EFFECTS OF RESISTANCE TRAINING ON SELECTED HEALTH-RELATED FITNESS VARIABLES AMONG FEMALE STUDENTS OF UNIVERSITI SAINS MALAYSIA, HEALTH CAMPUS

by

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ABSTRAK

Tujuan kajian ini dijalankan adalah untuk mengenal pasti kesan latihan beban dalam kalangan pelajar perempuan di Universiti Sains Malaysia, Kampus Kesihatan ke atas pemboleh ubah tertentu kecergasan berkaitan kesihatan yang meliputi komposisi badan, kekuatan otot, ketahanan otot dan kelenturan. Seramai dua puluh pelajar perempuan Universiti Sains Malaysia, Kampus Kesihatan (20.3 ± 0.7 tahun) yang sihat telah terlibat di dalam kajian ini. Semua subjek menjalani pra-ujian di mana ukuran antropometrikal, komposisi badan, kekuatan otot, ketahanan otot and kelenturan mereka diukur. Mereka dibahagikan kepada kumpulan kawalan (n=10) dan kumpulan senaman (n=10) secara rawak. Kumpulan kawalan akan meneruskan aktiviti fizikal mereka seperti biasa manakala kumpulan senaman akan menjalani program latihan beban yang terdiri daripada sepuluh senaman beban untuk satu sesi, sebanyak tiga sesi seminggu. Selepas enam minggu, semua subjek akan menjalani post-ujian untuk mengukur ukuran antropometrikal, komposisi badan, kekuatan otot, ketahanan otot and kelenturan mereka. Keputusan menunjukkan tiada perbezaan signifikan ($p > 0.05$) di kesemua ukuran di atas di antara dua kumpulan tersebut. Walaupun tiada keputusan yang signifikan, satu trend peningkatan dapat dilihat pada komposisi badan serta kekuatan belakang dan kaki dalam kalangan kumpulan senaman selepas enam minggu latihan beban. Keputusan ini menunjukkan bahawa latihan beban sememangnya membawa manfaat kepada kecergasan berkaitan kesihatan dalam kalangan pelajar perempuan dan ia sepatutnya dijadikan sebagai salah satu senaman rutin selain senaman aerobik.

ABSTRACT

The purpose of this study was to examine the effects of resistance training among female students of Universiti Sains Malaysia, Health Campus on selected health-related fitness variables including body composition, muscular strength, muscular endurance and flexibility. A total of twenty healthy female students of Universiti Sains Malaysia, Health Campus (20.3 ± 0.7 years old) were involved in this study. All subjects underwent pre-test where their anthropometrical measurements, body composition, muscular strength, muscular endurance and flexibility were measured. They were randomly assigned into control group (n=10) and exercise group (n=10). The control group resumed with their normal physical activity while the exercise group underwent resistance training programme which comprised of ten resistance exercises per session, thrice a week. After six weeks, all the subjects underwent post-test to measure their anthropometrical measurements, body composition, muscular strength, muscular endurance and flexibility. The findings revealed no significant difference ($p > 0.05$) in above measurements between the two groups. Although there were no significant differences, a trend of improvement could be observed in body composition and back and leg strength among exercise subjects after six weeks of resistance training. The results show that resistance training does bring benefits on health-related fitness among female students and it should be made a part of regular exercise apart from aerobic exercise to improve health-related fitness.

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Resistance training is a form of exercise whereby an individual is trying to lift or move a given weight or resistance through a certain range of motion. The actual resistance (weight) to be lifted or moved generally is expressed as a percentage of maximal capacity. 1-repitition maximum (1-RM) load refers to the maximum load or the highest resistance that can be moved only once. Resistance training can use static contractions, dynamic contractions or both. Dynamic contractions can include either or both concentric and eccentric contractions using free weights, variable resistance, isokinetic actions, and plyometrics.

Resistance training, also known as strength or weight training, is well established as an effective method of exercise for developing muscular fitness (Hass et al., 2001). Fleck and Kraemer (1988) describe the primary goals of resistance training as improving muscular strength and endurance, while other health-related benefits derived from resistance training include increases in bone mass, reduced blood pressure, increase in muscle and connective tissue cross-sectional area (CSA), reduced body fat, and it may relieve low back pain. Therefore, resistance training is not only for competitive athletes wishing to enhance their performance through increased muscular strength, power, endurance and hypertrophy, but also for general population who wish to alter their body composition or increase their capacity to perform tasks requiring muscular efforts.

However, one does not simply lift a weight without any planned or organized resistance training programme and expect to achieve a specific training outcome, be it the muscular strength, muscular endurance, power or hypertrophy. Bird et al. (2005) emphasized that designing a resistance training programme is a complex process which incorporates several acute programme variables and key training principles. The acute programme variables include muscle action, loading and volume, exercise selection and order, rest periods, repetition velocity and frequency. Proper programme design is essential to maximize the benefits associated with resistance training.

