COMBINED EFFECTS OF OAT BRAN CONSUMPTION AND BRISK WALKING EXERCISE ON BLOOD LIPID PROFILES IN 40 TO 50 YEARS OLD HYPERCHOLESTEROLEMIC WOMEN

by

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Dissertation submitted in partial fulfillment
of the requirement for the
Degree of Bachelor of Health Sciences
(Exercise and Sports Science)

JUNE 2016

ACKNOWLEDGEMENT

First and foremost, my greatest gratitude to God the Almighty for giving me opportunity and strength to carry out this final year project. Special thanks to both of my parents and family members who always support and motivate me while doing this project.

I would like to express my sincere gratitude to my supervisor Assoc. Prof. Ooi Foong Kiew for the continuous support, patience and motivation given to me throughout the process of completing this final year project. Special thanks are also extended to the staffs of Sports Science Unit, Universiti Sains Malaysia, especially Madam Jamaayah bt Meor Osman, Madam Norlida bt Azalan and Madam Norfadhilah Ain for their technical assistance in the laboratory for blood sample taking and analysis.

My sincere thanks also go to Ms Noraini Sahrir for sharing her knowledge, opinion and suggestions regarding the statistical analysis of this project. Last but not least, thanks to my friends and lecturers for the advices, moral support and helping me directly and indirectly along the process of this final year project.

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Combined Effects of Oat Bran Consumption and Brisk Walking Exercise on Blood Lipid Profiles in 40 to 50 years old Hypercholesterolemic Women.

ABSTRACT

Introduction: Evidences of exercise with moderate intensity can improve body compositions and oat bran containing β-glucan enable to improve lipid profile levels have been reported. However, to date, there was no study on the additional beneficial effects of combined brisk walking and oat bran consumption compared to oat bran consumption alone on blood lipid profiles among hypercholesterolemic women. **Objective**: To investigate the additional beneficial effects of combined oat bran consumption and brisk walking exercise compared to oat bran consumption alone and sedentary without oat bran consumption on blood lipid profiles among hypercholesterolemic women with age ranged from 40 to 50 years old. **Methods**: Thirty three hypercholesterolemic women were randomly assigned into 3 groups: sedentary without oat bran consumption control (C), oat bran consumption alone (Ob) and combined oat bran consumption and brisk walking exercise (ObEx) groups. Pre- and post tests were carried out to measure participants' body anthropometry, body composition and blood lipid profiles, i.e. serum total cholesterol (TC), triglycerides (TG), low density lipoprotein cholesterol (LDL-C) and high density lipoprotein cholesterol (HDL-C). During 6 weeks of study period, participants in Ob and ObEx groups consumed 18g of oat bran daily. Participants in ObEx executed brisk walking exercise with intensity of at 55%-70% of the participants' heart rate maximum for 30 minutes per session, 3 sessions per week for 6 weeks. Participants in ObEx group consumed oat bran 1 hour prior to brisk walking exercise on the exercise days. **Results**: After 6 weeks of study period, body weight decreased significantly in both Ob ($p=0.013$)

Keberkesanan Gabungan Pengambilan Bran Oat dan Senaman Berjalan Pantas ke atas Profil Serum Lipid dalam kalangan Wanita Hiperkolesterolemik.

ABSTRAK

Pengenalan: Kenyataan tentang senaman dengan intensiti sederhana dapat menambahbaik ke atas komposisi badan dan β-glukan yang terkandung dalam bran oat dapat menambahbaik tahap profil lipid telah dilaporkan. Walaubagaimanapun, setakat ini, tiada kajian tentang kesan manfaat tambahan daripada gabungan antara pengambilan bran oat dan senaman berjalan pantas berbanding dengan pengambilan bran oat sahaja terhadap profil serum lipid dalam kalangan wanita hiperkolesterolemik. **Objektif:** Untuk menyiasat kesan manfaat tambahan gabungan pengambilan bran oat dan senaman berjalan pantas dibandingkan dengan pengambilan bran oat sahaja dan sedentari tanpa pengambilan bran oat dan ke atas profil serum lipid dalam kalangan wanita hiperkolesterolemik berumur antara 40-50 tahun. **Kaedah:** Tiga puluh tiga wanita hiperkolesterolemik dibahagikan kepada 3 kumpulan secara rawak: kumpulan kawalan sedentary tanpa pegambilan bran oat (C), kumpulan pengambilan bran oat sahaja (Ob) dan kumpulan gabungan pengambilan bran oat dan senaman berjalan pantas (ObEx). Pra dan pasca ujian telah dijalankan untuk mengukur antropometri badan, komposisi badan dan profil serum lipid iaitu serum jumlah kolesterol (TC), trigliserida (TG), kolesterol lipoprotein ketumpatan rendah (LDL-C) dan kolesterol lipoprotein ketumpatan tinggi (HDL-C) peserta. Sepanjang 6 minggu tempoh kajian, peserta dalam kumpulan Ob dan ObEx mengambil 18g bran oat setiap hari. Peserta dalam kumpulan ObEx melakukan senaman berjalan pantas dengan intensiti 55%-70%

and ObEx (p=0.02) groups. There were also significant decrease in serum total cholesterol (TC) (p=0.02) and low density lipoprotein cholesterol (LDL-C) (p=0.019) concentrations in ObEx group. **Conclusion**: Six weeks of oat bran consumption with 18g of oat bran per day combined with brisk walking exercise for 30 minutes per session, 3 sessions per week could significantly reduce body weight, serum total cholesterol (TC) and low density lipoprotein cholesterol (LDL-C) concentrations. Therefore, this combination can be proposed as guidelines in nutritional and exercise promotion programme to improve lipid profiles in 40 to 50 years old hypercholesterolemic women.

