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# THE EFFECT OF AEROBIC EXERCISE WITH CALORIE RESTRICTION PROGRAM ON MUSCLE STRENGTH AND AEROBIC CAPACITY IN OVERWEIGHT AND OBESE WOMEN

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## ABSTRACT

*Background.* Few studies have demonstrated that different combinations of calorie restriction (CR) and aerobic exercise training improved aerobic capacity (Redman et al., 2007; Weiss et al., 2017) but did not change muscle strength (Weiss et al., 2017) in adult overweight subjects. However, the effect of six-month program combined of moderate intensity aerobic exercise (150 min/week) and 12.5% of CR on aerobic capacity and muscle strength remains unclear.

*The aim* of the present study was to estimate the effect of a six-month aerobic exercise with CR program on muscle strength and aerobic capacity in middle-aged, overweight and obese women.

*Methods.* Twenty-six overweight and obese sedentary women (36–56 years of age, body mass index (BMI) 25.0–37.5 kg/m$^2$) were recruited and randomly allocated to either control or experimental aerobic exercise with CR program group for six-month period. Changes in handgrip strength, knee extension and flexion strength and aerobic capacity ($VO_2$peak) were measured.

*Results.* Absolute peak $VO_2$ ($p < 0.001$) and normalized peak $VO_2$ ($p = 0.013$) significantly increased after the aerobic exercise with CR program. A greater normalized peak $VO_2$ ($p < 0.001$) was observed after the aerobic exercise and CR intervention compared with the control group. However, no effect was estimated on muscle strength in this study.

*Conclusions.* The combined 6-month aerobic exercise with CR program improved the aerobic capacity in middle-aged, overweight and obese women, but had no effect on isometric and isokinetic strength.

**Keywords:** diet; physical exercise; obesity; muscle; cardiovascular fitness.

## INTRODUCTION

Obesity rates worldwide have already reached alarming rates and almost one third of the whole population is currently classified as overweight or obese (*Global Burden of Disease Study,* 2015). Being overweight or obese increases the risk in developing various chronic conditions, such as diabetes mellitus, hypertension, cardiovascular disease, cancer (Bray, 2004; Singh et al., 2013), and impaired mental health (Anstey et al., 2011). In addition, obese individuals may experience a decline in motor functions (Wang et al., 2016) and demonstrate low level of aerobic

fitness (Prabhu et al., 2013). Thus, weight reduction is important in alleviating of such disadvantageous conditions.

Mostly researchers have examined the weight-loss effects of dietary restrictions or different types of exercise. Meta-analysis of clinical trials, which was conducted by J. Zibellini and colleagues (2016), identified that diet-induced weight loss have a great effect on reduced body weight, but it may have potential adverse effect on muscle mass and strength respectively. Moreover, weight loss induced by calorie restriction (CR) in overweight individuals includes effects such as a decrease in lean mass and a reduction in absolute aerobic capacity, which can be prevented by exercise (Larson-Meyer et al., 2010; Weiss et al., 2017). It is well established, that exercise-training programs can not only reduce the body weight, but also more importantly provoke fat tissue (Ross, Bradshaw, 2009), preserve skeletal muscle mass (Villareal et al., 2011) and improve aerobic capacity (Bouchonville et al., 2014). Consequently, few studies demonstrated that combination of CR and exercise training improved aerobic capacity in adult overweight subjects (Redman et al., 2007; Weiss et al., 2017). It was previously reported that muscle strength improved after resistance training with CR (eucaloric diet) intervention (Nicklas et al., 2015), but did not change in response to weight loss after CR (10% reduced calorie consumption) and moderate to vigorous cardiovascular exercise (60 min each day) (Weiss et al., 2017).

Even though there are several studies on the effect of different weight loss interventions combined of diet regimes and exercise trainings (Redman et al., 2007; Larson-Meyer et al., 2010; Nicklas et al., 2015; Weiss et al., 2017), the effect of the combination of slight CR (12.5%) with moderate intensity aerobic exercise (150 min/week) on muscle strength and aerobic fitness remains unclear. Thus, the aim of the present study was to estimate the effect of a 6-month aerobic exercise with CR program on muscle strength and aerobic capacity in middle-aged, overweight and obese women. The data in this report were from a study in which weight loss and its effect on psychosocial state, cognition and motor learning outcomes were primary outcomes. The primary outcomes have been published previously in L. Žlibinaitė et al.'s (2020) study, and the data in the present study reflect secondary outcomes.

