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Effects of 9 weeks of periodized, single-set resistance and aerobic training in untrained women

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## Abstract

**Introduction:** Modern sedentary behaviours are linked to several diseases and all-cause mortality, but can be prevented and avoided with regular physical activity. Resistance exercise has proven itself to be as important as aerobic exercise as a preventive method and can positively affect well-being. **Aim:** The aim of this study was to examine whether a periodized, single-set resistance exercise protocol combined with an aerobic warm up and cool down is sufficient to elicit positive changes in various measures of well-being. **Methods:** Eleven middle-aged women ( $56.4 \pm 3.3$  years) performed nine weeks of periodized, single-set resistance exercise combined with an aerobic warm up and a cool down. Maximal strength, body composition, blood pressure, total cholesterol, maximal oxygen uptake and quality of life was measured before and after the training intervention. **Results:** Maximal strength increased significantly (leg press:  $73 \pm 17$  vs.  $89 \pm 16$  kg,  $p < 0.01$ , chest press:  $12 \pm 4$  vs.  $15 \pm 4$  kg,  $p < 0.01$ , abdominal crunch:  $26 \pm 5$  vs.  $34 \pm 8$  kg,  $p < 0.05$ , high row  $21 \pm 4$  vs.  $25 \pm 4$  kg,  $p < 0.01$ ). Maximal oxygen uptake increased significantly ( $25.4 \pm 5.6$  vs.  $28.4 \pm 5.5$  ml/kg/min,  $p < 0.05$ ). Quality of life increased significantly ( $79.3 \pm 11.1$  vs.  $89.6 \pm 5.8$ ,  $p < 0.01$ ). Blood pressure decreased significantly (systolic:  $142.7 \pm 20.6$  vs.  $135.5 \pm 22.4$  mmHg,  $p < 0.05$  and diastolic:  $94.2 \pm 14.4$  vs.  $90.6 \pm 13.6$  mmHg,  $p < 0.05$ ). No significant differences were noted in body composition or total cholesterol. **Conclusion:** A periodized single-set strength training protocol combined with an aerobic warm up and cool down is sufficient to promote significant improvements in maximal strength, maximal oxygen uptake, and quality of life and both systolic and diastolic blood pressure in healthy, untrained middle-aged women.

**Keywords:** Cardiorespiratory fitness, muscular fitness, strength training.

## Abstrakt

**Introduktion:** Stillasittande livsstil är kopplat till en mängd olika sjukdomar och dödlighet men kan förebyggas och undvikas genom regelbunden fysisk aktivitet. Styrketräning har visat sig vara lika viktig som en förebyggande metod som aerob träning och påverkar hälsan positivt. **Syfte:** Syftet med denna studie var att undersöka om ett periodiserat single-set styrketräningsprogram är tillräckligt för att framkalla positiva förändringar i välbefinnandet. **Metod:** Elva medelålders kvinnor ( $56.4 \pm 3.3$  år) utförde nio veckor av periodiserat single-set styrketräning kombinerat med en aerob uppvärmning och nedvarvning. Maximal styrka, kroppssammansättning, blodtryck, total kolesterol, maximal syreupptagningsförmåga och livskvalité uppmättes före och efter träningsinterventionen. **Resultat:** Maximal styrka ökade signifikant (benpress:  $73 \pm 17$  vs.  $89 \pm 16$  kg,  $p < 0.01$ , bröstpress:  $12 \pm 4$  vs.  $15 \pm 4$  kg,  $p < 0.01$ , abdominal crunch:  $26 \pm 5$  vs.  $34 \pm 8$  kg,  $p < 0.05$ , latsdrag:  $21 \pm 4$  vs.  $25 \pm 4$  kg,  $p < 0.01$ ). Maximala syreupptagningsförmågan ökade signifikant ( $25.4 \pm 5.6$  vs.  $28.4 \pm 5.5$  ml/kg/min,  $p < 0.05$ ). Livskvalitén ökade signifikant ( $79.3 \pm 11.1$  vs.  $89.6 \pm 5.8$ ,  $p < 0.01$ ). Blodtrycket sänktes signifikant (systolisk:  $142.7 \pm 20.6$  vs.  $135.5 \pm 22.4$  mmHg,  $p < 0.05$  och diastolisk:  $94.2 \pm 14.4$  vs.  $90.6 \pm 13.6$  mmHg,  $p < 0.05$ ). Inga signifikanta skillnader framkom i kroppssammansättning eller total kolesterol. **Konklusion:** Periodiserad single-set styrketräning räcker för att framkalla signifikanta förbättringar i maximal styrka, maximal syreupptagningsförmåga, livskvalité och blodtryck på otränade medelålders kvinnor.

**Sökord:** Kardiorespiratorisk kondition, muskulär kondition, styrketräning.

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## **Introduction**

With increasing rates of our modern sedentary behaviours, which are linked to several diseases such as obesity, cardiovascular and metabolic diseases, cancer and psychological diseases that are linked to mortality (Tremblay et al., 2010), people still fail to meet the recommendations of physical activity (Guthold et al., 2008). Following the physical activity guidelines introduced by the American College of Sports Medicine (ACSM) has a positive effect on all-cause mortality, with people engaging in moderate intensity physical activity showing a 27% decreased risk of mortality and people engaging in vigorous physical activity three times a week for 20 minutes showing a 32% decreased risk (Haskell et al., 2007; Leitzmann et al., 2007).