daripada kadar degupan jantung maksima 30 minit bagi setiap sesi, 3 sesi seminggu selama 6 minggu. Peserta dalam kumpulan ObEx mengambil bran oat 1 jam sebelum melakukan senaman berjalan pantas pada hari senaman. **Keputusan:** Selepas 6 minggu tempoh kajian, penurunan berat badan secara ketara dapat diperhatikan bagi kumpulan Ob (p=0.013) dan ObEx (p=0.02). Penurunan yang ketara juga dapat diperhatikan dalam serum jumlah kolesterol (TC) (p=0.02) dan kolesterol lipoprotein ketumpatan rendah (LDL-C) (p=0.019) bagi kumpulan ObEx. **Kesimpulan:** Gabungan pengambilan 18g bran oat setiap hari dan senaman berjalan pantas selama 30 minit bagi setiap sesi, 3 sesi seminggu selama 6 minggu dapat menurunkan berat badan, serum jumlah kolesterol (TC) dan kolesterol lipoprotein ketumpatan rendah (LDL-C). Maka, kombinasi ini boleh dicadangkan sebagai garis panduan bagi rancangan promosi pemakanan dan senaman demi menambahbaik profil serum lipid dalam kalangan wanita hiperkolesterolemik berumur antara 40 hingga 50 tahun.

CHAPTER 1

INTRODUCTION

Physical inactivity is a state of concern as it leads to major health problems like obesity, hypertension and various metabolic disorders. Physical activity is defined as any bodily movement produced by skeletal muscles that result in energy expenditure above the basal level (Sallis & Owen, 1998). The world now is in the era where great advances of technology conceal people from doing physical activity, and it leads to the decrement in physical activity regardless of the scientific evidence has increased showing the importance of physical activity for health and well-being. Blair *et al.* (1996) stated that low levels of physical activity are important precursor of mortality and associated with higher rates of disease and premature death.

Furthermore, Karmen (2001) also mentioned that sedentary lifestyle with lack of exercise can increase the susceptibility of getting cardiovascular disease, which is related to high blood cholesterol. Cardiovascular disease (CVD) continues to be the major cause of morbidity and death in the world. Hypertension, dyslipidemia and excess body weight are among most potent accepted risk factors for CVD. In 2007, the American College of Sports Medicine suggested that adults should complete at least 30 minutes of moderate exercise intensity aerobic activity at 3 days/week (Haskell *et al.*, 2010).

Although there are many contributing factors to cardiovascular disease (CVD), inactivity has been shown to be one of the major risk factors (Howard *et al.*, 2008). It is also known that exercise with moderate activity can improve body composition by decreasing percentage of body fat and increasing lean body mass (Volaklis *et al.*, 2007).

Chen (2014) stated that brisk walking is an underestimated and underused modality to cope and overcome the issue of obesity in Malaysia and in other parts of the world since it can be performed in minimal instruction and not costly.

Oats contain many health-promoting components, such as dietary fibres, proteins and minerals (Butt *et al.,* 2008). Oat bran contains β-glucan, and it has been reported that oat bran can improve lipid profiles level of an individual (Berg *et al.,* 2003). It has been claimed by both US Food and Drug Administration (FDA) (1997) and European Food Safety Authority (EFSA) (2011) as a health benefits supplement.

USFDA has passed a ruling that allowed oat bran to be registered as the first cholesterol-reducing food at an amount of 3 grams of β-glucan daily. In 2011, European Union allowed food producers to market products containing 1 g β-glucan per portion with claims to reduce blood cholesterol concentrations and to attenuate post-prandial glycemic response (European Food Safety Authority, 2011). To date, information are lacking on the additional beneficial of combined effects of brisk walking and oat bran consumption compared to oat bran consumption alone and sedentary without consumption of oat bran on blood lipid profiles among 40-50 year old hypercholesterolemic women. Thus, this study was proposed.

1.1 Objective of the Study

To investigate the additional beneficial effects of combined oat bran consumption and brisk walking exercise compared to oat bran consumption alone or sedentary without consumption of supplementation on blood lipid profiles among hypercholesterolemic women with age ranged from 40 to 50 years old.

1.2 Significance of the Study

If the present study findings show that consumption of oat bran combined with brisk walking exercise can elicit beneficial effects on lipid profiles, thus this combination can then be proposed as guidelines in nutritional and exercise promotion programme to improve the status of blood lipid profiles in 40 to 50 years old hypercholesterolemic women.

1.3 Hypothesis

H_0: There are no significant differences between combined oat bran consumption and brisk walking exercise (ObEx) group, oat bran consumption alone (Ob) group and sedentary without oat bran consumption control (C) group in blood lipid profiles in 40 to 50 years old hypercholesterolemic women.