## METHODS

**Participants.** Twenty-six overweight and obese physically inactive women (36–56 years of age, body mass index (BMI) 25.0–37.5 kg/m$^2$) were recruited to participate in this study. Potential participants underwent eligibility assessment

and were excluded from the study if they smoked or were alcohol drinkers; if they had a history of diabetes or cardiovascular disease; if they had BMI lower than 25 kg/m$^2$; if they experienced body weight change > 2 kg within last 2 months prior to enrollment; if they performed regular physical activity ≥ 1 h/week, if they were pregnant, postmenopausal or undergoing lactation. Participants provided informed written consent to participate in the study, which was approved by the Kaunas Regional Biomedical Research Ethics Committee (No. BE-2-5) and was conducted in accordance with the Declaration of Helsinki.

**Protocol.** The study was designed as a prospective controlled randomized trial. The participants arrived at the experiment room in the afternoon hours (between 4:00 and 6:00 PM) on the day of baseline measurements. Then body weight measurement, muscle strength and aerobic fitness were evaluated. Afterwards study participants were randomized into two groups, experimental (n = 13) or control (n = 13). Experimental group underwent 6-month aerobic exercise with calorie restriction program, while control group participants were instructed to continue their usual physical activity and nutritional habits. Final testing measurements were conducted after a 6-month period.

**Intervention.** Study intervention was designed to reduce body weight by 5–10% over 6 months and included both CR and exercise, as described previously (Žlibinaitė et al., 2020). CR was intended to create a 12.5% energy deficit. Exercise program comprised of 50 min moderate (50-60% of maximum heart rate (HR)) intensity aerobic exercise three times per week.

## MEASUREMENTS

*Body weight and BMI.* Weight (*TBF-300 body composition scale; Tanita, UK Ltd., UK*) was measured while the participants wore only underwear. BMI was calculated as weight in kilograms divided by squared height in meters.

*Handgrip strength.* A Jamar dynamometer (*Lafayette Instrument Company, USA*) was used to measure *isometric* handgrip *strength* of the dominant hand. The participant stood straight with her arm pointing to the front and the elbow bent at 90°. The subject was allowed to perform three trials, and the best result was used in analyses.

*Knee extension and flexion strength.* The concentric isokinetic strength of the right knee extensor and flexor muscles was assessed using a Biodex isokinetic dynamometer (*System 4, Biodex Medical Systems, Shirley, NY, USA*). Participants sat upright in the dynamometer chair with hip and knee flexion at 90° and were tied up using chest, waist, and thigh straps. The axis of rotation of the dynamometer was

aligned with the axis of rotation of the participant's right knee joint. Prior to the test, the participants performed a test-specific warm-up, which consisted of three repetitions of alternating knee extension and flexion at 25%, 50%, and 75% of maximal effort. Participants were instructed to keep their hands crossed in front of their chest and were encouraged to execute maximal voluntary contractions with maximal exertion without holding their breath and continue until the technician told them to stop; then, they relaxed and let their leg return to a neutral position (»90° knee flexion). The subjects performed three repetitions of maximal knee extension and flexion at an angular velocity of 60°/s in the concentric mode. The range of motion varied from 75° to 160°. The peak torque value was used as the measure of muscle strength.

*Aerobic capacity ($VO_2$peak).* $VO_2$peak was assessed by a graded exercise test on an electronically braked cycle ergometer (*Ergometrics 800S; ErgoLine, Medical Measurement Systems;* Binz, Germany). Oxygen uptake ($VO_2$) and carbon dioxide output ($VCO_2$) breath-by-breath data were collected and analyzed using an automated system (*Oxycon Mobile, Jaeger/VIASYS Healthcare,* Germany). Heart rate was measured using an HR monitor (*S-625X, Polar Electro,* Finland). The protocol started with the participants performing 3 min of warm-up on the cycle ergometer at a work rate of 40 W. Following the warm-up, the load was increased by two watts every five seconds. Participants aimed to maintain pedaling cadence at 70 rev/min. The test was continued until participants exhibited volitional fatigue, defined as inability to maintain the required pedal cadence.