Regular physical activity decreases the risk of developing coronary heart disease (CHD), stroke, type 2 diabetes and cancer, lowers blood pressure, improves lipoprotein levels, enhances insulin sensitivity, preserves bone mass and can prevent mild to moderate depressive and anxiety disorders (Garber et al., 2011). However, most of the data on these health outcomes come from studies that only examine effects on body composition and cardiorespiratory aerobic fitness (Garber et al., 2011).

Weight training (resistance exercise) was previously considered to be only for exceptionally strong men and women, bodybuilders, powerlifters and people who compete in sports that require significant strength and that average individuals had no reason to participate or engage in such activities (Westcott, 2012). However, resistance exercise has proven itself to be very important as a preventive solution to many diseases and is effective in enhancing several aspects of physical and mental health (Westcott, 2012). Maintaining an appropriate amount of muscle mass, strength and muscle function is a crucial aspect in terms of exercise and to cope with daily activities (Wolfe, 2006). Resistance exercise plays a significant role in preventing and slowing down the process of loss of muscle mass associated with aging and can prevent various functional limitations in our daily activities, especially in the elderly population (Hurley et al., 2011). Nonetheless, the best

solution for enhancing muscular fitness, increasing muscle mass, muscle strength and power is to participate in regular resistance exercise (Ratamess, 2012).

Even though physical activity is a recommended component of weight management, resistance exercise seems not to be of particular significance in weight loss (Donnelly et al., 2009). However, resistance exercise affects body composition in many ways. A review article from Strasser and Schobersberger (2011) concluded that resistance exercise increases muscle mass, reduces fat mass and is at least as effective as aerobic training in reducing some major cardiovascular disease (CVD) risk factors. Similar results on body composition have been shown following both single- and multiple-set resistance exercise protocols (Abrahin et al., 2014; Radaelli et al., 2014; Ribeiro et al., 2015). Similar results have also been shown when aerobic exercise has been carried out in combination with resistance exercise (Westcott et al., 2009). There are also indications that resistance exercise in combination with aerobic exercise could be superior for loss of body weight and fat mass than aerobic exercise alone (Donnelly et al., 2009; Park et al., 2003).

The positive effects of resistance exercise on blood pressure have been known for a while. A meta-analysis by Kelley (1997) concluded that dynamic resistance exercise has a decreasing effect on both systolic and diastolic blood pressure. A later meta-analysis confirmed this, but concluded that participants performing both aerobic and resistance exercise had decreasing effects on diastolic blood pressure only (Cornelissen and Smart, 2013). However, a combination of both aerobic and resistance exercise according to the ACSM's recommendations has reportedly shown reductions in both systolic and diastolic blood pressure by 3.2 and 1.4 mmHg respectively (Westcott et al., 2009).

In addition to positively impacting blood pressure, resistance exercise has also been shown to lower cholesterol levels in adults. A meta-analysis showed reductions as high as 5.5 mg/dl in total cholesterol and a better LDL/HDL cholesterol with resistance exercise (Kelley and Kelley, 2009). Interestingly, there are also studies showing that combining resistance exercise with aerobic activities will lead to better lipoprotein profiles than aerobic exercise only (Pitsavos et al., 2009).

However, some controversy exists as there are also studies indicating that resistance exercise does not have any effect on total cholesterol levels (Kokkinos et al, 1988).

Studies on the effects of resistance exercise on mental health have been carried out with varying results. However, these studies often focus on some subgroup that ultimately forms the concept mental health or quality of life. This makes it rather difficult to directly conclude that resistance exercise has an effect on mental health. However, a rather massive review article by O'Connor et al., (2010) points out that resistance exercise has a positive effect on anxiety symptoms among healthy adults, cognition in older adults, reductions in symptoms of depression, fatigue and improvements in self-esteem. There are, however, studies that have directly measured the quality of life. One study was conducted on depressed elders (60-84 years old) where a ten-week resistance exercise protocol led to significantly decreased scores on various depression sub-scales (bodily pain, vitality, social and role emotional functioning) and enhanced the quality of life (Singh et al., 1997). However, there are also studies that show no effect of resistance exercise on quality of life. Elderly patients with chronic obstructive pulmonary disease (COPD) who underwent rehabilitation that consists of primarily aerobic-type exercise, completed a single-set resistance exercise protocol in combination with the rehabilitation program, but showed no significant improvements in quality of life (Benton and Wagner, 2013). It would seem that the current situation in life and medical history of illness has an effect on the outcome of the effect of resistance exercise on quality of life (Benton and Wagner, 2013; O'Connor et al., 2010).