H_A: There are significant differences between combined oat bran consumption and brisk walking exercise (ObEx) group, oat bran consumption alone (Ob) group and sedentary without oat bran consumption control (C) group on blood lipid profiles in 40 to 50 years old hypercholesterolemic women.

1.4 Operational Definitions

Brisk walking exercise programme: A brisk walking programme performed by participants in combined oat bran and exercise (ObEx) group for 30 minutes per session, 3 sessions per week for 6 weeks.

Oat bran supplementation: Participants in oat bran alone (Ob) and combined oat bran and exercise (ObEx) groups consumed two sachets of oat bran powder (18g of oat bran powder containing 3.6g of β-glucan) diluted with plain water per day, 7 days per week for 6 weeks.

Anthropometric and body composition measurements: Measurements of participants' body height, body weight, percentage of body fat and fat free mass.

Blood lipid profiles: Measurements of blood parameters, i.e. serum total cholesterol (TC), triglycerides (TG), low density lipoprotein cholesterol (LDL-C) and high density lipoprotein cholesterol (HDL-C).

Women participants: A group of Malaysian women with age between 40 to 50 years old.

Hypercholesterolemic: Blood cholesterol level ranged between 5.2 to 8.0 mmol/L (National Cholesterol Education Program, 2002)

CHAPTER 2

LITERATURE REVIEW

2.1 Components of Blood Lipid Profile

Components of blood lipid profile include total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C). LDL-C contains 25% proteins, 5% triglycerides, 20% phospholipids, and 50% cholesterol. LDL-C deposit in and around smooth muscle fibers in arteries, when presents in excessive numbers can form fatty plaques that increases the risk of coronary artery disease, and it is also known as bad cholesterol (Tortora & Derrickson, 2011).

On the other hand, HDL-C contains 40-45% proteins, 5-10% triglycerides, 30% phospholipids, and 20% cholesterol, removes excess cholesterol from blood cells, and transports it to the liver for elimination. It can prevent accumulation of the fatty plaques. High level of HDL-C is associated with decreased risk of coronary artery disease and known as good cholesterol (Tortora & Derrickson, 2011).

There is association between lipoproteins and atherosclerosis. LDL-C is categorised as atherogenic, which means it promotes the accumulation of fatty plaques. The chance of this accumulation increases with higher levels of circulating LDL-C at the susceptible regions in the arteries such as bifurcations (Cziraky, *et al.,* 2008; Lusis, 2000; National Cholesterol Education Program, 2002). It is vice versa with HDL-C as it is considered as anti-atherogenic because it gave a negative association with CVD (Lusis, 2000).

The test for serum lipid profile includes all the four main components and it is usually done in fasting blood specimen with complete dietary restriction except for water and medication. This may due to two main reasons which are increment of post prandial triglycerides for several hours and most reference values for serum lipids are established on fasting blood specimen (Campos *et al.,* 2005)

2.2 Oat Bran and Cholesterol Level

Oat is a rich source of beta glucans and bioactive phytochemicals. Beta glucans are very important in health-promoting. In year 1997, based on the US Food and Drug Administration (FDA), it was stated that viscous fibers oat β-glucan is one of good agent which can lower our body cholesterol and can improve our health. Biogrow Oat BG22™ oat bran powder contains 20% of beta glucan (Biogrow Company, 2014). Please refer to Table 2.1 for the nutrition fact of Biogrow Oat BG22™ oat bran powder. The scientific name for oat bran is Avena sativa. Oat bran is a part of oat and it is the combination of groat and bran. The characteristic of beta glucans are water soluble, viscous, and gelation.

β-glucan is a nonstarch polysaccharide composed of beta-(1-4)-linked glucose units separated every 2-3 units by beta-(1-3)-linked glucose. This soluble fiber, which is found in oat and barley, has potential to reduce LDL-C through the increase in intestinal viscosity that may lower cholesterol absorption (Naumann *et al*., 2006).

Wolever *et al.* (2010) mentioned that consumption of a minimum of 3g high molecular weight oat beta-glucan per day can reduce cardiovascular disease (CVD) risk by up to 12%. However, some other studies reported that the consumption of oat bran failed to show any effects on total plasma cholesterol (Bremer *et al.,* 1991; Leadbetter *et al*., 1991; Stewart *et al,*. 1992). It may be due to the baseline of subjects' cholesterol level which apparently showed low as mentioned by Ripsin *et al.* (1992), in their meta-analysis of several studies on the effects of oat products. They also mentioned that oat bran may have a great effect on subjects with elevated baseline level.