With that, the American College of Sports Medicine (2002) has come up with resistance training recommendations which give us an overview of different programme variables needed for progression with different fitness level. The ACSM guideline towards resistance training is presented in Figure 1.1.

Although resistance training is getting more popular among general population, there is still lack of interest among the females to actually engage with resistance training and made it as part of their exercise programme. Most of them fear that with resistance training they might get bulky or physically become too muscular. However females do not have that high level of testosterone hormone, which primary function is to promote muscle growth, as compared to their male counterparts. Therefore this fear should not stop them from engaging with resistance training and miss out the health-related fitness benefits.

	Muscle Action	Selection	Order	Loading	Volume	Rest Intervals	Velocity	Frequency
Strength			For Nov, Int, Adv:			For Nov, Int, Adv:		
Nov.	ECC & CON	SJ & MJ ex.	Large < small	60–70% of 1RM	1–3 sets, 8–12 reps	2–3 min. for core	S, M	2–3×/week
Int.	ECC & CON	SJ & MJ ex.	MJ < SJ	70–80% of 1RM	Mult. Sets, 6–12 reps	1–2 min. for others	M	2–4×/week
Adv.	ECC & CON	SJ & MJ ex. – emphasis: MJ	HI < L	1RM – PER.	Mult. Sets, 1–12 reps – PER		US-F	4–6×/week
Hypertrophy			For Nov, Int, Adv:					
Nov.	ECC & CON	SJ & MJ ex.	Large < small	60–70% of 1RM	1–3 sets, 8–12 reps	1–2 min.	S, M	2–3×/week
Int.	ECC & CON	SJ & MJ ex.	MJ < SJ	70–80% of 1RM	Mult. Sets, 6–12 reps	1–2 min.	S, M	2–4×/week
Adv.	ECC & CON	SJ & MJ	HI < L	70–100% of 1RM with emphasis on 70–85% – PER	Mult. Sets, 1–12 reps with emphasis or 6–12 reps – PER	2–3 min. – VH 1–2 min – L-MH	S, M, F	4–6×/week
Power		For Nov, Int, Adv:	For Nov, Int, Adv:	For Nov, Int, Adv:		For Nov, Int, Adv:		
Nov.	ECC & CON	Mostly MJ	Large < small	Heavy loads (>80%) – strength Light (30–60%) – velocity – PER	Train for strength	2–3 min. for core	M	2–3×/week
Int.	ECC & CON		Most complex < least complex		1–3 sets, 3–5 reps	1–2 min. for others	F	2–4×/week
Adv.	ECC & CON		HI < L		3–6 sets, 3–5 reps – PER		F	4–6×/week
Endurance			For Nov, Int, Adv:			For Nov, Int, Adv:	For Nov, Int, Adv:	
Nov.	ECC & CON	SJ & MJ ex.	Variety in sequencing is recommended	50–70% of 1RM	1–3 sets, 10–15 reps	1–2 min for high rep sets	S – MR	2–3×/week
Int.	ECC & CON	SJ & MJ ex.		50–70% of 1RM	Mult. Sets, 10–15 reps or more	<1 min for 10–15 reps	M – HR	2–4×/week
Adv.	ECC & CON	SJ & MJ		30–80% of 1RM – PER	Mult. Sets, 10–25 reps or more – PER			4–6×/week

ECC, eccentric; CON, concentric; Nov., novice; Int., intermediate; Adv., advanced; SJ, single-joint; MJ, multiple-joint; ex., exercises; HI, high intensity; LI low intensity; 1RM, 1-repetition maximum; PER., periodized; VH, very heavy; L-MH, light-to-moderately-heavy; S, slow; M moderate; US, unintentionally slow; F, fast; MR, moderate repetitions; HR high repetitions.

Figure 1.1 Summary of resistance training recommendations: an overview of different programme variables needed for progression with different fitness level.

(ACSM, 2002)

1.2 Objectives of the study

The general objective of this study is:

- To find out the effects of resistance training on selected health-related fitness variables among female students of Universiti Sains Malaysia, Health Campus.

The specific objectives of this study are:

1. To measure the effect of resistance training on body composition.
2. To measure the effect of resistance training on muscular strength.
3. To measure the effect of resistance training on muscular endurance.
4. To measure the effect of resistance training on flexibility.

1.3 Hypothesis of the study

H_o: There are no significant effects of resistance training on health-related fitness variables among female students of Universiti Sains Malaysia, Health Campus.

H_A: There are significant effects of resistance training on health-related fitness variables among female students of Universiti Sains Malaysia, Health Campus.