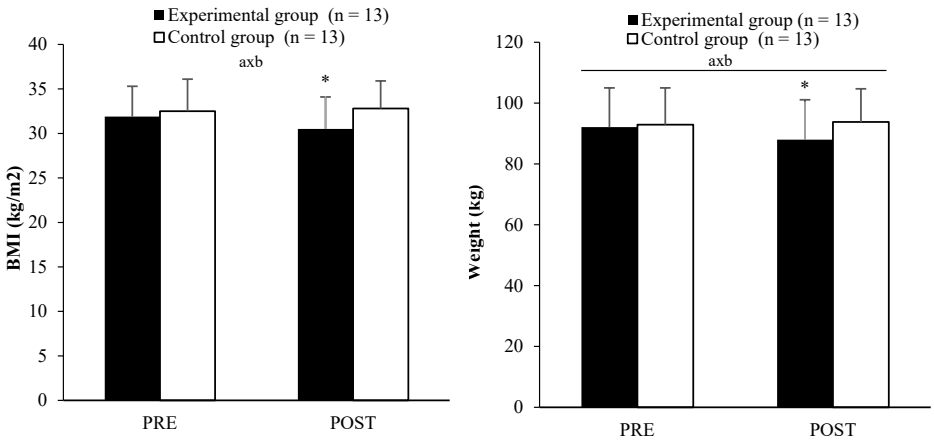
**Statistical analysis.** The normality of the data distribution was tested using the Kolmogorov–Smirnov test; all data were found to be normally distributed. A two-way ANOVA and a three-way ANOVA for repeated measures were used to determine the effect of the exercise plus CR intervention on selected variables. If significant time group or time group block interactions were found, *post hoc* testing was performed using paired *t* tests with a Bonferroni correction for multiple comparisons. Descriptive data are presented as mean ± SD. The level of significance was set at 0.05. If a significant effect was found, the observed power (OP) was calculated. All statistical analyses were performed using IBM SPSS Statistics for Windows (version 25.0, IBM Corp., Armonk, NY).

## RESEARCH RESULTS

*Weight and BMI.* The BMI and weight of the participants are presented in Figure 1. Although a two-way repeated-measures ANOVA of these anthropometric characteristics revealed no significant effects of time and state, it identified a significant time group interaction on BMI ($p < 0.001$, OP = 1.00) and weight

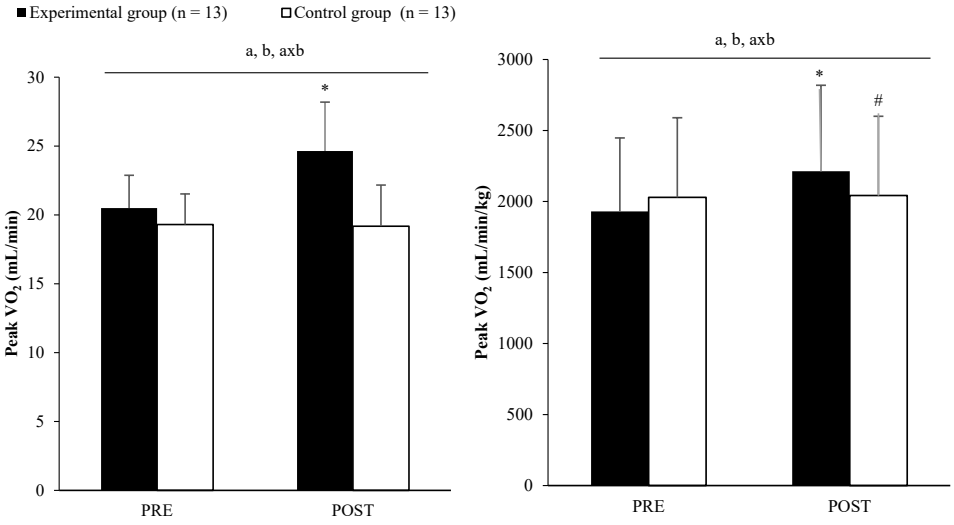
($p < 0.001$, OP = 1.00). Subsequent analysis showed that the combination of aerobic exercise with CR significantly decreased BMI ($p < 0.001$) and weight ($p < 0.001$).

*Aerobic capacity.* The aerobic capacity of the participants is presented in Figure 2. A two-way repeated-measures ANOVA of the aerobic capacity revealed a significant effect of time ($p = 0.003$, OP = 0.93 for absolute peak $VO_2$ and $p = 0.029$, OP = 0.63 for normalized peak $VO_2$), group ($p = 0.007$, OP = 0.84 for absolute peak $VO_2$), and the time group interaction ($p < 0.001$, OP = 0.99 for absolute peak $VO_2$ and $p = 0.007$, OP = 0.85 for normalized peak $VO_2$). Subsequent analysis showed that the combination of aerobic exercise and CR significantly increased absolute peak $VO_2$ ($p < 0.001$) and normalized peak $VO_2$ ($p = 0.013$). A greater normalized peak $VO_2$ ($p < 0.001$) was observed after the aerobic exercise with CR program compared with the control group.



