøkspersoner fra Body Pump gruppen.
- Blodprøver for analyse av blodstatus.
- Spørreskjema med demografiske spørsmål, samt jobb, aktivitetsvaner, røyk/alkoholdforbruk, ryggsmerter osv.

- **Tidsskjema – hva skjer og når skjer det?**

  All testing forut for treningsperioden vil skje i uke 36, og testing etter treningsperioden vil skje i uke 49 (eksakte tidspunkter og klokkeslett vil komme senere). Treningen vil foregå over 12 uker, da uke 37 til og med uke 48.

- **Mulige fordeler** (se ovenfor)
- **Mulige ubehag/ulemper** (se ovenfor)
- **Pasientens/studiedeltakerens ansvar**

- Alle forsøkspersoner må kunne transportere seg selv til og fra trening og testing. Forsøkspersonene i gruppen Personlig Trening må også booke tidspunktene på treningen med sin respektive personlige trener. Alle forsøkspersonene vil få utdelt en treningsdagbok som må fylles ut.

Kapittel B - Personvern, biobank, økonomi og forsikring

Personvern

Opplysninger som registreres om deg er resultatene fra testene inkludert i prosjektet, samt dine svar på spørreskjemaet. Ingen andre forskere utenfor dette prosjektet vil få tilgang til dataene.
Norges idrettshøgskole (seksjon for idrettsmedisinske fag) ved administrerende direktør er databehandlingsansvarlig.

Utlevering av materiale og opplysninger til andre

Nei.

Rett til innsyn og sletting av opplysninger om deg og sletting av prøver

Hvis du sier ja til å delta i studien, har du rett til å få innsyn i hvilke opplysninger som er registrert om deg. Du har videre rett til å få korrigert eventuelle feil i de opplysningene vi har registrert. Dersom du trekker deg fra studien, kan du kreve å få slettet innsamlede prøver og opplysninger, med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner.

Økonomi og rolle

Studien og biobanken er finansiert gjennom forskningsmidler fra Norges idrettshøgskole. Ingen andre eksterne parter bidrar økonomisk i studien.

Forsikring

Norges idrettshøgskole er en statlig institusjon og er således selvassurandør.

Informasjon om utfallet av studien

Deltakerne har rett til å få informasjon om utfallet av studien, og vil få tilsendt dette når resultatene foreligger.

Samtykke til deltakelse i studien

Jeg er villig til å delta i studien

(Signert av prosjektdeltaker, dato)

(Signert av nærstående, dato)

Jeg bekrefter å ha gitt informasjon om studien

(Signert, rolle i studien, dato)

Appendix 3

Check-off health profile scheme

Helsevurdering

ID nummer: ………

Har du /har hatt noen **av følgende sykdommer/skader siste år?**
Sett kryss bak dersom du har diagnostisert èn eller flere av følgende:

Ryggsmerter med utstråling til sete/ben	☐	
Psykiatriske sykdommer (f.eks angst, depresjon)	☐	
Osteoporose	☐	
Angina eller annen hjertesykdom	☐	
Høyt blodtrykk	☐	
Epilepsi	☐	
Diabetes type I	☐	
Astma	☐	
Kreft	☐	
Nevrologisk sykdom (f.eks MS, Parkinson)	☐	
Reumatisk sykdom (f.eks leddgikt, Bechterew)	☐	
Brudd	☐	Hvor……………..
Tar du noen form for medisiner?	☐	Hvilke…………..

Appendix 4

- **Questionnaire background characteristics**
- **Standardized Nordic Pain Questionnaire**

SPØRRESKJEMA

BodyPump og Personlig Trening – endringer i muskelstyrke og kroppssammensetning

I dette spørreskjemaet vil du bli bedt om å svare på spørsmål angående personopplysninger, fysisk aktivitet, ernæring, selvopplevd helse og motivasjon for trening, livskvalitet, muskel- og skjelettplager og urinlekkasje. Les spørsmålene nøye før du svarer.
Du svarer på spørsmålene enten ved å sette kryss i avkrysningsboksen ved det svaralternativet som best beskriver din situasjon, eller setter en ring der det bes om det. Dersom du ikke synes at noen av svaralternativene passer helt, ber vi om at du krysser av for det alternativet som passer best for deg.