1.4 Significance of the study

Time seems to be a common excuse among students to not participating in physical activity. Even if they do engage with physical activity, resistance training seems to be

their least preferred form of exercise, especially among the females. Within the busy academic schedule of female students, it seems important for us to examine the effects of physical activity in the form of resistance training. That may help combining studies with improvements in health-related fitness variables. Apart from that, this study will also help to provide the students with various options of physical activity for them to choose.

1.5 Operational definitions

1. Health-related fitness

   An ability to perform daily activities with vigor, and the possession of traits and capacities that are associated with a low risk of premature development of hypokinetic diseases (e.g., those associated with physical inactivity).

2. Resistance training

   A form of exercise whereby an individual is trying to lift or move a given weight or resistance through a certain range of motion.

3. 1 Reptition Maximum (RM)

   Maximum load or the highest resistance that can be moved only once.

4. Muscular strength

   Ability of a muscle or muscle groups to exert a single force against a resistance.

5. Muscular endurance

   Ability of a muscle or muscle groups to exert force repeatedly or over a period of time.

6. Flexibility

   Ability of a joint to move through its complete range of motion (ROM).

CHAPTER 2

REVIEW OF LITERATURE

2.1 Impact of resistance training on body composition in women

Resistance training is also known as a form of exercise which can modify or improve an individual's body composition. The usual improvements which can be seen after a resistance training programme were increase in lean body mass and reduced body fat mass. Broeder et al. (1991) conducted a study to examine the effect of 12 weeks high intensity resistance training among 47 males aged 18-35 years old. After 12 weeks they managed to see a significant decline in total body fat and an increase in fat-free mass among the subjects.

Campbell et al. (1994) demonstrated how resistance training helped in reducing the fat mass and increasing the fat-free mass among the older adults. In this study they examined the body composition and the components of energy metabolism among 12 men and women, aged 56-80 years old, before and after 12 weeks of resistance training. They concluded that resistance training is an effective way to increase energy requirements, decrease body fat mass, and maintain metabolically active tissue mass in healthy older adults and may be useful as an adjunct to weight-control programme for older adults.

One study has been conducted by Nindl et al. (2000) about the regional body composition changes in 31 healthy women after 6 months of periodized physical

training. The physical training consisted of a combination of aerobic and resistance exercise in which the subjects engaged for 5 days per week for 24 weeks. They found out that after 6 months of periodized physical training the subjects experienced a 2.2% decrease in body mass, a 10% decrease in body fat mass and a 2.2% increase in soft tissue lean mass.

Orsatti et al. (2010) conducted a study to examine the effects of resistance training and soy isoflavone on body composition among postmenopausal women. A total of 80 postmenopausal women participated in this study and they were divided into four groups (resistance training + soy isoflavone, no resistance training + soy isoflavone, resistance training + placebo, and no resistance training + placebo). After 9 months, they found out that resistance training improved muscle mass and strength and attenuated gain of fat mass, soy isoflavone did not alter body composition and muscle strength, and there were no additive effects of resistance training and soy isoflavone.

One of the studies conducted by Ballor et al. (1988) showed that adding resistance training exercise to a caloric restriction programme for 8 weeks results in maintenance of lean body weight and gain in muscular strength among obese women. In a study done by Hunter et al. (2008), it is reported that following weight loss, resistance training conserved fat-free mass, resting energy expenditure and strength fitness compared to those who did aerobic training or no training at all. However, a study by Kraemer et al. (1997) reported that weight loss during moderate caloric restriction is not altered by inclusion of aerobic and resistance exercise, but diet in conjunction with training can induce remarkable adaptations in aerobic capacity and muscular strength despite significant reduction in body mass.

2.2 Impact of resistance training on muscular fitness

Effects of resistance training on muscular fitness have been popular research topic over the decades. Resistance training is well established as an effective method of exercise for developing muscular fitness (Hass et al., 2001). In his study, Hakkinen (1985) found that there was a significant improvement in muscular strength among his subjects after 8 weeks of resistance training. He also mentioned that the reason behind such improvement could be contributed by neuro-muscular adaptations. This finding was supported with a study conducted by Bird et al. (2005) in which they highlighted that the early increases in strength are associated mainly with neural adaptations, while hypertrophic responses begin to occur at the latter stages of training. Bird et al. (2005) also demonstrated how an acute resistance exercise can improve the muscular strength by manipulating the programme variables such as the muscle action, loading and volume, exercise selection and order, rest periods, repetition velocity and frequency.