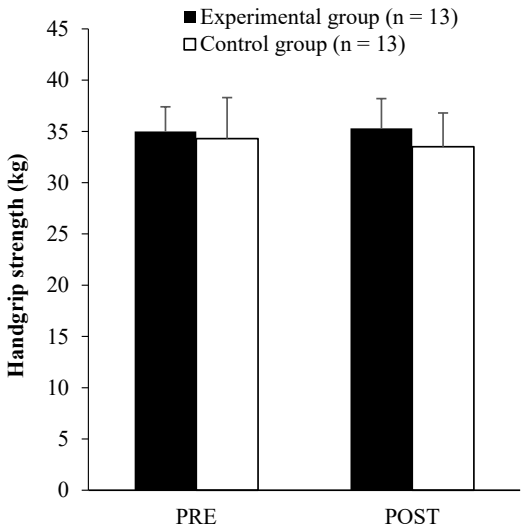

**Note.** Data are presented as mean ± standard deviation. $^{axb}p < 0.05$, time × group interaction effect; $*p < 0.05$, compared with before calorie restriction with aerobic exercise program. BMI, body mass index.

Figure 1. **The effect of aerobic exercise with calorie restriction program on the body weight and BMI**



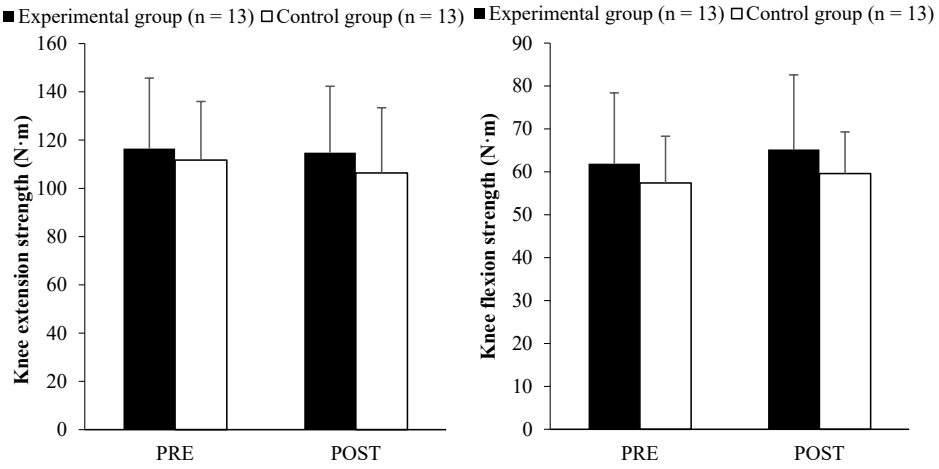

**Note.** Data are presented as mean ± standard deviation. $^{a}p < 0.05$, time effect.; $^{b}p < 0.05$, group effect; $^{axb}p < 0.05$, time × group interaction effect; $^{b}p < 0.05$, group effect; $^{*}p < 0.05$, compared with before calorie restriction and aerobic exercise program, $^{\#}p < 0.05$, compared with experimental group. $VO_2$, oxygen uptake.

Figure 2. **The effect of aerobic exercise with calorie restriction program on the aerobic capacity**




**Note.** Data are presented as mean ± standard deviation.

Figure 3. **The effect of aerobic exercise with calorie restriction program on the handgrip strength**




**Note.** Data are presented as mean ± standard deviation.

Figure 4. **The effect of aerobic exercise with calorie restriction program on the learning of the knee flexion and extension strength**

*Handgrip strength.* The handgrip strength of the participants is presented in Figure 3. A two-way repeated-measures ANOVA revealed the absence of a significant effect of time, group, or the time ´ group interaction on handgrip strength.

*Knee extension and flexion strength.* The knee extension and flexion strength is presented in Figure 4. A two-way repeated-measures ANOVA revealed the absence of a significant effect of time, group, or the time ´ group interaction on knee extension and flexion strength.

## DISCUSSION

The present study demonstrated how aerobic exercise with CR program affect isometric and isokinetic muscle strength and aerobic fitness in overweight and obese women. The 6-month program significantly reduced body weight and increased aerobic capacity, however muscle strength remained unchanged.

In accordance with the previous studies (Larson-Meyer et al., 2010; Washburn et al., 2014; Weiss et al., 2017), we observed a healthy effect of physical activity and CR on body-weight reduction. No losses of the upper or lower extremities muscle strength were observed in response to a decrease in body weight in present study.