After all these positive effects of resistance exercise on various aspects of physical and mental health, the crucial aspect is how much of physical activity is needed to achieve these positive health effects. The ACSM's guidelines for physical activity recommends 30 minutes of moderate-intensity physical activity on five days per week, or 20 minutes of vigorous-intensity aerobic activity three times per week (or a total amount of 75 min/week) and resistance exercise activities two times per week including one set of 8-10 different exercises with 8-10 repetitions (Haskell et al., 2007). These recommendations were reassessed in 2011 with minor changes to the previous ones (Garber et al., 2011). While the amount of aerobic physical activity per week remained the same, the amount and importance of resistance

exercise was discussed and recommendations increased from two to two to three times per week (Garber et al., 2011). The number of sets per exercise that should be performed was also assessed. With conflicting results from studies examining the effects of single and multiple-set protocols, new recommendations for two to four sets per exercise for most adults and experienced lifters and a single set for novice and elderly exercisers was set as the new guideline (Garber et al., 2011).

The amount of sets performed per exercise for optimal outcomes in strength and hypertrophy has throughout the years been debated with conflicting results. A meta-analysis concluded that multiple sets are superior to single sets of resistance exercise on muscle hypertrophy for both untrained and trained individuals (Krieger, 2010), but gained some criticism due its substantial limitations in training frequency, intervention duration, repetition duration and the method of measuring hypertrophy (Fisher, 2012). While there is evidence that for an athletic population multiple-set programs in a periodized manner are desirable for substantial increases in muscle strength (Kraemer, 2000), recent studies have published conflicting results on untrained individuals. Some studies have shown multiple-set resistance exercise to be more effective for both untrained and trained elderly women (Ribeiro et al., 2015), while others have shown no significant differences between multiple- and single-set training protocols on the same populations (Abrahin et al., 2014; Radaelli et al., 2014). However, all who participate in resistance exercise may not necessarily want to achieve the highest possible increase in some single parameter, but to enhance their lifespan, mental and physical health and prevent various diseases.

With the rising amounts of negative health effects of our sedentary lifestyles and the positive health effects of regular resistance and aerobic exercise, it is important to investigate whether the current ACSM guidelines of a single-set resistance exercise protocol combined with aerobic activity would be a suitable solution for individuals who want to reduce risk factors associated with various diseases and enhance their physical and mental health, but don't want to spend a lot of time performing the physical activity.



## **Aim & Hypothesis**

The aim of this study was to examine whether a periodized single-set resistance exercise protocol combined with an aerobic warm up and cool down is sufficient to elicit positive changes in maximal strength, body composition, blood pressure, total cholesterol, maximal oxygen uptake and quality of life among untrained middle aged women. It was hypothesised that the protocol would have a positive impact on all of the above mentioned variables.

## **Methods**

### *Participants*

Fifteen healthy, untrained middle-aged women (50-65 years old) volunteered to participate in this study (Table 1). Recruitment of the participants was carried out through the local human resources department in the city of Kotka in Finland by an advertisement through their internal informational system.

All participants completed an interview carried out via telephone and met the following criteria: had not participated in any form of resistance training or regular vigorous physical activity, were not consuming any medication that would prohibit engaging in physical activity and did not have any injuries or diseases that would prevent engagement in physical activities. All participants were informed about how the study would be carried out and the potential risks of the study before signing an informed consent form.

By the end of the study, 11 participants had completed the training intervention. Two participants dropped out due to seasonal flu, one participant due to lower back pain and one because of personal issues. Adherence to the study was good, with the remaining 11 participants completing > 95 % of the training sessions.

### *Dietary intake and leisure*

Participants were instructed to maintain their normal eating and leisure habits throughout the study. They were instructed not to participate in any other physical training activities during the time of the study.

### *Experimental design*

The study was carried out over a period of ten weeks. Participants performed 9 weeks of resistance training that was divided into three micro-cycles, each consisting of three weeks. During the first micro-cycle which served as the familiarization to the resistance exercise protocol, participants performed one set of 20 repetitions for each of the exercises at 50% of their predicted one repetition maximum (1RM). During the second micro-cycle they performed one set of 15 repetitions at 60% of their predicted 1RM and in the third and final micro-cycle participants performed one set of 10 repetitions at 73% of their predicted 1RM for each of the exercises. Strength testing was conducted between the micro cycles on the last training session of each micro cycle to evaluate the weights for the following micro cycle.

### *Maximal strength*

Maximal strength (1RM) tests were carried out before, during and after the training intervention for four different exercises which covered the major muscle groups of the body: leg press, chest press, abdominal crunch and high row. The testing procedure was carried out according to the ACSM's recommended guidelines (Ratamess, 2012). Two warm up sets were carried out with one- and three-minute rest intervals between the sets. The resistance was progressively raised during the warm up sets. On the third set participants were instructed to perform as many repetitions as possible, until muscular failure. If the maximal amount of repetitions was  $< 10$ , it was marked as the test result and the 1RM was calculated using the following equation (Brzycki, 1993):  $\text{weight} \div (1.0278 - (0.0278 \times \text{number of repetitions}))$ . If the participant performed  $> 10$  repetitions, an additional three-minute rest interval was prescribed and the resistance was increased. The strength testing phase of a single exercise did not exceed five sets. Verbal encouragement was given during the testing procedure.