Trudelle-Jackson et al. (2010) examined the relations of meeting or not meeting the *2008 Physical Activity Guidelines for Americans* recommendations for muscular strengthening activities with percentage of body fat, body mass index, muscular strength, and obesity classification in women. They analyzed data on 918 women aged 20 to 83 years in the Women's Injury Study from 2007 to 2009. They found out that women who met muscle strengthening activity recommendations had significantly lower BMI and percentage of body fat and higher muscle strength while women not meeting those recommendations were more likely to be obese (BMI≥30) compared with women who met the recommendations.

A study was conducted by Takahashi et al. (2008) to examine the effects of resistance training among healthy female university students. Students who were in the exercise group carried out the resistance training for both the upper and lower parts of the body using ankle and wrist weights three or four times a week. After 8 week, they found out that resistance training improved the physical fitness and muscle strength among the young female subjects.

Kato et al. (2011) reported that a daily routine involving ingestion of high protein snack 3 hours after a basal meal and subsequent light resistance exercise (dumbbell exercise) helped in increasing the mass and strength of human muscle. Their study found out that subjects who ate high protein snack and performed light resistance training for 5 weeks showed a significant increase in lean body mass and total cross-sectional area of the right forearm muscle along with a significant decrease in body fat mass. The exercise group also showed significant increase in grip strength and isometric knee extensor muscle strength.

2.3 Other impacts of resistance training

Other than improving muscular fitness and body composition, resistance training also brings other health benefits. In a review article written by Jan Sundell (2011), it is reported that resistance training is an effective tool against metabolic and frailty syndrome among the elderly population. Metabolic syndrome is a set of risk factors which include abdominal obesity, insulin resistance, hypertension and dyslipidemia while frailty syndrome is contributed by sarcopenia and osteoporosis. It is said that resistance training enhances insulin sensitivity, improves glucose tolerance, and reduces blood pressure values. Apart from that, resistance training is probably the most effective measure to prevent and treat sarcopenia and maintain or increase bone mineral density.

A study conducted by Suh et al. (2011) reported that 12 weeks of resistance training improved insulin sensitivity in overweight Korean adolescents. Misra et al. (2008) reported that moderate-intensity progressive resistance training for 3 months resulted in significant improvement in insulin sensitivity, glycemia (blood glucose and A1C levels), lipids, and truncal and peripheral subcutaneous adipose tissue compartments in patients with type 2 diabetes. Not only that, Dunstan et al. (2002) also reported that 6 months of high-intensity progressive resistance training, in combination with moderate weight loss, was effective in improving glycemic control in older patients with type 2 diabetes. Additional benefits of improved muscular strength and lean body mass identify high-intensity resistance training as a feasible and effective component in the management program for older patients with type 2 diabetes.

One study has been conducted by Tsutsumi et al. (1997) to find out the physical fitness and the psychological benefits of strength training in community dwelling older adults. The purpose of this study was to evaluate the effects of 12 weeks of high and low intensity resistance training on muscular fitness, psychological affect and neurocognitive functioning among 42 healthy but sedentary older adults (mean age= 68 years). This study demonstrated that participation in 12 weeks of high or low intensity resistance training can improve overall physical fitness, mood and physical self-efficacy in older adults while neurocognitive functioning remains constant.

Levinger et al. (2007) conducted a study to examine the effects of resistance training on the capacity to perform activities of daily living and quality of life for individuals with a high number of metabolic risk factors and compared any benefits with individuals with a low number of metabolic risk factors. The results of this study showed that resistance training improved muscle strength and the capacity to perform activities of daily living in individuals with high number of metabolic risk factors and low number of metabolic risk factors. Resistance training improved quality of life for the high number of metabolic risk factors group, and this result was independent of changes in body fat content or aerobic power.

CHAPTER 3

METHODOLOGY

3.1 Subjects

Twenty physically active young women engaged in recreational exercise activities such as jogging, volleyball and badminton (mean age: 20.3 ± 0.7 years old, height: 154.91 ± 6.39 cm, body weight: 52.36 ± 9.98 kg and body mass index: 21.69 ± 2.98) with no recent injury participated in this study. Each participant signed an informed consent approved by the USM Research and Ethical Committee before participation and was informed of all possible experimental risks and discomforts of participating in this investigation (Appendix B). As of the inclusion criterion for participation: each participant is an undergraduate student of University Sains Malaysia (USM), healthy volunteers and exercising at least 30 minutes per session, three times per week. In addition, each participant was not supposed to engage with any resistance training programme during the intervention period. One subject in the exercise group dropped out from the study due to fever during training intervention.

3.2 Research instruments

Throughout this study, various instruments were used for the purpose of data collection. The information on each instruments are as follows.

3.2.1 Body Meter 406 (SECA)

Body Meter 406 (SECA) was used to measure the height of the subjects. The reading was set to 1 decimal point.

3.2.2 Omron Karada Body Scan

Omron Karada Body Scan (Japan) was used to measure the weight and body composition of the subjects. The scale was set to 2 decimal points.