Nutrition Information of Biogrow Oat bran Powder

Serving size" 1 scoop or 1 sachet (≈ 9 g)

Serving per 480 g canister: 53 (scoops)

Serving per travel pack: 30 (sachets)

Table 2.1 Nutrition Fact of Biogrow Oat BG22™ Oat Bran Powder

	Per serving (1 scoops/sachet ≈ 9 g)	Per 100 g
Energy	114 kJ	1274 kJ
Calories	27 kcal	202 kcal
Total Fat	0.3 g	3.2 g
Monounsaturated Fat	0.1 g	1.4 g
Polyunsaturated Fat	0.1 g	1.2 g
Saturated Fat	<0.1 g	0.6 g
Trans Fat	0.0 g	0.0 g
Carbohydrate	2.7 g	30.5 g
Total Sugars	0.3 g	3.2 g
Total Dietary Fiber	3.7 g	40.7 g
Of which beta-glucan soluble fiber	1.8 g	20.0 g
Protein	1.7 g	18.6 g
Magnesium (Mg)	23 mg	260 mg
Iron (Fe)	0.8 mg	8.4 mg
Zinc (Zn)	0.5 mg	5.5 mg
Sodium (Na)	<1.0 mg	7.0 mg

Source: Biogrow Company (2014)

Nevertheless, Jenkins *et al.* (2002) found that viscous fibers oat β-glucan which meets the FDA requirements amounts could reduce the cholesterol even though it was a modest reduction, and it could eventually reduce the estimated risk of cardiovascular disease. This was based on their study finding that the ratio of total to HDL cholesterol and LDL to HDL cholesterol were reduced in modest level. Furthermore, in the study done by Kristensen and Bugel (2011), it was found that there was significant difference in total cholesterol reduction between oat bran and control groups. According to Wood (2000) and Jenkins *et al.*(2008) the potential physiological mechanism behind the efficacy of β-glucan is that it has the ability to lower down the absorption rate of food in the intestine due to increased viscosity, thus balancing the cholesterol and triglycerides level in the blood. Depending on physicochemical properties, fibers have a range of physiological consequences including viscosity in the upper gastrointestinal tract, fermentation in the colon and prebiotic effects (Jenkins, *et al.*, 1978; Wong, *et al.*, 2006; Macfarlane *et al.*, 2006). These effects in the gastrointestinal tract improve laxation and increase stool bulking and also have metabolic consequences including improvements in serum lipids and postprandial glycemia and promotion of satiety (Khoury *et al.*, 2012).

2.3 Nutritional Supplementation and Lipid Profile

According to US Department of Agriculture, the recommendation of dietary fiber consumption are related to age, gender and energy used (US Food and Drug Administration, 1997). The general adequate intake is 14 g/1000 kcal for adult. Using the energy guideline of 2000 kcal/day for women, they are recommended to take 28 g/day of dietary fiber intake.

Cardiovascular disease is the leading cause of death among women worldwide. Therefore, there are many potential interventions aim to improve health status of women especially issues about overweight and cardiovascular disease such as exercises and nutritional supplementation. In children, the data analysed by using National Health and Nutrition Examination Survey showed that the reduced risk for overweight linked with whole grain consumption was due to the dietary fiber content of the grain (O'Neil *et al.*, 2015). As reported by a study done by Johnson *et al.* (2008), there is association between low dietary fiber intake and greater fat mass and adiposity in children. Davis *et al.* (2009) reported that high risk and overweight youth Latinos participants showed a result of small reduction of dietary fiber consumption (mean decrease of 3 $g.1000\ kcal^{-1}.\ d^{-1}$) can give an intense effect on increasing the visceral adiposity.

It is known that hypercholesterolemic has been identified as a risk factor of various diseases. Therefore, Mohenizadeh *et al.* (2014) carried out a clinical trial on oat and wheat bread consumption to see its effect on the lipid profile, blood sugar and endothelial function. It was found that oat bread consumption reduced cholesterol levels.

In 2003, Berg *et al.* conducted a study of overweight and hypercholesterolemic participants who underwent 4 weeks of lifestyle health program which included healthy diet and physical activity. They found that there were significant decreases in total cholesterol and LDL-C. In a study done by Kashtan *et al.* (1992) which involved 82 healthy middle age men and women, the participants were supplemented with either oat and wheat bran. Wheat bran is particularly helpful for digestive issues, because the insoluble fiber can help bulk up the stools and limit the risk for constipation and other digestive issues. Oat bran, with its high soluble fiber content, may help for better control of blood sugar levels. Their study results showed a significant decrease in total cholesterol for those who consumed oat bran supplementation. Robitaille and Patrick (2005) evaluated the effect of oat bran-rich supplement on lipid profile of premenopausal overweight women and it was found that daily intake of 2.31g of β-glucan increased the level of plasma HDL-C. As in oat bran, soy protein contains macronutrient of protein. Potter *et al.* (1998) investigated the effect of 40g soy protein and 1.39mg isoflavones on blood lipid in postmenopausal women, and it was found that HDL-C increased and LDL-C decreased for groups which consumed the supplementation of soy protein. Another study done by Baum *et al.* (1998) demonstrated that different amounts of isoflavones supplementation decreased the risk of cardiovascular disease via improved blood lipid profiles among hypercholesterolemic postmenopausal women.

As summary, the above mentioned previous studies showed that β-glucan in the oat bran is responsible for lowering blood cholesterol.