Ved feil setter du strek over den gale markeringen, og nytt kryss i rette alternativ.
Det er viktig at du svarer på alle spørsmålene du blir bedt om å svare på.

På forhånd takk for at du tar deg tid til å fylle ut skjemaet!

ID nr:	**Pretest**	**Posttest**
Dagens dato		
Høyde i cm		
Vekt i kg		
Alder		

PERSONOPPLYSNINGER

Kryss av for ett alternativ på de følgende spørsmålene:

1. Har du barn?

- ☐ Ja   Hvis ja; hvor mange av disse har du født selv? ☐☐
- ☐ Nei

2. Er du

- ☐ Gift
- ☐ Samboende
- ☐ Separert
- ☐ Skilt
- ☐ Singel
- ☐ Enke

3. Hva er din høyeste fullførte utdannelse?

- ☐ Grunnskole
- ☐ Videregående/gymnasium
- ☐ Høgskole/Universitet inntil 4 år
- ☐ Høgskole/Universitet mer enn 4 år
- ☐ Annen utdannelse

4. Hvor stor stillingsprosent har du idag? ……………………… % stilling

5. Dersom du <u>ikke</u> er yrkesaktiv i dag, hva er hovedårsaken til det?

- ☐ Ønsker ikke å jobbe
- ☐ Arbeidssøkende
- ☐ Sykemeldt
- ☐ Delvis sykemeldt ………… %
- ☐ Student
- ☐ Hjemmeværende pga permisjon etc.
- ☐ Uføretrygdet

□ Pensjonert
□ Annet

6. Dersom du har vært i jobb de siste 6 månedene, kan du anslå antall fraværsdager?

Ved egenmelding ……………………………………

Med sykemelding fra lege …………………………..

7. Dersom du har hatt fravær med sykemelding, hva var årsaken til dette fraværet? Du kan her krysse av flere alternativ.

□ Forkjølelse/influensa
□ Muskel- og skjelettsmerter
□ Revmatisme
□ Psykiske lidelser
□ Utmattelse
□ Sykdom i nær familie
□ Operasjoner/opptreningsopphold
□ Livsstilssykdommer/medisiner
□ Annet

KOSTHOLD OG ERNÆRING

8. Hvor mange hovedmåltider spiser du vanligvis per dag? ………………………………

9. Spiser du vanligvis noe mellom disse måltidene?

□ Ja
□ Nei

Dersom ja, hvor ofte? ………………………………………

10. Omtrent hvor ofte drikker du alkohol? …………………………enheter per uke

…………………………enheter per måned

11. Røyker du? Kryss av for ett alternativ.

- ☐ Ja, daglig: Antall per dag:
- ☐ Ja, av og til: Antall per uke:
- ☐ Kun til fest/spesielle anledninger
- ☐ Nei, jeg sluttet for mindre enn et år siden
- ☐ Nei, jeg sluttet for mer enn et år siden
- ☐ Nei, jeg har aldri røykt

FYSISK AKTIVITET

12. Har du drevet regelmessig fysisk aktivitet under din oppvekst? Kryss av for ett alternativ.

- ☐ Ja, regelmessig (ukentlig) under hele oppveksten
- ☐ Ja, sporadisk (av og til) under hele oppveksten
- ☐ Kun korte perioder under oppveksten
- ☐ Svært sjelden, utenom gymtimene på skolen
- ☐ Ingenting utenom gymtimene på skolen

Hvis ja; hvilken idrett aller aktivitet har du drevet mest med? ……………………………

13. Dersom du tidligere har drevet regelmessig fysisk aktivitet/idrett, men sluttet, hva vil du si er hovedårsakene til det? Ranger med tall fra 1 til 3, hvor 1 representerer den viktigste årsaken.