3.2.3 Back and leg strength dynamometer

Back and leg strength dynamometer (Lafayette) was used to measure the back and leg strength of each subject during pre-test and post-test.

3.2.4 Harpenden handgrip dynamometer

Harpenden handgrip dynamometer was used to measure the right and left handgrip strength of the participants during pre-test and post-test.

3.2.5 Sit and reach box

Sit and reach box (Lafayette) was used to measure the flexibility of the subjects during pre-test and post-test.

3.2.6 Yoga mat

Yoga mat was used by the participants while performing sit ups and push ups during pre-test and post-test.

3.2.7 Stopwatch

Casio Hs-30 (Japan) digital stopwatch was used to measure the time while doing the sit ups and push ups and also during rest intervals in between sets and exercises. The same watch is being used during pre-test and post-test to standardize all measurements.

3.3 Research protocol

3.3.1 Testing procedure

Prior to the tests, all subjects were briefed on the procedures. After the briefing, subjects then completed and signed the participation information and consent form. Then, the subjects went for anthropometric measurements with their height, body weight and body mass index measured. After that, subjects performed the pre-test that included the body composition analysis, muscular strength, muscular endurance and flexibility. Then, the study continued with all the twenty subjects divided randomly into two groups, namely exercise group and control group. The exercise group underwent resistance training for 6 weeks while the control group resumed their normal physical

activity for 6 weeks. After 6 weeks, subjects returned back for post-test measurements (Figure 3.1).

3.3.2 Resistance training procedure

All workouts started with a general warm-up and included cool-down periods (i.e., stretching, etc.) of approximately 5-10 min. The researchers supervised all subjects so that all essential programme characteristics were strictly enforced. Specifically, researchers were responsible for seeing that exercise prescriptions were properly carried out and achieved during a workout (e.g., velocity of movement, appropriate spotting, appropriate safety considerations, prescribed rest periods, and proper hydration requirements). Also, it has been recently demonstrated that direct supervision of resistance training is vital to optimize strength performance adaptations (Mazzetti et al., 2000). The 6 weeks programme consisted of resistance exercises using free weights. The exercise group performed all upper- and lower-body exercises in three training sessions per week for 6 weeks. Resistance training program included; bench press, squat, shoulder press, lunges, biceps curl, leg extension, triceps extension, leg curl, bent-over row and crunches. Subjects performed 10 repetitions of 2 sets for each exercise. The rest period was set to 30-90 seconds between sets and 2-3 minutes between exercises. The load of resistance exercises were increased gradually by week depending on subjects' current fitness level and capability.

3.3.3 Assessment of variables

3.3.3.1 Body composition

The body composition of the subject was analyzed using the Omron Karada Body Scan (Japan). Subject was asked to stand on the scale barefooted while holding the hand piece straight in front of their body and remain in idle position for few seconds until the readings were taken.

3.3.3.2 Muscular strength

The muscular strength was measured using the back and leg dynamometer (Lafayette) and also Harpenden hand grip dynamometer.

For back and leg strength, subject was asked to stand on the back and leg dynamometer with position where the feet were shoulder-width apart, knees slightly bend, back straight and chest forward. The subject held a handle which was hooked to the chain which was connected to the dynamometer. When ready, the subject attempted to pull the handle upward as in lifting motion with maximum effort while avoiding pulling it backward. Reading was taken before the dynamometer was set to zero again. Subject was given three attempts and few minutes rest before proceeding with the next attempt. The highest reading was taken as their score.

For handgrip strength, subject was asked to hold the Harpenden handgrip dynamometer at the side of their body with elbow flexed at 90° and stand with shoulder-width apart. Subject will then squeezed the dynamometer with maximum effort. Three

attempts were given to the subject for each left and right hand. The highest reading was taken as their score.

3.3.3.3 Muscular endurance

The muscular endurance was tested by measuring the number of repetitions that the subject could do in one minute for push ups up and sit ups.

For push ups, subject was asked to do the modified push ups where the knees of the subject were flexed. Subject was asked to get ready in push up position on the yoga mat and with the instructor signal; subject will do the push ups as many repetitions as they could within one minute. Subject was told to breathe in when going down and exhale when going up while maintaining straight posture all the way.

For sit ups, subject was told to lie down on the yoga mat with the knees flexed and the arms at the side of their head or crossing their chest. A partner helped to hold their legs while the subject was doing the sit up. Subject was told to breathe out when going up and breathe in when coming down. With the instructor signal, subject attempted to do as many sit ups as they could within one minute time.