2.4 Exercise Recommendation and Brisk Walking Exercise

According to World Health Organization (WHO), healthy adults aged 18-64 years are recommended to do at least 150 minutes of moderate-intensity aerobic physical activity for examples, walking or cycling, throughout the week, or for at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week, or an equivalent combination of moderate and vigorous intensity activity (World Health Organization, 2016). Ehrman (2010) stated that, the recommended components of an exercise training sessions are such as warm up at least 5-10 minutes with low to moderate intensity activities, followed by 20 to 60 minutes of conditioning activities such as walking and dancing, and at least 5-10 minutes with low to moderate intensity activities as cool down.

The exercise recommendation framework for frequency, intensity, time of exercise and type of exercise (FITT) for sedentary healthy adults are 3 to 5 days per week, 57% to 67% of heart rate maximum (HRmax), 20 to 30 minutes per day/60 to 150 min per week, with walking, jogging, stepping and cycling exercise (Haskell *et al.*, 2010).

It was stated in Chen (2014) that brisk walking is an one of the tools to cope and overcome the issue of obesity in Malaysia and other parts of the world, based on the fact that it can be performed with less cost and equipment.

2.5 Exercise and Lipid Profiles

Exercise is defined as any structured, planned, bodily movement that can help to increase or maintain physical fitness (McArdle *et al.*, 2010) and it is a key of healthy behavior intervention to improve lipid levels and lower cardiovascular disease risk.

Haskell (1986) reported that moderate-intensity, endurance-type activities produce favorable lipoprotein changes in healthy persons as well as in patients with ischemic heart disease, diabetes, and renal failure. Execution of regular physical activity can positively alter cholesterol metabolism as it can increase the production and action of several enzymes that function to enhance the reverse cholesterol transport system such as cholesteryl ester transfer protein (CETP) and lecithin–cholesterol acyltransferase (LCAT) (Durstine & Haskell 1994). Research done by Duncan *et al.* (1991) showed that pre and postmenopausal women with low levels of HDL-C are more likely to respond positively to exercise training and it was suggested that moderate exercise can increase the level of HDL-C.

Spate-Douglas and Keyser (1999) found that moderate-intensity training over a 12-week period was sufficient to improve the HDL-C profile, and high-intensity training appeared to be of no further advantage as long as training volume was constant in healthy adult female. A supervised exercise intervention was done by Ruppar *et al.* (2014) on healthy adults and it was found that total cholesterol was reduced in the participants.

Regular exercise can decreased one's blood total cholesterol (TC) and low-density lipoprotein cholesterol (LDL-C) (Trejo-Gutierrez & Flercher, 2007). There are also several previous studies showed the evidences that exercise can elicit positive effects on lipid profiles. Kim et al. (2007) reported that serum lipid profiles were significantly improved with exercise among Korean elderly women. Marques *et al.* (2009) also reported significant decreases in triglycerides and significant increases in HDL-C were observed in the multicomponent exercise group with aerobic exercises, muscular endurance exercises and activities targeted to improve balance and flexibility after 8 months in older women.

In another previous study done by Kannan *et al.* (2014) which included 51 obese adults with sedentary lifestyle, the participants were divided in two groups and performed moderate intensity and high intermittent intensity exercise for 15 weeks respectively. Their result showed that there were significant reduction in LDL-C with high intensity exercise and there was significant difference in body mass index in between both of the groups.

Regular physical activity has been shown to improve lipid and glucose metabolism by increasing insulin sensitivity and serum high density lipoprotein (HDL) cholesterol, and decreasing serum LDL cholesterol and triglycerides (Blumenthal *et al.,* 1991). Prabhakaran (1999) found that the amount of exercise is associated with total cholesterol, LDL-C and body fat percentage, however no difference was shown in HDL-C and triglycerides in premenopausal women who carried out 14 weeks of resistance training.

Savage (1986) reported that 10 weeks of high intensity exercise training (75% of VO_2 max) in prepubescent boys and adult men showed significant changes in HDL-C and total cholesterol. As claimed by Kelley and Kelley (2006), aerobic exercise is recommended for improving lipid profiles because their study showed that there were significant improvements in total cholesterol, HDL-C and triglycerides in adult men who performed aerobic exercise.

According to Marandi *et al.* (2013), after 10 weeks of training program, it was demonstrated that both light and moderate aerobic dance exercise improved body composition and lipid profiles in overweight middle age women.

As summary, the above mentioned previous studies showed that different intensity, duration and type of exercises elicited different results on lipid profiles. In general, aerobic moderate intensity exercises are proven to lower cholesterol level effectively.

2.6 Combined Effect of Nutritional Supplementation and Exercise on Lipid Profile

In a previous studies done by Hill *et al.* (2007) which combined 6g fish oil supplementation with aerobic exercise with the participants walked for 3 times per week. Their study found that after 12 weeks, fish oil supplementation alone could increase HDL-C and combined both fish oil and exercise could reduce body fat.

In another study done by Oh *et al.* (2007) with twenty five female Sprague-Dawley rats regarding on combination of 2.39mg soy isoflavone supplementation and running on treadmill exercise for 16-17m/min (for 30 minutes). It was found that after 12 weeks of intervention, the exercise alone, supplementation alone and combined exercise and supplementation group showed lower serum total cholesterol, triglycerides and LDL-C compared to the control group.