□ Prioriterte istedet skole og utdanning
□ Jobb tok for mye tid
□ For dyrt å trene regelmessig
□ Venner eller kollegaer ikke interesserte og falt derfor av
□ Familie- og barn tok all tid
□ Sykdom og/eller skade
□ Fantes ikke gode treningstilbud i nærmiljøet
□ Var ikke gøy og motiverende
□ Slitsomt
□ Annet

14. Når sluttet du med regelmessig fysisk aktivitet/idrett? Kryss av for ett alternativ.

□ Mindre enn 6 mnd siden
□ 6 -12 mnd siden
□ 2 år siden
□ 5 år siden
□ mer enn 10 år siden

15. Hva vil du si er det viktigste som skal til for at du i dag skal bli regelmessig fysisk aktiv? Ranger med tall fra 1 til 3, hvor 1 representerer den viktigste årsaken.

□ Mer fritid
□ Tilbud om fysisk aktivitet på jobben
□ Større treningstilbud i nærmiljøet
□ Venner som ønsker å være fysisk aktive
□ Familie som ønsker å være fysisk aktive
□ Må bli frisk fra skade/sykdom
□ Må finne en motiverende aktivitet

☐ Må bli billigere å være fysisk aktiv

☐ Må få mer kunnskap om fysisk aktivitet

☐ Annet

16. Hva slags aktivitet liker du, eller har du mest lyst til å prøve? Kryss av for ett alternativ.

☐ Ballspill

☐ Svømming

☐ Ski

☐ Gå turer

☐ Løpe/jogge

☐ Sykle

☐ Fjellturer

☐ Treningssenter: individuell trening i treningsstudio

☐ Treningssenter: gruppetrening i sal

☐ Turn

☐ Dans

☐ Styrketrening

☐ Annet

17. Drev noen i din nærmeste familie regelmessig fysisk aktivitet under din oppvekst (før 18 år)?

☐ Ja

☐ Nei

18. Dersom ja, hvem? Kryss av for de alternativer som passer for deg.

☐ Mor (kvinnelig foresatt)

☐ Far (mannlig foresatt)

☐ Begge foreldre

☐ Søsken

☐ Besteforeldre

□ Tante/onkel og søskenbarn

19. Hvor vanlig var det å være i regelmessig fysisk aktiv i din omgangskrets? Kryss av for ett alternativ.

□ Ikke vanlig

□ Forekom

□ Svært vanlig

20. Er din partner/ektefelle regelmessig fysisk aktiv?

□ Ja

□ Nei

□ Har ikke partner/ektefelle

Dersom ja, hvor ofte vil du anslå at din partner trener? ……………………….per uke.

21. Hva kan motivere deg for å bli mer fysisk aktiv? Kryss av for ett alternativ.

□ Noen å trene sammen med – sosiale aspekter

□ Mer tid

□ Mindre kostbart å trene

□ Dersom legen min eller annet helsepersonell anbefaler det

□ Dersom det blir treningsmuligheter på jobb

□ For å oppnå vektreduksjon

□ Dersom helsen min trenger det

□ Annet

22. Har du noen gang mottatt råd om fysisk aktivitet av helsepersonell?

□ Ja

□ Nei

Hvis ja, av hvem? Kryss av for de alternativer som passer for deg.

□ Lege

□ Fysioterapeut

□ Kiropraktor

□ Manuellterapeut

□ Naprapat

□ Sykepleier

□ Personlig trener/treningsveileder

□ Annet

SELVOPPLEVD HELSE

23. Stort sett, vil du si at din helse er: (sett ring rundt ett tall)

Utmerket……………………..................1

Meget god.………………………………2

God……...………………………………3

Nokså god.……………………………..4

Dårlig…….……………………………..5

24. Sammenlignet med for ett år siden, hvordan vil du si at din helse stort sett er nå? (sett ring rundt ett tall)

Mye bedre enn for ett år siden……………	1
Litt bedre enn for ett år siden…………….	2
Omtrent den samme som for ett år siden…	3
Litt dårligere enn for ett år siden…………	4
Mye dårligere enn for ett år siden………..	5

LIVSKVALITET - tilfredshet med livet

25. Nedenfor står fem utsagn om tilfredshet med livet som et hele. Vis hvor godt eller dårlig hver av de fem påstandene stemmer for deg og ditt liv ved å sette en ring rundt det tallet som du synes stemmer best for deg. (Sett kun èn ring for hvert spørsmål).

