COMBINED EFFECTS OF OAT BRAN CONSUMPTION AND BRISK WALKING EXERCISE ON IMMUNE FUNCTIONS IN 40 TO 50 YEARS OLD WOMEN

By

MUHAMMAD AMRUN HAZIQ BIN ABIDIN

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ABSTRAK

PENGENALAN: Aktiviti fizikal sederhana dan pengambilan nutrisi yang mencukupi adalah dipercayai boleh meningkatkan fungsi imuniti seseorang individu. Setakat ini, pengetahuan tentang kesan kombinasi senaman dan pengunaan bran oat ke atas fungsi imuniti dalam kalangan wanita yang berumur 40 hingga 50 tahun masih terhad. Oleh itu, kajian ini telah dijalankan. **MATLAMAT:** Kajian ini dijalankan untuk mengkaji kesan baik gabungan pengambilan bran oat dan senaman berjalan cepat pada fungsi imuniti dalam kalangan wanita yang berumur 40 hingga 50 tahun. **KAEDAH:** Tiga puluh tiga wanita yang berumur 40 hingga 50 tahun telah dikumpul dan dibahagikan kepada tiga kumpulan yang terdiri daripada sebelas peserta bagi setiap kumpulan (n = 11): kumpulan kawalan yang tidak aktif dan tidak mengambil bran oat (C), kumpulan yang mengambil bran oat sahaja (Ob) dan kumpulan gabungan pengambilan bran oat dan senaman berjalan cepat (ObEx). Senaman berjalan cepat dijalankan oleh para peserta sebanyak tiga kali seminggu selama enam minggu. Serbuk bran oat telah diambil oleh para peserta sebanyak dua paket setiap hari (18g serbuk bran oat yang mengandungi 3.6 gram beta glucan) yang dilarutkan dalam 250ml air kosong, tujuh hari seminggu selama enam minggu dalam kumpulan Ob dan ObEx. Peserta dalam ObEx mengambil minuman bran oat satu jam

sebelum melakukan senaman. Sebaik sahaja sebelum dan selepas enam minggu tempoh kajian, parameter-parameter antropometri peserta diukur. Sampel darah diambil sebelum dan selepas tempoh kajian untuk mengukur sel-sel darah putih, neutrofil, basofil, eosinofil, monosit, jumlah limfosit, jumlah T limfosit ($CD3^+$), sel T penolong ($CD4^+$), sel T sitotoksik ($CD8^+$) dan sel pembunuh semula jadi ($CD16^+$) untuk menentukan tahap fungsi imuniti. **KEPUTUSAN:** Berat badan peserta menurun secara ketara ($p<0.05$) pada ujian pos dalam kumpulan Ob dan ObEx. Terdapat peningkatan ketara ($p<0.05$) dalam eosinofil dan neutrofil pada ujian pos dibandingkan dengan ujian pra dalam kumpulan Ob. Terdapat juga penurunan ketara ($p<0.05$) dalam nilai-nilai jumlah T sitotoksik ($CD8^+$) dan sel-sel pembunuh semulajadi ($CD16^+$) dalam ujian pos berbanding dengan ujian pra dalam kumpulan ObEx. Bagi sel-sel darah putih, monosit, basofil, jumlah limfosit, jumlah T limfosit ($CD3^+$) dan sel T penolong ($CD4^+$), tiada perubahan ketara telah diperhatikan dalam ujian pos berbanding dengan ujian pra dalam semua kumpulan. **KESIMPULAN:** Penggunaan bran oat sahaja selama enam minggu dapat memberi kesan yang baik terhadap fungsi imuniti. Oleh itu, pengunaan bran oat sahaja mungkin mempunyai potensi untuk disyorkan bagi meningkatkan fungsi imuniti dalam kalangan wanita yang berumur 40 hingga 50 tahun. Walaubagaimanapun, kajian dengan intensiti senaman yang berbeza dan tempoh masa yang lebih lama adalah dicadangkan untuk dijalankan pada masa hadapan untuk menyiasat kesan gabungan pengambilan bran oat dan senaman berjalan cepat ke atas fungsi imuniti dalam populasi ini.