### *Body composition*

Body mass (kg), body fat (% Fat), fat mass (kg), fat-free mass (FFM) and skeletal muscle mass (SMM) were measured with a Tanita MC-780 MA (Tanita Corporation, Tokyo, Japan) bioelectrical scale (Kabiri et al., 2015). Assessment

was carried out before and one day after finishing the last training session of the study. Participants were instructed according to the Tanita instructions manual not to eat or drink for four hours prior testing, not to consume alcohol 48 hours prior testing and not to wear any objects containing metal. During the testing procedure, participants were allowed to use light clothing and 0.5 kg of weight was automatically deducted from the test result.

#### *Blood pressure and total cholesterol*

Blood pressure and total cholesterol were measured before and one day after finishing the last training session of the study. Blood pressure measurements were taken in the sitting position with the measurement hand relaxed on a table using an Omron M2 blood pressure monitor (Omron Healthcare Europe B.V, Hoofddorp, Netherlands). Participants were instructed to sit still for five minutes before the measurement. Blood pressure was measured twice, and the lower values for diastolic and systolic pressure were noted. The cholesterol measurements were carried out with an Accutrend Plus system (Roche Diagnostics Ltd., Rotkreuz, Switzerland) with a blood sample from the fingertip. Participants were informed to eat a little lighter the day before the testing session.

#### *Maximal oxygen uptake*

Maximal oxygen uptake ( $VO_{2max}$ ) was estimated before and after the training intervention by using an incremental cycle ergometer test with an Ergoline Ergoselect 200P (Ergoline GmbH., Blitz, Deutschland) cycle ergometer. The initial start stage was set at 40 W and increments of 20 W were used every two minutes throughout the test. Participants were instructed to stop the test when they had reached 80% of their estimated maximal heart rate ( $HR_{max}$ ), which was estimated with the following equation (Inbar et al., 1994):  $205.8 - 0.685(\text{age})$ , they were also allowed to continue as long as they could, if they wanted. Estimation of the  $VO_{2max}$  was carried out with Fitware Pro (Aino Health Management Oy, Helsinki, Finland) from the linear curve of heart rate (HR) against  $VO_2$  (Takalo, 2001). HR was measured using a Polar H7 heart rate sensor (Polar Electro Oy, Kempele, Finland).

### *Quality of life*

Quality of life was measured before and after the training intervention. Participants filled out a Rand-36 health questionnaire translated to Finnish (Aalto et al., 1999) with 36 questions including different sections (physical capability, physical- and mental role functioning, vigourousity, mental wellbeing, social functioning, analgesia and perceived health) that ensemble a quantifiable average of their perceived life quality on a scale ranging from 0-100, where 100 is the best possible score (Aalto et al., 1999).

### *Resistance training*

Training was performed three times a week on non-consecutive days. Ten minutes of aerobic exercise either on a cross-trainer or a stationary cycle at 70-80% of the participants predicted  $HR_{max}$  was carried out before and after the resistance training protocol. The resistance training protocol consisted of 11 different exercises (3 lower body and 8 upper body) for all the major muscle groups: calf press, leg press, hamstring curl, back extension, abdominal crunch, side rotations, chest press, high row, shoulder press, biceps curl and triceps press. Participants performed only a single set on each of the exercises in a circular fashion, moving directly to the following exercise. To ensure progression during the training phase, 1 kg of resistance was automatically added to the specific exercise, if two repetitions were completed over the assigned amount. The exercises were not performed to muscular failure, but the participants were instructed that performing every exercise had to feel demanding and if they could, they should do two repetitions over the assigned amount, so that 1 kg of resistance would be added for the following training session. All of the resistance training exercises were performed with HUR resistance exercise machines (Ab HUR Oy, Kokkola, Finland) that utilize air-pressure technology. The air-pressure technology allows the resistance to remain constant throughout the whole movement. The machines utilize a smart-card technology that recognizes individual training programs and adjusts the resistance automatically to assigned values. All data for the training sessions (time of day, time spent at the gym, exercises performed, weight used and repetitions performed) were automatically saved on an internal system utilizing the smart-card technology, to

monitor that all exercises and training sessions were carried out according to the protocol.

### *Statistical analyses*

Normality of the data was checked by the Shapiro-Wilk test. When the data was normally distributed, paired samples T-tests were used to analyse the data. For not-normally distributed data, the Wilcoxon Signed Rank test was used. The level of significance was set to  $\alpha = 0.05$ . The SPSS 23 package (IBM Corporation, Armonk, New York) was used for all the statistical analyses.

### *Ethics*

Before engaging in the study participants were informed about the background to the study, how the study would be carried out, the potential risks during the study, the benefits of the study, how personal confidential information would be handled, that participating in the study was voluntary and that they would be free to withdraw from the study whenever they so desired. Participants were allowed to ask questions regarding the study and contact the researcher at any time, if they so desired. Participants signed an informed consent with all the previously described information before the beginning of the study (Appendix 1 & 2). All personal information was anonymised so that participants could not be identified. All data was stored in a way that only the researcher could access and after the study all data with confidential personal information was destroyed.

## **Results**

### *Maximal strength*

There were significant increases in 1RM for leg press (23.3%,  $p < 0.01$ ), chest press (24.6%,  $p < 0.01$ ), abdominal crunch (30.4%,  $p < 0.05$ ) and high row (19.9%,  $p < 0.01$ ) before and after the training intervention (Figure 1).