	Stemmer dårlig						Stemmer perfekt
På de fleste måter er livet mitt nær idealet mitt	1	2	3	4	5	6	7
Mine livsforhold er utmerkede	1	2	3	4	5	6	7
Jeg er tilfreds med livet mitt	1	2	3	4	5	6	7
Så langt har jeg fått de viktige tingene jeg ønsker i livet	1	2	3	4	5	6	7
Hvis jeg kunne leve livet på nytt, ville jeg nesten ikke forandret på noe	1	2	3	4	5	6	7

MOTIVASJON FOR TRENING

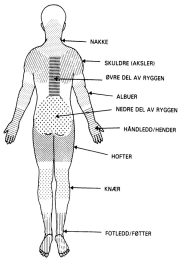
26. Sett en ring rundt det svaret som er sant for deg. NB! Det er ingen rette eller gale svar. Vi ønsker bare å kartlegge hva du personlig føler om trening.

		Ikke sant for meg		Av og til sant for meg		Helt sant for meg
1	Jeg trener fordi andre mennesker sier jeg burde	0	1	2	3	4
2	Jeg føler skyld når jeg ikke trener	0	1	2	3	4
3	Jeg verdsetter fordelene ved trening	0	1	2	3	4
4	Jeg trener fordi det er gøy	0	1	2	3	4
5	Jeg ser ikke hvorfor jeg bør trene	0	1	2	3	4
6	Jeg deltar i trening fordi familie/venner/ partner sier at jeg bør	0	1	2	3	4
7	Jeg føler skam når jeg går glipp av en treningsøkt	0	1	2	3	4
8	Det er viktig for meg å trene regelmessig	0	1	2	3	4
9	Jeg ser ikke hvorfor jeg skulle bry meg om trening	0	1	2	3	4
10	Jeg liker treningstimene mine	0	1	2	3	4
11	Jeg trener fordi andre ikke vil være fornøyd med meg hvis jeg ikke trener	0	1	2	3	4
12	Jeg ser ikke poenget med trening	0	1	2	3	4
13	Jeg føler jeg feiler hvis jeg ikke har trent på en stund	0	1	2	3	4
14	Jeg synes det er viktig å gjøre en innsats for å trene regelmessig	0	1	2	3	4
15	Jeg synes trening er en fornøyelig aktivitet	0	1	2	3	4
16	Jeg føler press fra familien/venner til å trene	0	1	2	3	4
17	Jeg blir rastløs hvis jeg ikke trener regelmessig	0	1	2	3	4
18	Jeg blir fornøyd og tifreds ved å delta på trening	0	1	2	3	4
19	Jeg mener trening er bortkastet tid	0	1	2	3	4

MUSKEL- OG SKJELETTPLAGER

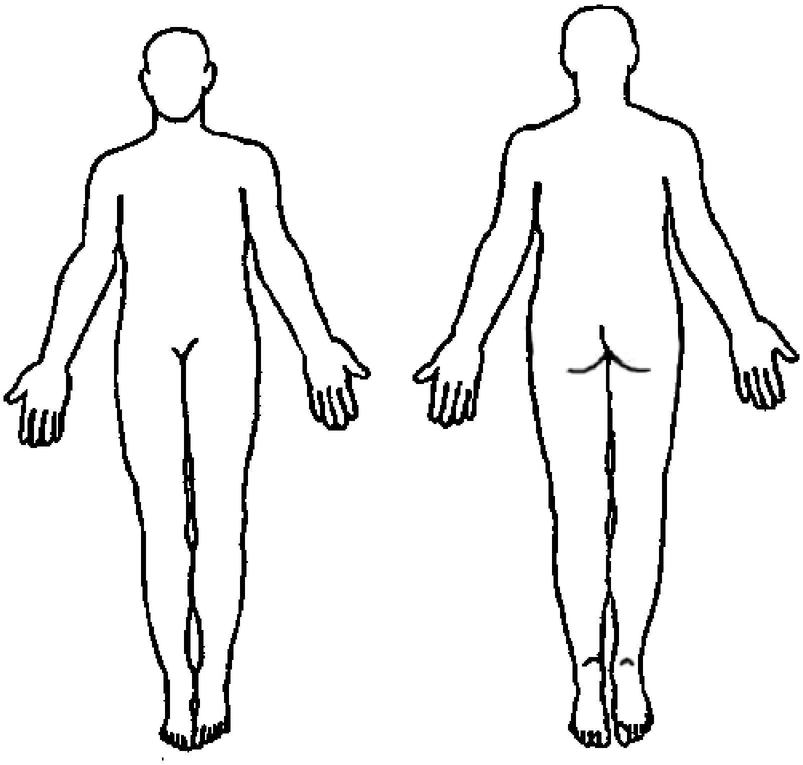
27. Nedenfor følger spørsmål om plager i forskjellige kroppsdeler. Kryss av for hvert spørsmål.