COMBINED EFFECTS OF OAT BRAN CONSUMPTION AND BRISK WALKING EXERCISE ON IMMUNE FUNCTIONS IN 40 TO 50 YEARS OLD WOMEN

ABSTRACT

INTRODUCTION: Moderate physical activity and adequate nutritional intake are believed can enhance immune function of an individual. To date, little is known about combination effects of exercise and oat bran consumption on immune functions in 40 to 50 years old women. Therefore, the present study was carried out. **PURPOSE:** This study was carried out to examine the beneficial effects of combined brisk walking exercise and oat bran consumption on immune functions in 40 to 50 years old women. **METHODS:** Thirty three 40 to 50 years old women were recruited and assigned into three groups, with eleven participants per group (n=11): sedentary without oat bran consumption control (C), oat bran consumption alone (Ob) and combined oat bran consumption and brisk walking exercise (ObEx) groups. The brisk walking exercise was performed by the participants three times per week for six weeks. Oat bran powder was consumed by the participants with two sachets per day (18g of oat bran powder containing 3.6 grams of β-glucan) diluted with plain water, 7 days per week for 6 weeks in Ob and ObEx groups. Participants in ObEx consumed oat bran drink one hour before performing the exercise. Immediately before and after six weeks of the experimental period, participants' anthropometric parameters were measured. Blood samples were taken before and after experimental period in order to measure total white blood cells, neutrophils, basophils, eosinophils, monocytes,

total lymphocytes, total T lymphocytes ($CD3^+$), T helper cells ($CD4^+$), T cytotoxic cells ($CD8^+$) and natural killer cells ($CD16^+$) for determining the level of immune functions. **RESULTS:** Participants' body weight decreased significantly ($p<0.05$) at post test in Ob and ObEx group. There were significant ($p<0.05$) increases in eosinophil and neutrophil counts in post test compared to pre test in Ob group. There were also significant ($p<0.05$) decreases in values of T cytotoxic ($CD8^+$) and natural killer cells ($CD16^+$) in post test compared to pre test in ObEx groups. For white blood cells, monocytes, basophils, total lymphocytes, total T lymphocytes ($CD3^+$) and T helper cells ($CD4^+$), no significant changes were observed in post test compared to pre test among all groups. **CONCLUSION:** Six weeks of oat bran consumption alone elicited the beneficial effect on immune functions. Thus, consumption of oat bran alone may have the potential to be recommended for increasing immune functions in 40 to 50 years old women. Nevertheless, future study with different exercise intensities and longer duration are proposed to be carried out to investigate the effects of combined oat bran consumption and brisk walking exercise on immune functions in this population.

CHAPTER 1

INTRODUCTION

The immune system defends against, identifies, attacks and demolish elements that are unfamiliar to the body. The immune system can be divided into two broad functions which are innate (natural and non-specific) and acquired (adaptive and specific) immunity. Both work together synergistically (Gleeson *et al.*, 2004). According to the Chaplin (2010), the first set of responses represents the innate immune response while the second set of responses represents the adaptive immune response. Chaplin (2010) also stated that the innate and adaptive immune systems are often illustrated as contrasting separate arms of the host response. However, they commonly work together, with the innate immune system picturing the first line of host defense and the adaptive immune system becoming noticeable after several days as antigen-specific T and B cells have experienced clonal expansion. Parkin and Cohen (2001) mentioned that innate immunity includes physical, chemical, and microbiological barriers, but more usually embraces the elements of the immune system such as neutrophils, monocytes, macrophages, complement, cytokines, and acute phase proteins which provide immediate host defense. Meanwhile, adaptive immunity is response consists of antigen-specific reactions through T lymphocytes and B lymphocytes.

Nutrition also has a vital influence on immune function, and closely all nutrients provide support for the immune system in its work against viruses and bacteria (Nieman,

2011). Based on that, inadequate or inappropriate nutrition can compound the adverse influence of heavy exertion on immunocompetence. Dietary deficiencies of protein and specific micronutrients also have long been correlated with immune dysfunction (Gleeson *et al.*, 2004). Oat bran is a good source of B-complex vitamins, protein, fat, minerals and soluble fiber β-glucan (Butt *et al.*, 2008). Oat bran, the edible outermost layer of the oat kernel is full in soluble fiber and is called β-glucan. Oat β-glucan plays an important role in promoting health and prevention against diseases. It has capacity to enhance the immune functions of an organism by elevating immunoglobulin, NK cells, killer T-cells and boost the resistance to infectious and parasitic diseases of an individual (Daou and Zhang, 2012).

