

The Effects of Resistance Training Voluntary to Failure on Muscle Mass and Strength in Overweight Men

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ABSTRACT

Skeletal muscle has an often-underappreciated role in health, with low muscle strength being linked with increased risk of a range of poor health outcomes such as diabetes, cardiovascular disease, cancer, and respiratory disease mortality. Recently, if exercise is performed voluntary to failure, then gains in muscle mass and strength are similar regardless of the load at which exercise is performed. This study aimed to examine the effects of three days per week of resistance training voluntary to failure on muscle adaptations in overweight men consisting of one set of eight exercises. A total of 10 overweight men were recruited for this study. Each exercise was performed based on 80% of 1-RM voluntary to failure and lasted around 30 minutes. The 1-RM test and body composition tests were performed during the baseline and post-intervention. The three sessions per week for six weeks of resistance training of one set per eight exercises to voluntary failure resulted in an increment of 2.3% in muscle mass, and 25.5% in muscle strength. Other than that, a 4.9% reduction in body fat percentage was also observed in this study. It could be concluded that six weeks of three-session resistance training per week voluntary to failure results in an improvement in muscle strength, muscle mass, and reduction of body fat percentage in overweight men.

Keywords: muscle mass, muscle strength, overweight, resistance training, voluntary to failure

INTRODUCTION

A recent meta-analysis found that high-intensity resistance training failure (HIRT-F) did not result in greater improvements in muscle strength than non-failure HIRT. The impact of resistance training on muscle failure on muscle mass, on the other hand, remains unknown (Nóbrega et al., 2018). Overweight people have emerged as a larger percentage of the population over time. Overweight is defined as a body mass index (BMI) of more than or equal to 25 kg-m² (World Health Organization, 2021).

According to Stevens et al. (2012), the prevalence of overweight and obesity has increased across the country since 1980. In Malaysia, the number of overweight adults has increased since 1996 (Khambalia & Seen, 2010). Overweight adults accounted for 39 per cent of deaths, while cardiovascular disease accounted for two-thirds of deaths among those with a high BMI (Afshin et al., 2017). Malaysian adults aged 55 to 59 years old had the highest prevalence of overweight people. Besides that, a nationwide survey conducted in 2019 revealed a rising trend in obesity prevalence, increasing from 15.1% in 2011 to 17.7% in 2015, and finally to 19.9% in 2019 and Malaysia has the highest prevalence of obesity among adults in Southeast Asia (NHMS, 2019).

Due to time constraints, the majority of people did not engage in physical activity (Petrin et al., 2017) and lack of time due to social and family responsibilities was considered the most important barrier to physical activity among students in Malaysia (Annuruzal et al., 2021). Low muscle strength has been related to a higher risk of cardiovascular disease, pulmonary disease, and cancer (Celis-Morales et al., 2018) and is directly linked to muscle growth and strength gains (Mangine et al., 2015) as a vital to lower the risk of developing health problems (Ashton et al., 2020). According to the American College of Sports Medicine, resistance exercise should be done two to three times per week (ACSM). Overweight or obese people, on the other hand, should adhere to other rules. They should exercise five days or more per week at a moderate to vigorous level to maximise calorie expenditure. A resistance-training-based exercise programme is crucial for enhancing lean mass in overweight people, according to Willis et al. (2012). Six weeks of resistance exercise has been found to improve muscular strength and quality (Scanlon et al., 2014). High-intensity resistance training, according to Mangine et al. (2015), led to a greater improvement in strength and hypertrophy in a shorter period. Training to failure has also been shown to increase exercise-induced metabolic stress, allowing for a higher possibility of hypertrophic response (Schoenfeld, 2010). Ismail et al. (2019) found that six weeks of single-set resistance training to voluntary failure results in a favourable adaptation to muscle strength and mass increase in overweight people. Individuals from the Caucasian population were found to benefit from three sessions of short-duration resistance training each week for six weeks to improve muscle strength. In this study, researchers examine how three sessions of resistance training, consisting of three rounds of each exercise to voluntary failure over six weeks, influenced muscle strength, muscle mass, and body fat in overweight men in Malaysia.