### *Body composition*

The characteristics of the participants and body composition results before and after the training intervention are presented in Table 1. No significant differences were observed in any of the measured variables ( $p > 0.05$ ).

### *Blood pressure*

The results for resting blood pressure before and after the training intervention are presented in Table 1. A significant decrease in both systolic ( $-7.1 \pm 10.0$  mmHg,  $p < 0.05$ ) and diastolic ( $-3.6 \pm 4.7$  mmHg,  $p < 0.05$ ) blood pressure was noted.

### *Total cholesterol*

No significant differences were found in total cholesterol levels following the training intervention (pre:  $6.5 \pm 1.1$  mmol/L and post:  $6.2 \pm 1.2$  mmol/L,  $p > 0.05$ ).

### *Maximal oxygen uptake*

A significant increase was found in  $\text{VO}_{2\text{max}}$  (before:  $25.4 \pm 5.6$  ml/kg/min and after:  $28.4 \pm 5.5$  ml/kg/min,  $p \leq 0.01$ ) following the training intervention (Table 1).

### *Quality of life*

An increase of 13% on the Rand-36 quality of life scale was recorded after the training intervention (before:  $79.3 \pm 11.1$  and after  $89.6 \pm 5.8$ ,  $p < 0.01$ ).

Table 1: Characteristics of the participants and body composition measurements, systolic and diastolic resting blood pressure, and VO<sub>2Max</sub> values before and after the training intervention. Data are presented as mean ± standard deviation.

\* Significant difference from before.

		Before	After	P value
	Age (y)	56.4 ± 3.3		
	Height (cm)	168.6 ± 8.6		
Body Composition	Body mass (kg)	85.5 ± 19	85.6 ± 20.5	p = 0.723
	Body fat (%)	37.3 ± 5.9	37.2 ± 6	p = 0.875
	Fat mass (kg)	32.7 ± 11.9	32.8 ± 12.2	p = 0.874
	FFM (kg)	52.7 ± 8.8	52.8 ± 9.1	p = 0.769
	SMM (kg)	50.1 ± 8.4	50.1 ± 8.6	p = 0.783
Blood Pressure	Systolic (mmHg)	142.7 ± 20.6	135.5 ± 22.4	p = 0.039*
	Diastolic (mmHg)	94.2 ± 14.4	90.6 ± 13.6	p = 0.030*
VO <sub>2max</sub>	ml/kg/min	25.4 ± 5.6	28.4 ± 5.5	p = 0.001*

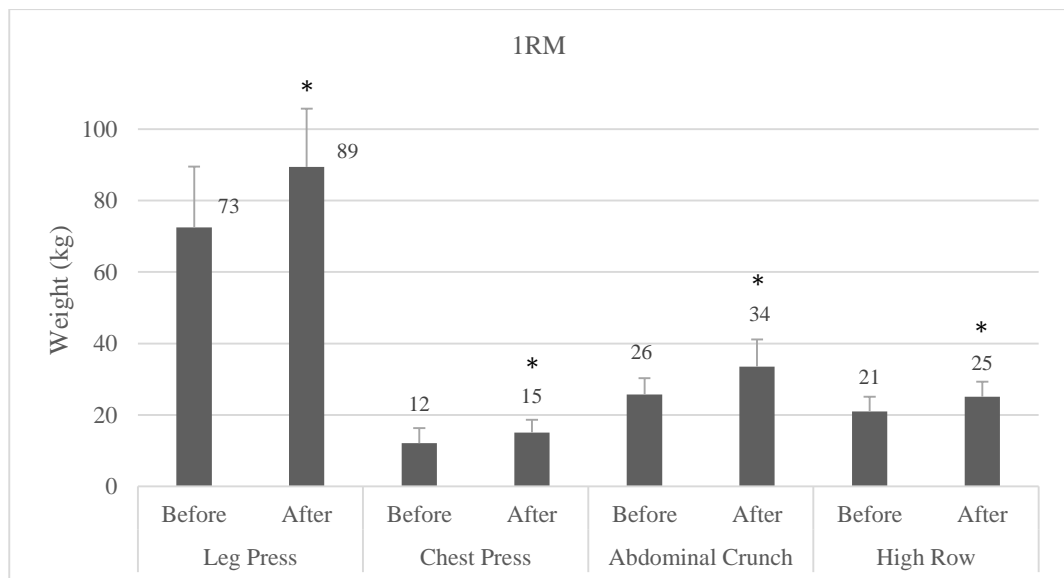


Figure 1: Muscular strength (1RM) in leg press, chest press, abdominal crunch and high row before and after the training intervention. Data are presented as mean and standard deviation.

\* Significant difference from before.

## **Discussion**

### *Results Discussion*

The aim of this study was to examine whether a periodized single-set resistance exercise protocol combined with an aerobic warm up and cool down is sufficient to elicit positive changes on body composition, blood pressure, total cholesterol, maximal strength,  $VO_{2max}$  and quality of life. The main findings were that maximal strength, blood pressure, maximal oxygen uptake and quality of life were all significantly improved after the training intervention. However, no significant changes were noted in any of the body composition parameters or total cholesterol levels.