In the previous studies, it was indicated that muscle mass decreases after CR intervention. On the contrary, aerobic exercise can prevent from muscle mass de-

crease after weight loss. These findings are similar to results from E. P. Weiss et al. (2017) study, where no changes in muscle strength were observed after CR and aerobic exercise intervention. Furthermore, it has supporting evidence that aerobic exercise training can produce muscle hypertrophy in sedentary individuals through different mechanisms like molecular regulation and protein metabolism (Konopka, Harber, 2014).

It seems that only resistance training in combination with CR may have an effect on muscle function improvements (Nicklas et al., 2015). Therefore, the application of both CR and resistance training for most effective weight loss is recommended not only to reduce weight but also to avoid negative changes in muscular efficiency (Villareal et al., 2017).

We have also observed that aerobic capacity, as expressed by peak oxygen consumption, significantly improved by 20.9 ± 17.3% for normalized and 17.2 ± 26.1% for absolute values. These improvements are in accordance with the previous studies on CR and exercise training interventions (Redman et al., 2007; Villareal et al., 2011; Weiss et al., 2017). It is apparently established that exercise programs consistent with the minimum physical activity guidelines (150 min/week of moderate-intensity physical activity or 75 min/week of vigorous intensity PA) are associated with cardiovascular health benefits (Haskell et al., 2007).

This study has limitations. First, the number of participants was not sufficiently large. Second, overweight and obese women were nor separated in this study. Third, the duration of the program may not have been sufficient to observe the decline in aerobic capacity and muscle functions in the control group to occur. Future studies should be considered revising the type of physical activity in order to ascertain the effect on muscle strength.

In conclusion, the combined 6-month aerobic exercise with CR program described here improved the aerobic capacity in middle-aged, overweight and obese women, but had no effect on isometric and isokinetic strength.

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**Conflict of interests**: Not applicable.

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# AEROBINIŲ PRATIMŲ RIBOJANT KALORIJAS PROGRAMOS POVEIKIS NUTUKUSIŲ IR TURINČIŲ ANTSVORĮ MOTERŲ RAUMENŲ JĖGAI IR AEROBINIAM PAJĖGUMUI

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SANTRAUKA

*Tyrimo pagrindimas.* Yra nustatyta, kad taikant skirtingas aerobinių fizinių pratimų ir kalorijų apribojimo kombinacijas svoriui mažinti, gali pagerėti suaugusių antsvorį turinčių asmenų aerobinis pajėgumas (Redman et al., 2007; Weiss et al., 2017), tačiau raumenų jėga išlieka nepakitusi (Weiss et al., 2017). Visgi lieka neaišku, kokį poveikį turi šešių mėnesių trukmės 12,5% kalorijų apribojimo ir 150 minučių per savaitę vidutinio intensyvumo aerobinių pratimų programa.

*Tyrimo tikslas* – įvertinti šešių mėnesių trukmės aerobinių pratimų ribojant kalorijas programos poveikį nutukusių ir turinčių antsvorį moterų raumenų jėgai ir aerobiniam pajėgumui.

*Metodai.* Dvidešimt šešios turinčios antsvorį ir nutukusios (36–56 metų, kūno masės indeksas (KMI) 25,0–37,5 kg/m$^2$) fiziškai neaktyvios moterys buvo atsitiktinai suskirstytos į kontrolinę (n = 13) arba tiriamąją (n = 13) grupę, kuriai buvo taikyti aerobiniai pratimai ir kalorijų apribojimas. Tyrimas truko šešis mėnesius. Buvo išmatuoti plaštakos sugriebimo jėgos, blauzdos tiesimo ir lenkimo raumenų jėgos, aerobinio pajėgumo ($VO_2$peak) pokyčiai.

*Rezultatai.* Absoliutus $VO_2$peak ($p < 0{,}001$) ir santykinis $VO_2$peak ($p = 0{,}013$) reikšmingai padidėjo po aerobinių pratimų ribojant kalorijas intervencijos. Palyginus su kontroline grupe, didesnis santykinis $VO_2$peak ($p < 0.001$) buvo nustatytas po intervencijos. Visgi nebuvo nustatyta reikšmingo plaštakos sugriebimo, blauzdos lenkimo ir tiesimo raumenų jėgos pokyčio.

*Išvados.* Šešių mėnesių trukmės aerobinių pratimų ribojant kalorijas programa pagerino turinčių anstvorį ir nutukusių moterų aerobinį pajėgumą, tačiau neturėjo įtakos jų izometrinei ir izokinetinei raumenų jėgai.

**Raktažodžiai:** dieta, fiziniai pratimai, nutukimas, raumenys, širdies ir kraujagyslių sistemos pajėgumas.

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