3.3.3.4 Flexibility

The flexibility of the subject was measured using the sit and reach box. The sit and reach box was placed against a wall. The subject was asked to remove shoes before starting the test. Subject was told to put right hand on top of the left hand and exhale while reaching forward. Subject was given three attempts and the furthest attempt was taken as a score.

3.4 Statistical analysis

All the statistical analysis was computed using the Statistical Analysis for the Social Sciences (SPSS) version 18.0. All the data reported were expressed in mean and standard deviation (Mean ± SD). Independent t-test was used to determine the significant differences of all the variables mean change of pre-test and post-test between the two groups. Statistical significance was accepted at $p < 0.05$.

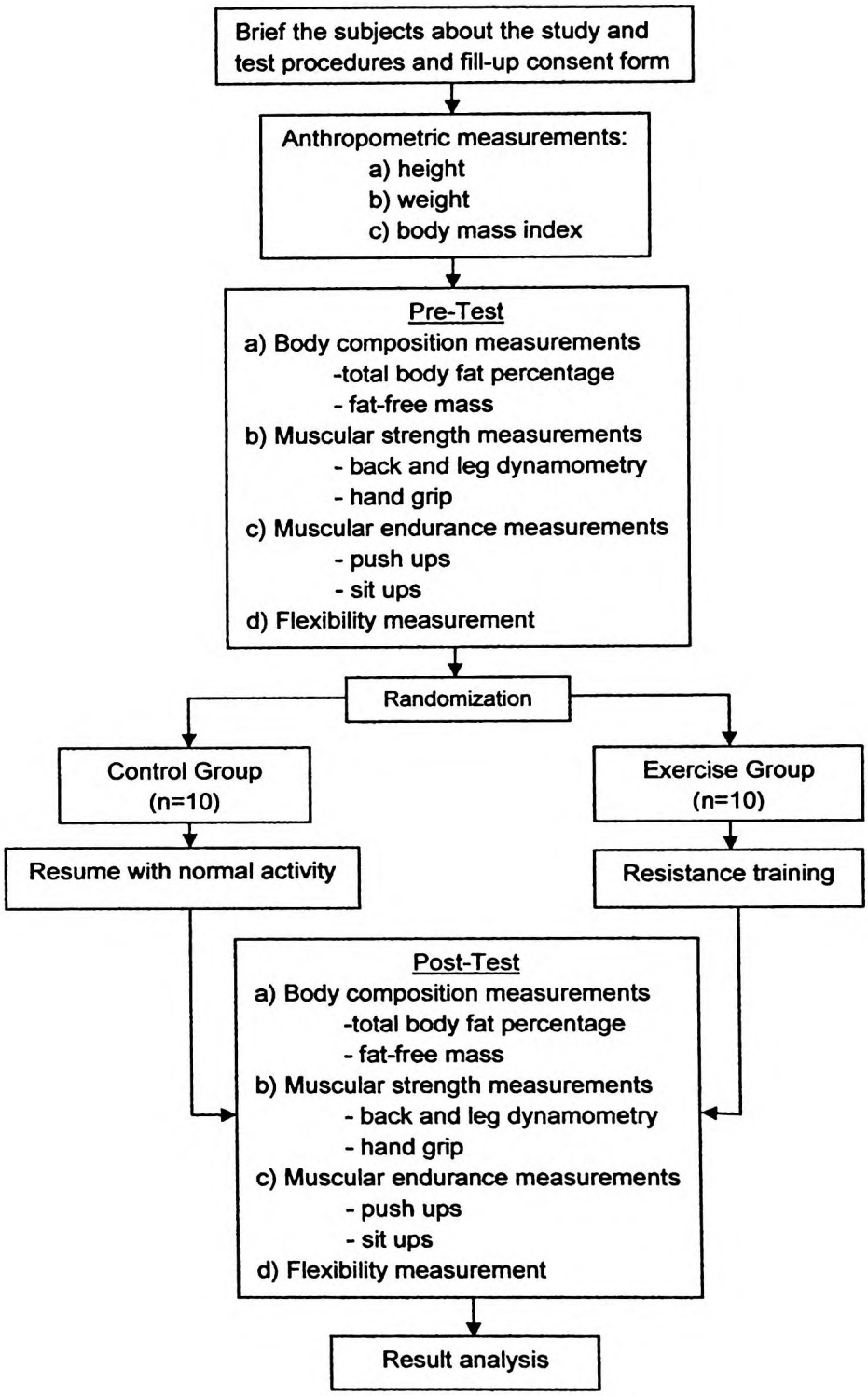

Figure 3.1: Flow chart for the research protocol

CHAPTER 4

RESULTS AND ANALYSIS

4.1 Characteristics of the subjects

A total of twenty female students from Universiti Sains Malaysia, Health Campus were recruited for this study. Table 4.1 shows the physical and physiological characteristics of the subjects including age, height, weight and body mass index (BMI).