One of the major problems in elderly people is their tendency to infection is higher, particularly due to immunological insufficiencies (Kuroiwa *et al.*, 2004). Numerous studies have indicated that exercise encourages the notable physiological change in the immune system (Pedersen and Laurie, 2000). Physical exercise contributes a challenge to homeostasis throughout the body and the immune system shows significant disruption in reaction to a single bout of exercise according to Koch (2010). Regular physical activity improves immune function, whereas sustained and intense exertion has the opposite effect (Nieman, 2011). The relationship between exercise and susceptibility to infection has been modeled in the form of a "J"-shaped curve (Nieman, 1994). This model indicates that, while engaging in moderate activity may improve immune function above sedentary levels, excessive amounts of prolonged, high-intensity exercise may impair immune function (Gleeson, 2007).

Physical activity can elicit acute and chronic beneficial effects on the immune systems of elderly people. Moderate exercise performed by elderly participants can cause temporary but positive improvements in immune surveillance that increase host protection and vaccine antibody responses (Nieman, 2011). A previous study on the influence of moderate exercise training on immune function reported that daily brisk walking can reduce the number of sickness days by half over a 12 to 15-week period compared to inactivity (Nieman and Pedersen, 1999).

Understanding the combined effects of oat bran supplementation and physical activity is important for maintaining and enhancing immune functions. Since no study has been undertaken to determine the additional beneficial effects of a combined brisk walking exercise and oat bran consumption compared to oat bran consumption alone on immune functions in adult women, the present study was proposed to examine the effectiveness of combined brisk walking exercise and oat bran consumption on immune functions in 40 to 50 years old women.

1.1 OBJECTIVE OF THE STUDY

General objective:

To determine the additional beneficial effects of combined oat bran consumption and brisk walking exercise on immune functions in 40 to 50 years old women.

Specific objective:

To determine 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 immune function parameters, i.e. white blood cells, neutrophils, basophils, eosinophils, monocytes, total lymphocytes, total T lymphocytes, T helper cells, T cytotoxic cells and natural killer cells in 40 to 50 years old women.

1.2 SIGNIFICANCE OF THE STUDY

Proper immune functioning is required for maintaining health status of an individual. Since to date, the information on the beneficial effects of combined oat bran consumption and brisk walking exercise with moderate intensity on immune functions in adult women are lacking, therefore, the present study was proposed. It is hoped that the results obtained from this study can be used to plan exercises and nutritional promotion programmes for increasing immune functions in 40 to 50 years old women.

1.3 HYPOTHESIS

H_o: 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 group (C) in immune function parameters in 40 to 50 years old 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 group (C) in immune function parameters in 40 to 50 years old women.

1.4 OPERATIONAL DEFINITIONS

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

Oat bran powder consumption: Biogrow Oat BG22^{TM} oat bran powder consumed by participants in oat bran consumption alone group (Ob) and combined brisk walking exercise with oat bran consumption group (ObEx), with two sachets per day of oat bran

powder (18g of oat bran powder containing 3.6 grams of β-glucan) diluted with plain water, 7 days per week for 6 weeks.

Immune function: Measurements of blood immune function parameters, i.e.: white blood cells, neutrophils, basophils, eosinophils, monocytes, total lymphocytes, total T lymphocytes, T helper cells, T cytotoxic cells and natural killer cells.

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

CHAPTER 2

LITERATURE REVIEW

2.1 IMMUNE SYSTEM

The immune system acts to defend the host from infectious agents that exist in the environment such as bacteria, viruses, fungi, parasites and also from other noxious insults. It is always active and acts to differentiate 'non-self' from 'self' (Calder and Kew, 2002). The immune response starts when an invading foreign agent like a microorganism, enters the chemical and physical barriers that are protecting the body of an individual (Mackinnon, 1999). The immune system has developed to protect the host from a cosmos of infective microorganisms that are themselves constantly evolving (Chaplin, 2010). It defends against, identifies, attacks and demolish elements that are unfamiliar to the body. The immune system can be divided into two broad functions which are innate (natural and non-specific) and acquired (adaptive and specific) immunity, which work together synergistically (Gleeson *et al.*, 2004).