In the study by Willis and colleagues (2012), a training program that includes resistance training is crucial to increase muscle mass among overweight individuals. This is further corroborated by the research of Ismail et al. (2019), which found that the resistance training intervention improved the lean muscle mass and strength of the overweight participants. Several factors, including frequency, volume, and intensity, are controlled in the resistance training programme in order to create certain muscle adaptations (ACSM, 2013; Schoenfeld et al., 2017). For a short-term training period, it is proven that high-intensity training will stimulate greater improvement in muscle hypertrophy and strength (Mangine et al., 2015). If the load of the exercise is low and did not induce any fatigue in the muscle, the hypertrophic response could not be achieved (Burd et al., 2012).

Nowadays, there are a lot of studies that investigate the effects of different frequencies and duration of resistance training on the adaptation in the body. The most common frequencies of resistance training are three times per week and followed by two times per week (Ashton et al., 2020). Bear in mind that body fat percentage will increase over time if nothing is done to replace the lean muscle lost over time. Strength training can help in preserving and enhance muscle mass at any age. According to an article in *New Science* (Sept 21, 2022) on a systematic review and meta-analysis that reviewed and analysed existing evidence, about 1.4% of entire body fat can be lost through strength training alone, which is similar to how much that can be lost through cardio or aerobics.

The study by Garber et al. (2011) has proven that exercise is essential in promoting a healthy lifestyle to maintain function through the effects on muscle mass and strength. By consistently engaging in aerobic or resistance exercise, several adaptations to the body's systems can be observed (Marzetti et

al., 2017). A person's cardiovascular and muscular fitness can be improved by engaging in both aerobic and resistance training (Garber et al., 2011).

A single set of resistance training to voluntary failure for six weeks can improve muscle strength, size, and insulin sensitivity among overweight men (Ismail et al., 2019). Dankel et al. (2016) stated that exercising to failure is an appropriate strategy to compare the efficacy of the exercise protocols.

METHODS

Research Design and Procedure

This study's research design is an experimental design. A baseline assessment was performed on all participants. The participant's body composition, which includes body mass, height, BMI, muscle mass, body fat, and 1-RM measures, were measured during the baseline visit. During the six-week training programme, 1-RM data were used to assess the intensity. The study was approved and carried out in accordance with the guideline established by the board of the research ethics committee (REC) Universiti Teknologi MARA (REC/156/2022). The participants were informed about the study's goal, given the PAR-Q (Warburton et al., 2021), a consent form to participate, and given an overview of the experimental protocol. A body composition analyser (TANITA BC-418, Tokyo, Japan) was used to measure the participants' body fat and muscle mass according to the manufacturer's instructions. Eight exercises were used to assess the individuals' 1-RM strength (Ismail et al., 2019) and the subjects completed all eight exercises at their highest one-rep lifting capabilities by machine for leg press, leg extension, calf raise, bench press, bent-over row, lat pull down, bicep curl & triceps curl. The resistance training intervention was carried out for six weeks after the baseline data was obtained. The participants visited four times a week: three times for resistance training and one time for body composition measurements. At the conclusion, of the six weeks intervention, the post-intervention data were collected three days later. The 1-RM Strength Test was performed both before and after the intervention. Before starting the 1-RM Strength Test, the individuals went through a recommended warm-up. After getting instructions from the researcher, the subjects begin the 1-RM Strength Test (Ismail et al., 2019). The 1-RM evaluation was documented by the same researcher at both the baseline and post-intervention visits.