These findings reinforce the 2011 ACSM's guidelines for physical activity, supporting the notion that single-set resistance exercise can elicit increases in 1RM in untrained individuals (Garber et al., 2011). Increases in 1RM were also similar to those recorded earlier in single-set protocols (Abrahin et al., 2014; Radaelli et al., 2014; Ribiero et al., 2015).

The fact that no significant differences was noted in any of the body composition variables conflicts with previous studies (Abrahin et al., 2014; Ribieiro et al., 2015; Westcott et al., 2009). It is suggested that the high repetition amounts (20 and 15 repetitions) during 2/3 of the study may possibly not be the most optimal to achieve significant increases in SMM and FFM and may explain the lack of significant differences. The lack of change in fat mass may be due to lack of nutritional supervision during the study, which other studies have done (Abrahin et al., 2014). Interestingly, participants reported having a bigger appetite than normal, which may have caused them to eat more than usual.

A significant decrease in blood pressure was noted after the exercise intervention for both systolic and diastolic blood pressure. Interestingly, similar results were noted as in the study by Westcott et al., (2009) in both systolic and diastolic blood pressure, which are in conflict with the meta-analysis by Cornelissen and Smart (2013), where no effect on diastolic blood pressure was noted in the combination groups. However, from this study and the study by Westcott et al., (2009), it seems



that a bout of both resistance and aerobic exercise together are capable of producing lowering effects on resting systolic and diastolic blood pressure.

No significant differences occurred in the total cholesterol levels after the training intervention. The findings are in an agreement with previous studies where resistance exercise had no effect on the amount of total cholesterol (Boardley et al., 2007; Kokkinois et al., 1988). However, the findings are in conflict with numerous studies and meta-analyses, where both aerobic, resistance and a combination of these two have led to significantly lower total cholesterol levels (Kelley and Kelley, 2009; Mann et al., 2014; Pitsavos et al., 2009). It is suspected that in this study, the preparation phase before the testing procedure was not standardized enough to observe any differences in total cholesterol. It may also be due to the lack of standardisation of nutritional intake during the study that may have negatively affected the cholesterol values during the study.

Interestingly, the 10-minute warm up and cool down at 70-80% of predicted  $HR_{max}$  resulted in 60 minutes of total aerobic activity during the week, which was enough to promote significant increases in  $VO_{2max}$ . These results are in an agreement with the ACSM's guidelines for physical activity, strengthening the argument that 20 minutes of vigorous physical activity three times a week is enough to achieve positive effects on physical health (Garber et al., 2011). Interestingly, this could be debated as there is evidence that concurrent exercise (resistance- and aerobic exercise performed in combination) inhibits the exercise response, resulting in lower gains of musculoskeletal aspects (Schumann et al., 2015), which could possibly explain the lack of significant increases in SMM. However, there are publications that dispute these claims about concurrent training (Lundberg et al., 2013), that could possibly explain why participants were able to increase both their maximal strength and maximal oxygen uptake simultaneously. However, this subject is beyond the scope of this paper, and it can be argued that worrying about the negative effects about concurrent training is nothing a sedentary individual who wants to engage in health promoting physical activity should worry about.

Most of the studies concerning exercise and mental health are often carried out in a fashion that measures some small sub-section that ultimately forms the concept

mental health or life quality. This study was able to use an instrument (RAND-36) that evaluates different sub-sections that are quantifiable into a mean value on a scale of 0-100 that represents the perceived quality of life. With the instrument it was possible to show a significant improvement on quality of life after the exercise intervention and conclude that a single-set resistance exercise protocol combined with aerobic activity indeed has a positive impact on quality of life on healthy middle-aged women. These findings are in agreement with a lot of studies discussed by O'Connor et al., (2010), but especially with a study done by Geirsdottir et al., (2012) that showed significant increases in health-related quality of life after a 12-week resistance exercise protocol, which was measured with a similar quality of life questionnaire. However, our results are in a conflict with the study by Benton and Wagner (2013), where no effect on quality of life was seen after resistance exercise with COPD patients, which may indicate that the outcome of resistance exercise on quality of life may be dependent on the health status of the participants, suggesting that different diseases may have an impact on the outcome.

#### *Methods discussion*

The fact that the maximal strength measurements were carried out with repetitions to failure and estimating the 1RM by the Brzycki (1993) formula - because the lack of resources and the potential risks of 1RM testing with participants who are not familiar with the proper techniques, and not with a traditional 1RM test, may have some effect on the trustworthiness of the results. However, there was a clear increase in all of the strength parameters and it can be assured that the maximal strength increased, but actually by how much, can be questioned.

The fact that no significant differences were noted in the body composition variables may depend on several factors. First, the bioelectrical impedance scale used in this study, even though it is approved for medical use, may not have been as accurate as needed to spot the small differences in the variables under such a short intervention time. In various other studies where differences in body composition after resistance exercise has been noted (Abrahin et al., 2014; Radaelli et al., 2014; Ribeiro et al., 2015), a more accurate dual-energy x-ray absorptiometry has been used, which is more accurate than a bioelectrical impedance scale (Kabiri

et al., 2015). Secondly, the lack of monitoring of the diet. Even though participants were informed to maintain their normal diet and leisure habits, several participants commented that they had felt a bigger appetite than normally and also ate more than normal. This would affect the results of body composition and body mass directly, as nutrition is as or even more important than physical activity in managing weight (Donnely et al., 2009).