The host uses both innate and adaptive mechanisms to discover and remove infective microorganisms, and both of these mechanisms include self-nonself discrimination (Chaplin, 2010). Both elements of immunity involve various blood-borne factors such as complement, antibodies, and cytokines as well as cells. These cells are

broadly termed as leucocytes or also known as white blood cells. Leucocytes separate into two broad categories, i.e. i) phagocytes which include granulocytes (neutrophils, basophils, eosinophils), monocytes and macrophages and ii) lymphocytes (Calder and Kew, 2002).

Dietary deficiencies of protein and specific micronutrients have long been correlated with immune dysfunction. An adequate intake of iron, zinc and vitamins A, E, B6 and B12 is specifically important for the conservation of immune function. However, excess intakes of some micronutrients can also weaken immune function and have other negative effects on health. To conserve immune function, an individual should eat a well-balanced diet sufficiently to meet their energy requirements, and for ensuring an enough intake of protein and micronutrients (Gleeson *et al.,* 2004). It has been speculated that athletes lacking in carbohydrate are placing themselves at risk from the known immunosuppressive effects of cortisol, including the suppression of antibody production, lymphocyte proliferation and natural killer cell cytotoxic activity (Gleeson *et al.*, 2004). In the elderly, consequent as increasing of age, the number of circulating T lymphocytes and T helper ($CD4^+$) cells are decreased, whereas the number of T-cytotoxic ($CD8^+$) cells is variously reported as normal, decreased, or increased (Chandra, 1997).

2.1.1 Innate immunity

Innate immunity includes physical, chemical, and microbiological barriers, but more usually embraces the elements of the immune system such as neutrophils, monocytes, macrophages, complement, cytokines, and acute phase proteins which provide instant host defense (Parkin and Cohen, 2001). Innate immunity is the first aspect of the

immune system experienced by a foreign agent and includes soluble mediators as well as physical and chemical barriers on the body's surface. Cells involved in innate immunity can discover and act against "non-self" i.e. cells from another organism without prior exposure (Mackinnon, 1999). Innate immunity is concerned with preventing entry of infectious agents into the body and, if they do enter, with their rapid elimination (Calder and Kew, 2002). The first set of responses represents the innate immune response. The recognition molecules used by the innate immunity are expressed widely on a large number of cells, therefore, this system is poised to act rapidly after an invading pathogen or toxin is experienced and thus represents the initial host response (Chaplin, 2010). The effort of an infectious agent to enter the body immediately activates the innate immune system. This so-called 'first-line of defence' consists three general mechanisms with the standard goal of preventing the entry of microorganisms into the body: (i) physical or structural barriers such as skin, epithelial linings, mucosal secretions; (ii) chemical barriers, i.e. pH of bodily fluids and soluble factors such as lysozymes and complement proteins; and (iii) phagocytic cells, e.g. neutrophils and monocytes or macrophages (Gleeson *et al.*, 2004). According to Koch (2010), neutrophils and monocytes play important roles in innate or nonspecific immunity.

2.1.1.1 Neutrophil, eosinophil and basophil

Neutrophils represent one of the key nonspecific host defense cell populations responsible for the phagocytosis of many microbial, bacterial and viral pathogens. Neutrophil is also known to be involved in the synthesis and release of immunomodulatory

cytokines that influence T cell and B cell activities (Pyne, 1994). Previous studies reported that neutrophils act as effectors in both innate and adaptive immunoregulatory networks. In fact, once enrolled into inflamed tissues, neutrophils engage into complex bidirectional interactions with macrophages, natural killer, B and T lymphocytes, or platelets (Scapini and Cassatella, 2014). Neutrophils, like most cells involved in immune responses, are not static within a specific area but are mobile cells that travel around the body (Parkin and Cohen, 2001). For eosinophils, based on Parkin and Cohen (2001), the main physiological role of eosinophils is in the protection of the host from parasitics, specifically nematode infections. Eosinophils are not phagocytic but have large granules containing major basic protein, eosinophilic cationic protein, eosinophil per-oxidase, and eosinophil-derived neurotoxin, which are highly cytotoxic when released onto the surface of organisms. In more-developed countries, the eosinophil is more often considered as a pathological participant in allergic reactions. Basophils are comparatively few in number compared with the other white cells. They are involved in some of the most critical immunological reactions, such as angioedema and anaphylaxis (Parkin and Cohen, 2001).