Table 4.1: Physical and physiological characteristics of the subjects (n=20)

Physical characteristics	Mean ± SD
Age (years)	20.3 ± 0.7
Height (cm)	154.9 ± 6.3
Weight (kg)	52.4 ± 10.0
Body mass index (BMI)	21.7 ± 3.0

4.2 Body composition

4.2.1 Body weight

The results show no significant differences ($p > 0.05$) in mean change for weight between control group and exercise groups. Table 4.2 shows the mean ± SD for weight of subjects. Mean results of weight of subjects are presented in Figure 4.1.

Table 4.2: Mean ± SD of weight of the subjects (kg)

Subjects	Pre-test	Post-test	Mean change
Control group	50.2 ± 10.6	50.4 ± 10.1	0.2
Exercise group	54.5 ± 9.4	54.8 ± 9.6	0.4

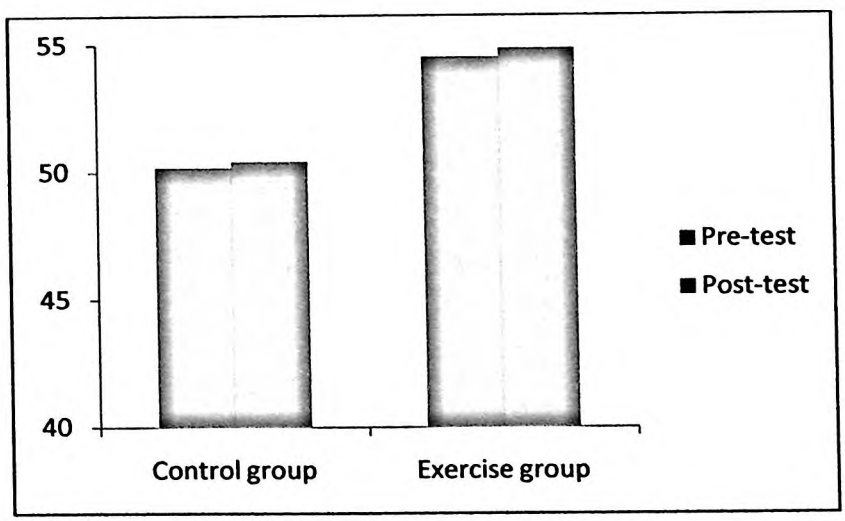

Figure 4.1: Mean values of weight (kg)

4.2.2 Percentage body fat (%)

The results show no significant differences ($p > 0.05$) in mean change for percentage body fat between control group and exercise group. Table 4.3 shows the mean ± SD of percentage body fat of the subjects. Mean results of percentage body fat of the subject are presented in Figure 4.2

Table 4.3: Mean ± SD of percentage body fat (% BF)

Subjects	Pre-test	Post-test	Mean change
Control group	23.9 ± 6.1	25.8 ± 4.2	1.9
Exercise group	29.7 ± 5.9	28.7 ± 3.9	-0.9

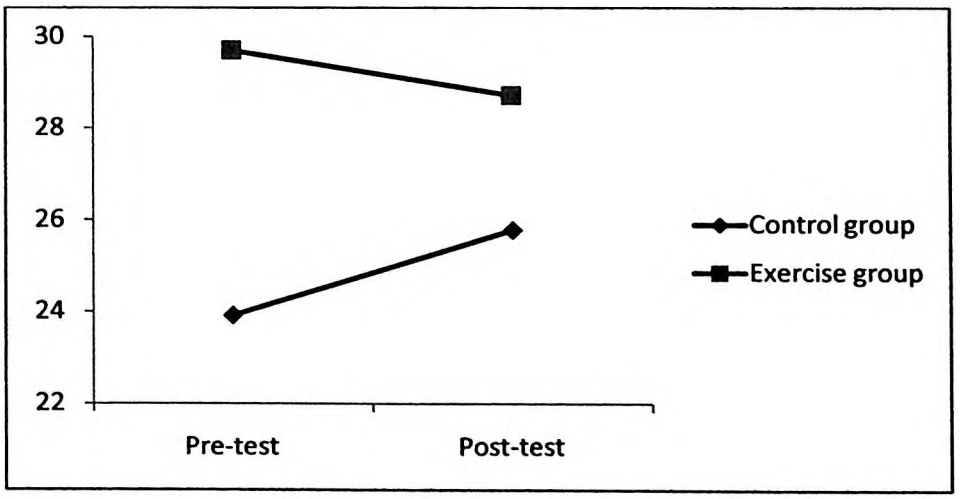

Figure 4.2: Mean of the percentage of body fat (%)