Participants

A total of 10 male subjects, ranging between 18 to 45 years old and with a BMI of $25 \text{ kg}\cdot\text{m}^{-2}$ to $29.9 \text{ kg}\cdot\text{m}^{-2}$, were recruited for this study (Ismail et al., 2019). With the statistical power of $1-\beta = 0.80$ and $\alpha = 0.05$, the sample size calculation (Dupont & Plummer, 1998) found that 10 participants would allow the detection of a significant difference of 1 per cent in body fat mass (Ismail et al. 2019). The inclusion criteria were males aged between 18 – 45 years old and a BMI of $25 \text{ kg}\cdot\text{m}^{-2}$ to $29.9 \text{ kg}\cdot\text{m}^{-2}$. We excluded those with injuries, metabolic, and cardiovascular diseases, blood pressure $<140/90\text{mmHg}$, and participated in moderate-high intensity aerobic exercises and resistance training in the past two years.

Data Analysis

All the data were presented as mean \pm standard deviation. All data obtained in this research were analysed using the Statistical Package for the IBM SPSS v26 2016. The muscle mass, body fat, and 1-RM were compared (baseline versus post-intervention) using paired sample t-tests. The significance value was set at $p < 0.05$.

RESULTS

Physical Characteristics

Table 1 presents the physical characteristics of the participants including height, weight, and body mass index. The mean height of the participants is 170.4 ± 6.16 cm, the mean weight of the participants is 81.6 ± 8.2 kg, while the mean body mass index of the participants is 28.0 ± 1.4 kg/m².

Table 1: Physical Characteristics of Participants

(N=10)	Mean	Sd	Min	Max
Height (kg)	170.4	6.16	160.0	177.5
Weight (cm)	81.6	8.2	69.0	92.0
Body Mass Index (kg·m ⁻²)	28.0	1.4	26.0	29.5

Muscle Mass

Based on the result obtained, Figure 1 shows the main effects of time on muscle mass. The mean muscle mass during the baseline was 48.9 ± 12.3 kg. After six weeks of resistance training intervention, the mean muscle mass during the post-intervention was 50.1 ± 11.9 kg. Results show $3.0 \pm 3.1\%$ improvement in muscle mass ($r=0.0012$).

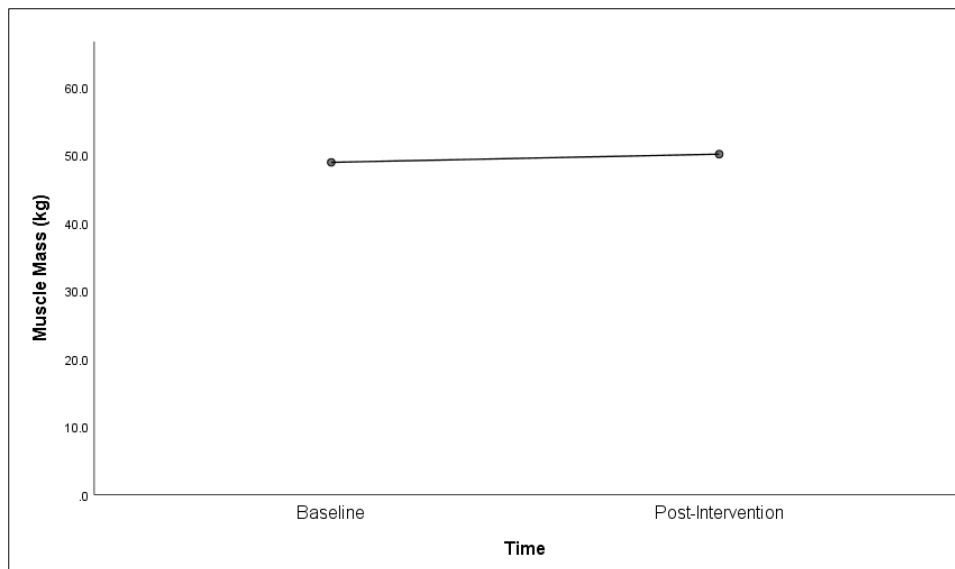


Figure 1: Muscle Mass Time-Course of Adaptations in Response to Six Weeks of Resistance Training Voluntary Failure Intervention. Data are presented as mean \pm SD.