Seo *et al.* (2012) investigated the effect of three times per week of regular exercise within 60% of predicted maximum heart rate and 80mg aged garlic extract (AGE) in combination among postmenopausal women. They found that AGE supplementation reduced cardiovascular risk factors independently of exercise in postmenopausal women. Nevertheless, another study done by Bashiri (2014) which combined 500mg garlic supplementation with regular aerobic exercise which was 30-45 minutes running running at 60-75% of maximum heart rate, found that this combination could significantly increase HDL-C levels.

In summary, the above mentioned previous studies showed that nutritional supplementations were able to lower cholesterol in conjunction with performing exercise.

CHAPTER 3
METHODOLOGY

3.1 Participants

This was an interventional study. The participants' recruitment was announced and advertised through posters and it is on voluntary basis. Firstly, the participants were screened in order to determine the inclusion criteria were met. The inclusion criteria of participants of this study were:

i. Age ranged between 40 to 50 years old.
ii. Free from chronic diseases such as cardiovascular disease, diabetes, chronic inflammatory disease, cancer, renal or hepatic disease.
iii. Hypercholesterolemic with serum total cholesterol concentration ranged between 5.2 to 8.0 mmol/L (National Cholesterol Education Program, 2002; National Heart, Lung and Blood Institute, 2002) (Appendix A)
iv. Non-smoker.
v. Did not engange with any training programme or did not exercise more than once per week.

The exclusion criteria of the participants were:

i. Have the habit of taking oat bran as daily supplementation prior to experiment.
ii. Engaged in any training programme and exercise more than once per week.

If qualified, the participants proceed to the next stage of this study, which was grouping process. The participants were age-matched and then being assigned randomly into 3 groups, i.e. sedentary without oat bran consumption group (C), oat bran consumption alone group (Ob), and combined oat bran consumption with brisk walking exercise group (ObEx). Please refer to Figure 3.1 for the experimental design.