The fact that both systolic and diastolic blood pressure dropped significantly during the training intervention can be discussed. There may have been a measurement error and that participants have not been as stressed out during the final testing occasion that have lowered their blood pressure, however, the results indicated such a high drop in blood pressure, especially in systolic, that it can be assured that this training intervention has had a lowering effect.

No effect on total cholesterol was noted following the training intervention. This may be due the lack of a scientifically-accurate measurement device (Scafoglieri et al., 2012), from where the blood sample was taken (fingertip blood sample) and that this study did not have a device that could distinguish the difference between LDL and HDL cholesterol, which are affected of resistance exercise. However, there should be also some visible changes in total cholesterol after a resistance exercise intervention (Kelley and Kelley, 2009).

The indirect method that was used to estimate  $VO_{2max}$  has not been proven to be as accurate as a direct method, but has a correlation of 0.916, with a standard error of  $2.5 \pm 7.5$  % with the testing protocol that utilizes two minute increments described by Takalo (2001). However, the two-minute testing protocol was only validated on men and women using a testing protocol that utilized one-minute increments, which had a significantly lower correlation (0.793) and a standard error of  $11.7 \pm 6.8$  %, Takalo (2001) concludes that the one-minute increment was not enough to reach steady-state heart rate on the participants, which may have reduced the validity of the protocol (Takalo, 2001).

Taking in to consideration that this study used the two-minute testing protocol, even though the participants were women, it can be fairly certainly concluded that there in fact has been an increase in  $VO_{2max}$ .

Future research should aim to determine whether similar results could be obtained in men and if similar multiple-set resistance exercise protocol could result in similar or better increases in the measured parameters. Future studies should also use more accurate measurement instruments and monitor the nutritional intake of the participants.

### *Conclusion*

A periodized single-set strength training protocol combined with an aerobic warm up and cool down is sufficient to promote significant improvements in maximal strength,  $VO_{2max}$ , and quality of life and both systolic and diastolic blood pressure in healthy, untrained middle-aged women. However, it may not be sufficient to elicit changes in body composition and total cholesterol levels.

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# Appendices

## Appendix 1: Informed consent.



### 1. Tausta ja tarkoitus

Liikunnalla on lukuisia positiivisia terveysvaikutuksia, kuten parantunut lihaskunto, sydämen ja verenkiertoelimistön toiminta sekä pienentynyt riski sairastua moniin tauteihin.

Tämän tutkimuksen tarkoituksena on selvittää yhdeksän viikkoa kestävästä periodisoidun kuntosalilla tapahtuvan harjoittelun vaikutuksia muun muassa lihasten voimantuottokykyyn, kehonkoostumukseen, kokonaiskolesterolin määrään sekä hapenottokykyyn.

### 2. Osallistumispyyntö

Olet vapaaehtoisesti Kotkan kaupungin tietojärjestelmän avulla ilmaissut halukkuutesi osallistua tutkimukseen "Health Effects of Periodized Single Set Resistance Training on Middle Aged Women" ja täten sinua pyydetään osallistumaan tutkimukseen.

### 3. Miten tutkimus suoritetaan?

Ennen harjoitusintervention alkamista suoritetaan jokaiselle osallistujalle testejä ja tutkimuksia, joissa mitataan kehonkoostumus, kokonaiskolesteroli, verenpaine, arvioitu maksimaalinen voima neljässä (4) eri harjoitusliikkeessä (jalkaprässi, rintaprässi, vatsarutistus sekä ylätalja) ja lopuksi arvioitu submaksimaalinen hapenottokyky porrastetulla polkupyöräergometritestillä.

Harjoitusinterventio on jaettu kolmeen (3) eri sykliin, jossa ensimmäisessä käytetään 20- toistoa kuntosaliharjoitteissa, toisessa syklissä 15- toistoa ja viimeisessä syklissä 10- toistoa. Harjoittelu tapahtuu kolme kertaa viikossa. Vastusten arvioimiseksi harjoitusjakson ajaksi käytetään kuntotesteistä saatuja tuloksia. Jokainen harjoitusyksi kestää kolme (3) viikkoa.

Harjoitusintervention aikana pienimuotoisemmat kuntotestit tullaan suorittamaan 3 viikon välein. Viimeisen harjoitusinterventioviikon jälkeen täysimuotoiset kuntotestit tullaan suorittamaan uudelleen. Viimeisten kuntotestien jälkeen tutkimus on valmis.

### 4. Riskit

Kaikkeen liikuntaan, kuntotestaaminen ja kuntosaliharjoittelu mukaan lukien, liittyy aina mahdollinen loukkaantumisriski, joka kuitenkin on hyvin minimaalinen, mikäli harjoitteet suoritetaan oikein ja henkilökunnan ohjeita noudatetaan.

### 5. Hyödyt

Osallistumalla ja suorittamalla tutkimuksen autat luomaan uutta tutkimustietoa kyseisestä harjoitusmenetelmästä muillekin ihmisille hyödyksi, jota voidaan tulevaisuudessa kehittää ja käyttää kansanterveyttä parantavassa tarkoituksessa.