Muscle Strength

Table 2 shows the descriptive detail of the changes in the mean values of muscle strength across the resistance training intervention. The 1 – RM test for all eight exercises showed significant differences between the baseline and the post-intervention measurements. Overall, the sum of the individuals 1 – RMs for all eight exercises is $25.5 \pm 4.9\%$ higher after the intervention when compared to the baseline values.

Table 2: One Repetition Maximum for Training Exercises Before and After Six Weeks of Resistance Training Intervention. Data are Means \pm SD.

Variables	Baseline (kg)	Post – Intervention (kg)	Percentage Increase (%)
Leg Press 1RM	198.1 \pm 24.8	259.8 \pm 30.9	31.8 \pm 11.8
Leg Extension 1RM	54.5 \pm 4.7	82.4 \pm 4.6	51.5 \pm 8.4
Calf Raises 1RM	76.9 \pm 6.2	93.2 \pm 8.6	20.6 \pm 4.5
Bench Press 1RM	47.6 \pm 4.3	61.6 \pm 7.9	29.1 \pm 9.5
Bent Over Row 1RM	17.5 \pm 1.7	22.3 \pm 1.4	27.6 \pm 5.8
Lat Pull Down 1RM	9.1 \pm 1	10.8 \pm 1.2	18.8 \pm 8.8
Bicep Curl 1RM	12.5 \pm 1.7	21.4 \pm 1	73.3 \pm 18.4
Triceps Curl 1RM	12.5 \pm 1.7	21.4 \pm 1	73.3 \pm 18.4
Sum of Individual 1RM	456.4 \pm 37.1	57.2 \pm 47.1	25.5 \pm 4.9

Body Fat Percentage

Based on the result obtained, Figure 2 shows the main effect of time on body fat. The mean body fat during baseline was $27.6 \pm 2.9\%$. After six weeks of resistance training intervention, the mean body fat percentage during the post-intervention was $26.2 \pm 2.7\%$. The body fat shows $4.9 \pm 2.8\%$ decrement after six weeks of resistance training intervention ($r=0.01$).

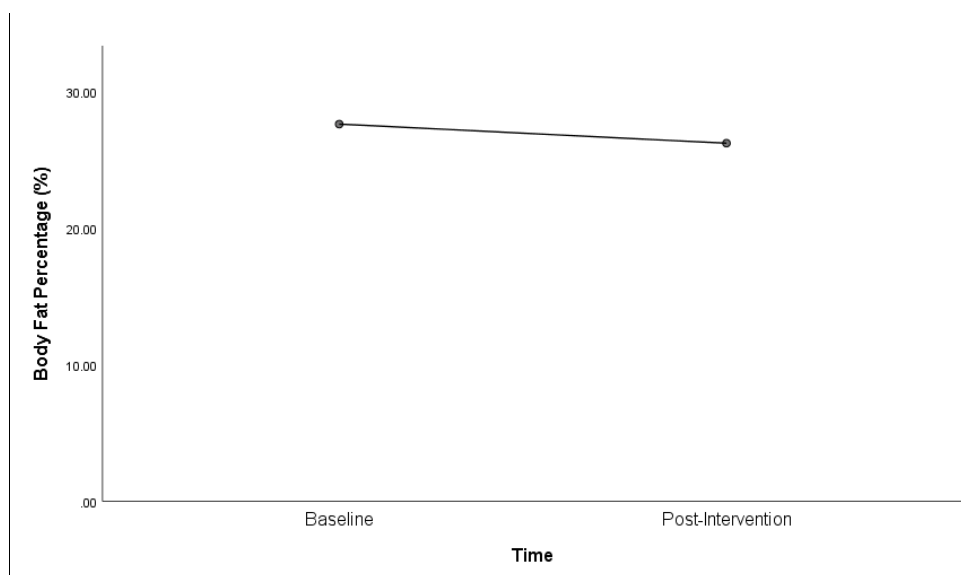


Figure 2: Body fat percentage time-course of adaptations in response to six weeks of Resistance Training voluntary to failure intervention. Data are presented as mean \pm SD.