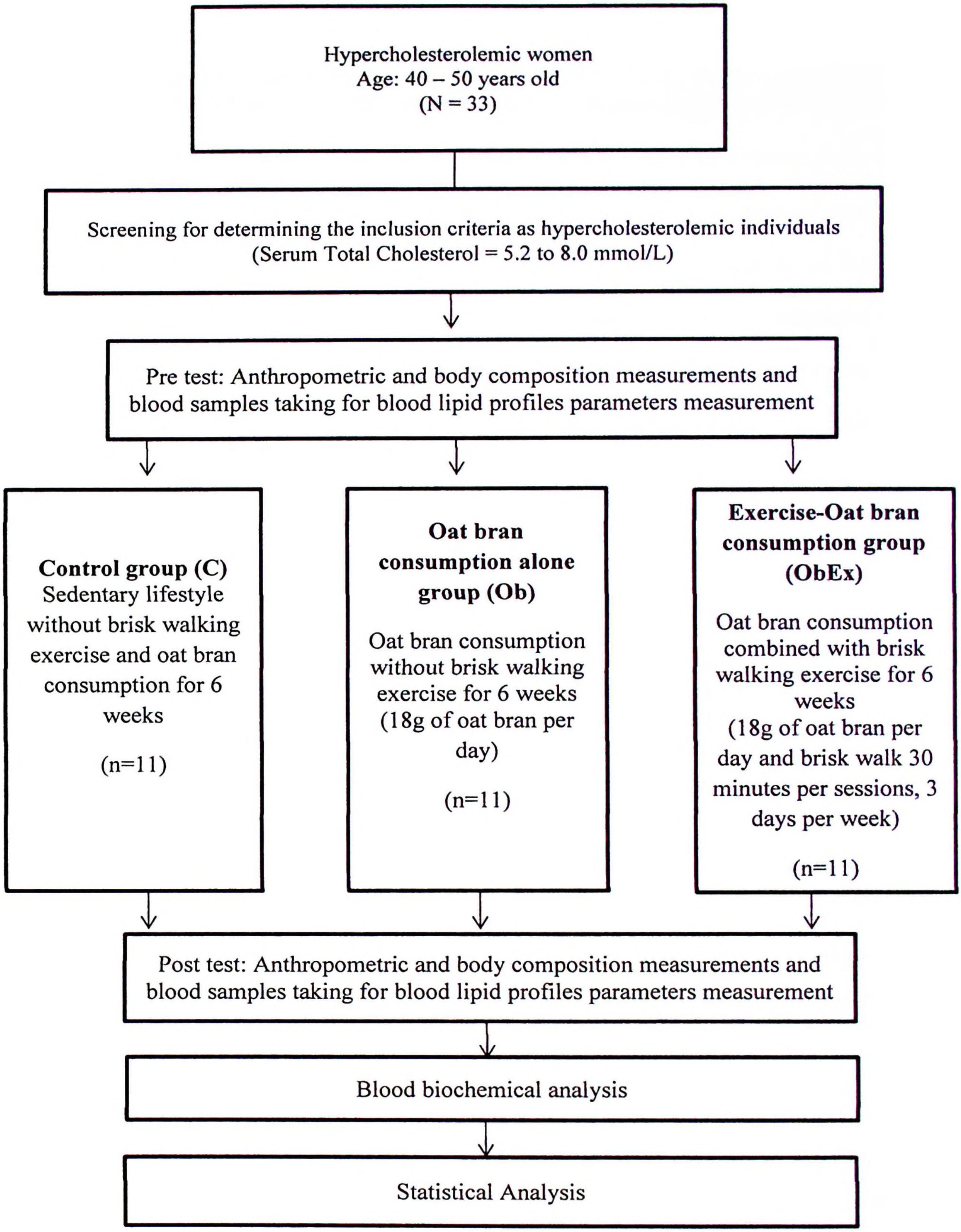

Figure 3.1: Flow Chart of the Experimental Design

Participants were informed that they have the right to withdraw themselves from this study at any time during the study period. Their participation can also be terminated due to following reasons: If they did not follow the prescribed brisk walking programme and stopped taking oat bran supplementation for a week or if they did not complete all the laboratory tests. Each participant was given a detail explanation about the objectives, procedures benefits, risks and possible discomforts. The present study was approved by Human Research Ethics Committee of Universiti Sains Malaysia (No USM/JEPeM/15100398) (Appendix B)

3.2 Experimental Design

3.2.1 Participants' grouping

In the present study, the participants were assigned into three groups, with 11 participants per group, i.e. sedentary without oat bran consumption group (C), oat bran consumption alone group (Ob) and combined oat bran consumption with brisk walking exercise group (ObEx).

Participants in the control group (C) did not perform brisk walking exercise or having oat bran consumption for 6 weeks. Meanwhile, participants in oat bran consumption alone group (Ob) consumed 18g of oat bran per day without performing brisk walking exercise for 6 weeks. Whereas participants in combined oat bran consumption and brisk walking exercise group (ObEx) consumed 18g of oat bran per day for 6 weeks and performed brisk walking exercise 30 minutes per session, 3 sessions per week for 6 weeks.

3.2.2 Anthropometric measurement and blood sample taking

In this study, anthropometric parameters such as body height, body weight and body composition (percentage of body fat and fat free mass) were measured during pre- and post test. A stadiometer (Seca 220, Germany) was used to measure the body height. Meanwhile, body composition and body weight were measured using a body composition analyzer (Tanita, TBF-410). Approximately six mL of blood was taken before and after the experimental period. The participants fasted overnight form 10 p.m. until the next morning of blood sample taking at 8.30 a.m.. Blood taking session for participants in ObEx for the post test were carried out at 8.30 a.m. the next morning after performing brisk walking exercise, i.e. 14 hours post exercise. The blood sample was then centrifuged for 10 minutes at 4000rpm and 4°C (Hettich Zentrifuger-Rotina 46RS, Germany) and only serum was collected and stored at -70°C for subsequent analysis.

3.2.3 Oat bran consumption

The participants in both oat bran consumption alone group (Ob) and combined oat bran consumption with brisk walking exercise group (ObEx) consumed oat bran with 2 sachets per day of oat bran powder BG22™ (18 g of oat bran powder containing 3.6g of β-glucan) diluted with water, 7 days per week for 6 weeks. The participants were required to consume 1 sachet of oat bran powder which was mixed with 250 ml of plain water before breakfast and another 1 sachet of oat bran which was mixed with 250 ml of plain water before lunch or dinner. On the exercise days, the participants in ObEx group consumed oat bran one hour before performing brisk walking exercise.

3.2.4 Brisk walking exercise

Participants in the combined oat bran consumption with exercise group (ObEx) performed the brisk walking programme for 6 weeks. In the 6 weeks of study period, the participants were required to perform brisk walking 3 times per week in the evening. In each session, five minutes of warming up session with stretching activities was carried out, then followed by 30 minutes of brisk walking exercise and ended with five minutes of cooling down session with stretching activities. The estimated walking distance covered was approximately 2.0 km. The exercise intensity during brisk walking was set at 55%-70% of the participants' age-predicted HRmax (HRmax = 220 – age). The intensity of brisk walking exercise was estimated by referring to the heart rate of the participants after finishing the exercise, in which a heart rate monitor (Polar watch) was worn by participant throughout the brisk walking session. In order to ensure that the exercise intensity was maintained with the targeted range, the participants were required to record their post exercise heart rate at the end of brisk walking session. If the walking pace did not elicit a heart rate within the targeted heart rate, the participants were requested to change their pace during the subsequent walking session. This programme was carried out under the supervision of the researchers at the jogging track in Health Campus of Universiti Sains Malaysia. The participants were also required to record their exercise frequency in a checklist (Appendix C).

3.2.5 Blood biochemical analysis

Blood samples were analysed for blood lipid profiles of total cholesterol (TC), triglycerides (TG), low density lipoprotein cholesterol (LDL-C) and high density lipoprotein cholesterol (HDL-C) by enzymatic method using commercial kits (RANDOX laboratories, UK) on ARCHITECT automated analyser.

3.2.6 Sample size calculation

Sample size used in this study was calculated by using PS Power and Sample Size Calculation version 3.0.43. Based on a study which carried out by *Kim et al.* (2007), the power of study was set at 80% with 95% confident interval. The standard deviation (SD) observed was 15 mg/dL of high density lipoprotein cholesterol (HDL-C). Calculated sample size was 11 participants per group. Therefore, we recruited 11 participants per group. In this study, three groups of participants were recruited. Thus, total number of participants were 33 participants.