## **6. Henkilö- ja tutkimustietojen käsittely ja yksityisyys**

Tiedot tullaan anonymisoimaan syöttövaiheessa siten, että henkilötiedot korvataan tietyillä koodeilla. Pelkästään vastaavalla testaajalla on pääsy kyseiseen henkilötietotiedostoon. Tietoja joita teiltä tullaan kysymään ovat: nimi, syntymäaika, pituus, terveystieto ja harjoitustausta, jonka olette jo puhelimitse luottamuksellisesti kertoneet.

Päätät itse mikäli haluat ylimääräistä tietoa itsestäsi kertoa. Tutkimuksesta vastaava henkilö on ainoa, jolla tutkimuksen aikana on pääsy henkilötietoihin ja ainoa henkilö, joka niitä analysoi.

Anonymisoituja testituloksia ja dataa tullaan kuitenkin analysoimaan ja esittelemään tieteellisissä artikkeleissa pelkkinä numerotietoina.

Sinulla on henkilötietolain perusteella oikeus tietää mitä henkilötietoja sinulta kysytään ja mihin niitä käytetään.

## **7. Käytännön informaatio**

Kaikki testit ja harjoittelu tullaan suorittamaan HealthEx Kotkan tiloissa osoitteessa:

Keskuskatu 12, 48100 Kotka

## **8. Miten saan tietää tutkimuksen tuloksista?**

Tutkimuksen päätyttyä, kun tulokset ovat valmiita, tulet saamaan mahdollisuuden tulla tapaamiseen jossa tulokset esitellään.

## **9. Vapaaehtoisuus**

Osallistuminen tutkimukseen on täysin vapaaehtoista ja voit koska tahansa tutkimuksen aikana keskeyttää osallistumisen, ilman mitään perusteluja tekemääsi päätökseen. Mikäli päätät keskeyttää osallistumisen tutkimukseen aikana, tullaan kaikki henkilöön liittyvä tieto hävittämään välittömästi.

## **10. Yhteystiedot**

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## **Tietoinen suostumus**

Vakuutan, että olen saanut tämän tietolomakkeen ja lisätietoja suullisesti kyseisestä tutkimuksesta. Annan suostumukseni olla mukana tutkimuksessa ja tiedän, että osallistumiseni on täysin vapaaehtoista. Olen tietoinen, että voin koska tahansa tutkimuksen edetessä keskeyttää osallistumiseni tutkimukseen. Annan suostumukseni siihen että henkilötietojani kerätään ja käytetään edellä mainitulla tavalla edellä mainittuun tarkoitukseen.

Annan suostumukseni myös siihen, että henkilötietojani säilytetään elektronisesti tutkimusvastaavan toimesta. Annan suostumukseni siihen, että tiedot jotka minusta kerätään, säilytetään ja niitä käytetään tutkimuksessa.

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Päivämäärä

Testihenkilön nimikirjoitus

Nimenselvennys

## Appendix 2: Health questionnaire.

### Tietoinen suostumus

Nimi: \_\_\_\_\_ Sosiaaliturvatunnus: \_\_\_\_\_

Sähköposti: \_\_\_\_\_ Puhelinnumero: \_\_\_\_\_

Ikä: \_\_\_\_\_ Pituus: \_\_\_\_\_ Paino: \_\_\_\_\_

### Täyttäkää ystävällisesti seuraavat kysymykset ennen kuntotestiin osallistumista:

Kyllä Ei Onko lääkäri suositellut sinua pidättäytymään liikunnasta?

Kyllä Ei Onko sinulla ollut rintakipuja viimeisten kuukausien aikana vaikka et  
ole harrastanut liikuntaa?

Kyllä Ei Huimaako sinua ja menetät helposti tasapainon kun harrastat  
liikuntaa?

Kyllä Ei Onko sinulla lihas- tai nivelkipuja jotka pahenevat liikuntaa  
harrastaessa?

Kyllä Ei Onko sinulla korkea verenpaine? (Systolinen >140mmHg,  
Diastolinen >90mmHg)

Kyllä Ei Onko sinulla diabetes? Jos kyllä, minkä tyyppinen: \_\_\_\_\_

Kyllä Ei Onko sinulla astma?

Kyllä En Syötkö vakituisesti jotain lääkettä? Jos kyllä, mitä: \_\_\_\_\_

Kyllä Ei Onko sinulla jokin muu syy miksi sinun ei tulisi harrastaa liikuntaa?  
Jos kyllä, mikä: \_\_\_\_\_

Täten annan suostumukseni vapaaehtoisesti osallistua kuntotestiin, jotta fyysinen kapasiteettini voidaan arvioida. Ymmärrän että suoritan kuntotestin vapaaehtoisesti ja voin keskeyttää testin koska tahansa, jos niin haluan.

Olen lukenut tietoisesti suostumukseni ja ymmärtänyt suoritettavan testiprotokollan ja sen riskit. Minulle on suullisesti kerrottu kuntotestistä ja olen saanut esittää kysymyksiä siihen liittyen. Tämän tiedon valossa annan suostumukseni kuntotestien suorittamiseen.

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Päivämäärä

Allekirjoitus