4.2.3 Fat-free mass

The results show no significant differences ($p > 0.05$) in the mean change for fat-free mass between control group and exercise group. Table 4.4 shows the mean ± SD of percentage body fat of the subjects. Mean results of percentage body fat of subject are presented in Figure 4.3

Table 4.4: Mean ± SD of fat-free mass (kg)

Subjects	Pre-test	Post-test	Mean change
Control group	37.7 ± 5.7	37.2 ± 6.0	-0.6
Exercise group	37.9 ± 4.6	38.8 ± 4.7	0.8

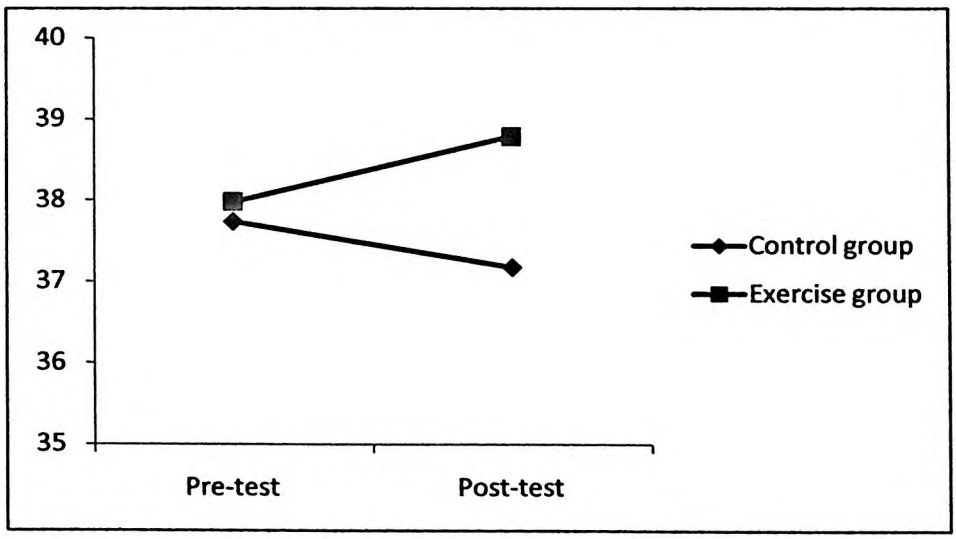

Figure 4.3: Mean of fat-free mass (kg)

4.3 Muscular strength

4.3.1 Back and leg strength

The results show no significant differences ($p > 0.05$) in mean change for back and leg strength between control group and exercise group. Table 4.5 shows the mean ± SD of back and leg dynamometry of the subjects. Mean results of back and leg dynamometry of subjects are presented in Figure 4.4 and Figure 4.5

Table 4.5 Mean ± SD of back and leg dynamometry (kg)

Subjects	Pre-test	Post-test	Mean change
Control group	75.5 ± 29.8	76.5 ± 28.4	1.0
Exercise group	64.0 ± 18.5	76.7 ± 12.5	11.1

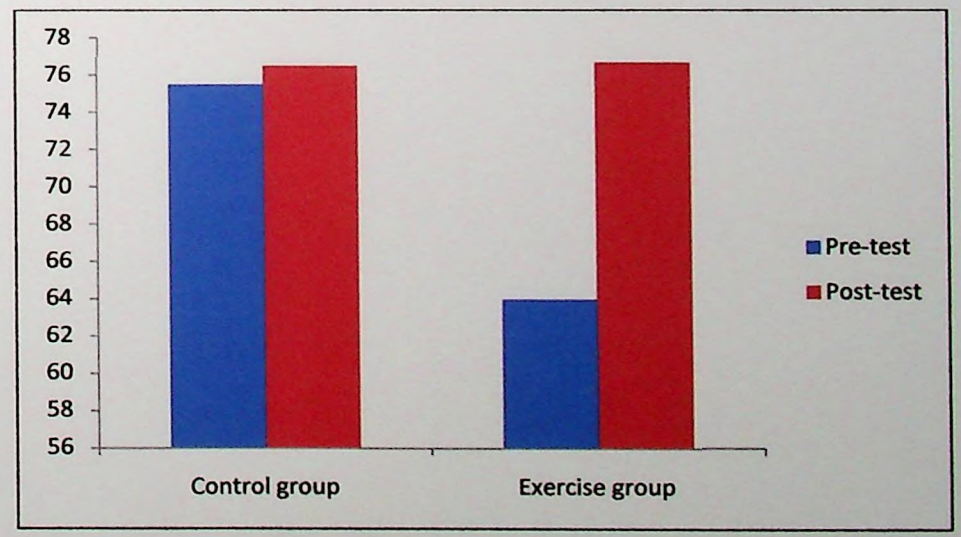

Figure 4.4: Mean of back and leg dynamometry (kg)