3.2.7 Statistical Analysis

Data was analyzed using statistical software in the Statistical Package for Social Science (SPSS) Version 22.0. All the data are expressed as means and standard deviation (±SD). Repeated measure ANOVA was performed to determine the significance of the difference between and within the groups. Statistical significance was accepted at $p<0.05$.

CHAPTER 4

RESULTS

4.1 ANTHROPOMETRIC CHARACTERISTICS AND BODY COMPOSITION OF THE PARTICIPANTS

The means age of the participants of this study were C: 44.6 ± 4.1, Ob: 45.3 ± 4.7 and ObEx: 45.5 ± 3.5 years old, and the means body weight of the participants were C: 59.26 ± 11.10, Ob: 67.69 ± 13.95 and ObEx: 65.40 ± 12.47 kg.

Table 4.1.1 illustrates the baseline means body weight, body height, body mass index (BMI), percentage body fat and fat free mass of all participants and according to groups at the beginning of the study.

Table 4.1.1 Baseline means body weight, body height, body mass index (BMI), percentage body fat and fat free mass

Parameters		Groups (Mean ± SD)		
		C	Ob	ObEx
Body weight	(kg)	59.26 ± 11.10	67.69 ± 13.95	65.40 ± 12.47
Body height	(cm)	153.50 ± 5.90	153.71 ± 5.39	154.00 ± 4.12
Body mass index (BMI)	(kg/m^2)	24.9 ± 5.2	28.5 ± 4.4	32.1 ± 9.2
Percentage body fat	(%)	34.1 ± 4.6	40.4 ± 8.4	40.4 ± 8.6
Fat free mass	(kg)	35.8 ± 3.5	39.2 ± 7.2	39.7 ± 4.4

4.1.1 Body weight

Mean body weight of all the groups are shown in Table 4.1.2. At pre test, there were no significant differences of body weight among all the groups. Similarly, at post test, there were also no significant differences in body weight among all groups.

After 6 weeks of experimental period, means body weight were significantly lower in post test compared to pre test in Ob (p=0.013) and ObEx (p=0.02). The percentage decrease of body weight in ObEx was the highest (-1.4%) among the groups, and the percentage decrease of this parameter in Ob was -1.1%. The percentage change of body weight in C was 1.1%.

Table 4.1.2 Mean body weight at pre- and post tests

Groups	Body weight (kg) (Mean±SD)			
	Pre test	Post test	Mean difference between pre- and post tests	Percent difference compared to pre test (%)
C	59.26 ± 11.10	59.93 ± 11.42	0.67 ± 1.09	1.1
Ob	67.69 ± 13.95	66.95 ± 13.83[a]	-0.74 ± 0.93	-1.1
ObEx	65.40 ± 10.78	64.47 ± 10.27[a]	-0.59 ± 0.71	-1.4

a, significantly different from pre test (p<0.05)

4.1.2 Body mass index

Means body mass index of all the groups are shown in Table 4.1.3. At pre test, there were no significant differences of mass index among all the groups. Similarly, at post test, there were also no significant differences in body mass index among all the groups.

After 6 weeks of experimental period, there was no significant difference of body mass index between pre- and post tests in all the groups. Nevertheless, further analysis showed that the percentage change of body mass index in ObEx was the highest (-11.3%) among the groups. The percentage change in other groups was Ob: -1.1% and C: 1.1% respectively.

Table 4.1.3 Mean body mass index (BMI) at pre- and post tests

Groups	Body mass index (kg/m^2) (Mean±SD)			
	Pre test	Post test	Mean difference between pre- and post tests	Percent difference compared to pre test (%)
C	24.9 ± 5.2	25.2 ± 5.3	0.3 ± 0.4	1.1
Ob	28.5 ± 4.4	28.2 ± 4.4	-0.3 ± 0.4	-1.1
ObEx	32.1 ± 9.2	28.5 ± 5.8	-3.6 ± 10.2	-11.3

4.1.3 Percentage of body fat

Means percentage of body fat of all the groups are shown in Table 4.1.4. At pre test, there were no significant differences of percentage body fat among all the groups. Similarly, at post test, there were also no significant differences in percentage body fat among all the groups.

After 6 weeks of experimental period, results indicated that there was no significant difference between pre- and post tests in all the groups. Nevertheless, further analysis showed that the percentage change of percentage body fat in Ob was -1.2%, ObEx was 2.2% and C was 4.5%

Table 4.1.4 Mean percentage of body fat (%) at pre- and post tests

Groups	Percentage body fat (%) (Mean±SD)			
	Pre test	Post test	Mean difference between pre- and post tests	Percent difference compared to pre test (%)
C	34.1 ± 4.6	35.7 ± 6.5	1.5 ± 4.1	4.5
Ob	40.4 ± 8.4	39.9 ± 7.8	-0.5 ± 1.9	-1.2
ObEx	40.4 ± 8.6	41.3 ± 10.6	0.9 ± 4.9	2.2