Discussion

The present study has shown that three sessions per week for 6 weeks of resistance training of one set per eight exercises to voluntary failure resulted in an increment of 3.0% in muscle mass and 25.5% in muscle strength. Other than that, we also found a reduction in body fat percentage even though

this was not our main objective of this study. As the previous study has shown that a short period of resistance training had improved insulin sensitivity among overweight men and did reduction on body fat percentage (Ismail et al., 2019), this present study has proven that three sessions per week for six weeks of resistance training had a positive effect on muscle strength and muscle mass.

A single set of resistance training to voluntary failure for six weeks can improve muscle strength, size, and insulin sensitivity among overweight men (Ismail et al., 2019). For a short-term training period, it is proven that high-intensity training will stimulate greater improvement in muscle hypertrophy and strength (Mangine et al., 2015). The results of previous studies are supported by this present study, as the muscle strength of this present study has stated a 25.5% of muscle increment at the post-intervention. Such increment is done at a short-term training period that was done for 6 weeks of resistance training voluntary to failure. Continuous loss of body fat through resistance training is an effective method to improve cardiometabolic health as it improves the resting blood pressure, V_{O2max} , and blood biomarker for both healthy people and people with cardiometabolic risk (Ashton et al., 2020). According to the article in *New Science* (Sept 21, 2022), a systematic review and meta-analysis of existing evidence show that 1.4 per cent of entire body fat can be lost through strength training alone, which is similar to how much that can be lost through cardio or aerobics.

Even by not adding a dietary plan to their resistance training program, doing resistance training voluntary to failure alone can help the decrement of body fat percentage. The results have shown that three sessions per week for six weeks of resistance training voluntary to failure had a 4.9% decrement among overweight men. Being physically inactive will cause weight gain, loss of muscle mass, and bone density (Shiroma et al., 2017). Having low muscle strength is associated with a higher risk of getting health problems such as cardiovascular disease, respiratory disease, and cancer (Celis-Morales et al., 2018). As a result, this study has been able to show that doing only three sessions of short-duration resistance training voluntarily to failure was able to increase muscle strength. This study also supports the previous study by Ismail et al. (2019) that doing a single set of resistance training voluntary to failure three times per week is effective to increase muscle strength and muscle thickness. On top of this, the present study included 10 subjects and in future could be suggested to increase the number of subjects and the duration of the intervention. Therefore, the true magnitude of the effect of resistance exercise might differ from that reported here.

CONCLUSION

In conclusion, the present study shows that three sessions per week for six weeks of resistance training voluntary to failure performed at 80% of 1-RM for one set per exercise show an increase in muscle strength, muscle mass, and a reduction of body fat percentage. This finding supports the previous study of three sessions per week of resistance training. All the results were significant ($p < 0.05$) and rejected all the null hypothesis.

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AUTHORS' CONTRIBUTION

Dzulkarnain, A., Basil, I., and Gray, S. conceived and planned the experiments. Dzulkarnain, A. and Basil, I. carried out the experiments and data preparation. Kamal, H. and Al Hafiz, A. planned and carried out the simulations. Kamal, H. contributed to the interpretation of the results. Dzulkarnain, A. and Basil, I. took the lead in writing the manuscript. Gray, S., Ain, E., and Masshera, J. provided critical feedback and helped shape the research, analysis, and manuscript.

CONFLICT OF INTEREST DECLARATION

We certify that the article is the Authors' and Co-Authors' original work. The article has not received prior publication and is not under consideration for publication elsewhere. This research has not been submitted for publication nor has it been published in whole or in part elsewhere. We testify to the fact that all Authors have contributed significantly to the work, validity and legitimacy of the data and its interpretation for submission to Jurnal Intelek.

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