Inndeling av kroppsdeler:



	Har du noen gang i løpet av de siste 12 måneder hatt plager (smerter, vondt, ubehag) i:	Har du noen gang i løpet av de siste 12 måneder ikke kunnet utføre ditt dagligdagse arbeid (i eller utenfor hjemmet) på grunn av disse plagene?	Har du noen gang i løpet av de siste 7 døgn hatt plager (smerter, vondt, ubehag) i:
20. Hodet	ja □ nei □	ja □ nei □	ja □ nei □
21. Nakken	ja □ nei □	ja □ nei □	ja □ nei □
22. Skuldre	ja □ nei □	ja □ nei □	ja □ nei □
23. Albuer	ja □ nei □	ja □ nei □	ja □ nei □
24. Håndleddene	ja □ nei □	ja □ nei □	ja □ nei □
25. Øvre del av rygg	ja □ nei □	ja □ nei □	ja □ nei □
26. Nedre del av rygg	ja □ nei □	ja □ nei □	ja □ nei □
27. Hofter	ja □ nei □	ja □ nei □	ja □ nei □
28. Knær	ja □ nei □	ja □ nei □	ja □ nei □
29. Fotledd/føtter	ja □ nei □	ja □ nei □	ja □ nei □

28. Skraver med kulepenn områdene på kroppen hvor du eventuelt har hatt smerter i løpet av de siste **4 uker**
:



URINLEKKASJE

Mange mennesker lekker urin av og til. Vi forsøker å finne ut hvor mange mennesker som lekker urin og hvor mye dette plager dem. Vi er takknemlige om du vil besvare følgende spørsmål. (Vi vil gjerne vite hvordan du har hatt det, gjennomsnittlig, de siste 4 ukene).

1 Vennligst skriv inn din fødselsdato: ☐☐ ☐☐ ☐☐

DAG MÅNED ÅR

2 Du er *(kryss av i korrekt firkant)***:** Kvinne ☐ Mann ☐

3 Hvor ofte lekker du urin? *(Kryss av i èn boks)*

aldri	☐	0
omtrent èn gang i uken eller sjeldnere	☐	1
2 – 3 ganger i uken	☐	2
ca. 1 gang per dag	☐	3
flere ganger per dag	☐	4
hele tiden	☐	5

4 Vi vil gjerne vite hvor mye urin du tror du lekker.
Hvor mye urin lekker du vanligvis (enten du bruker beskyttelse eller ikke)?
(Kryss av i en rute)

ikke noe	☐	0
en liten menge	☐	2
en moderat mengde	☐	4
en stor mengde	☐	6

5 Hvor mye påvirker urinlekkasje ditt hverdagsliv?
Vær vennlig, sett en ring rundt et tall mellom 0 (ikke i det hele tatt) og 10 (mye)

0 1 2 3 4 5 6 7 8 9 **10**

ikke i det hele tatt — svært mye

ICI-Q score: sum scores 3+4+5 ☐ ☐

6 Når lekker du urin? *(Vennligst kryss av alt som passer for deg)*

- aldri, jeg lekker ikke urin ☐
- lekker før jeg når toalettet ☐
- lekker når jeg hoster eller nyser ☐
- lekker når jeg sover ☐
- lekker når jeg er fysisk aktiv/trimmer ☐
- lekker når jeg er ferdig med å late vannet og har tatt på meg klærne ☐
- lekker uten noen opplagt grunn ☐
- lekker hele tiden ☐

Mange takk for at du besvarte spørsmålene!

Anne Mette Rustaden // The effect of BodyPump and resistance training with and without a personal trainer on overweight and obese women