2.1.1.2 Monocytes and macrophages

Macrophages react both to phagocytosable particles e.g. bacteria, viruses and cell debris and to a number of soluble factors (Pyne, 1994). Macrophages are broadly distributed immune cells that play an essential role in homeostasis and defense. They can be phenotypically polarised by the microenvironment to rise specific functional programs (Martinez *et al.*, 2008). Monocytes and macrophages are involved in many aspects of

immunity including the release of cytokines, phagocytosis, antigen-presentation and tumor cytotoxicity (Mackinnon, 2000).

2.1.1.3 Natural killer cells

According to the Parkin and Cohen (2001), natural killer cells have the morphology of lymphocytes but do not carry a specific antigen receptor. Natural killer cells play a major role in the innate immune response against infections and tumors, which are seen with elevating incidence during ageing (Bruunsgaard and Pedersen, 2000). According to Ogata *et al.* (2001), low natural killer cell activity is correlated with the development of infections and death due to infection in immunologically normal elderly participants with an impaired performance status. Besides, Tan and Vanitha (2004) mentioned that natural killer cells constitute the innate immune system and mount an immediate non-specific response to foreign microbial agents. According to McFarlin *et al.* (2008), one of the most standard measurements of innate immunity is natural killer cell activity.

2.1.2 Adaptive immunity

Adaptive immunity involves the specific recognition of molecules such as antigens on an invading pathogen, which differentiates it as being foreign to the host. The recognition of antigens is by antibodies produced by B lymphocytes and by T lymphocytes (Calder and Kew, 2002). Adaptive immunity is characterised by specificity to the infectious agent and a short lag period i.e. a few days to become fully activated

(Mackinnon, 1999). The adaptive immune response is the second set of responses. The adaptive immune system is consisted of small numbers of cells with specificity for any individual pathogen, toxin, or allergen, the responding cells must expand after encountering the antigen to achieve sufficient numbers to mount an effective response against the microbe or the toxin (Chaplin, 2010). The adaptive immune system differentiates itself from the innate immune system by the following features such as specificity of antigen recognition, diversity of the antigen receptor repertoire, rapid clonal expansion, adaptiveness to the changing environment, and immunological memory. Lymphocytes are the primary cells of adaptive immunity. Lymphocytes are divided into T cells and B cells (Alam and Gorska, 2003).

2.1.2.1 Lymphocytes

Lymphocytes are classified as T lymphocytes and B lymphocytes. T lymphocytes are further separated into T helper cells (these are distinguished by the presence of the molecule CD4 on their surface) and T cytotoxic cells (these are distinguished by the presence of CD8 on their surface) (Calder and Kew, 2002). Besides, Calder and Kew (2002) also mentioned that B lymphocytes proliferate and mature into antibody-producing cells (plasma cells) and T lymphocytes proliferate and are able directly to kill virally infected cells (T cytotoxic lymphocytes) or control the activity of other cells involved in the response (T helper cells). Two major types of effector T cells have been identified which are T helper and T cytotoxic, bearing either CD4 or CD8 molecules on their surface, respectively. T helper cells ($CD4^+$) are the orchestrating cells of the immune response,

recognising foreign antigen, and activating other parts of the cell-mediated immune response to kill the pathogen (Parkin and Cohen, 2001). The B lymphocyte response to an antigen is termed as humoral immunity and the T cell response is termed as cell-mediated immunity. B cells produce the antibody that helps to neutralize toxins, blocks organisms binding to mucosal surfaces, activates complement, opsonizes bacteria for phagocytosis, and sensitizes tumor and infected cells for antibody-dependent cytotoxic attack by killer cells (Parkin and Cohen, 2001).

2.2 NUTRITIONAL SUPPLEMENTATION AND IMMUNE FUNCTION

Nutrient status is an important factor contributing to immune function, undernutrition impairs the immune system, suppressing immune functions that are basic to host protection. Low nutrition intake leading to impairment of immune function can be due to insufficient intake of energy and macronutrients and/or due to deficiencies in specific micronutrients (Calder and Kew, 2002). Gleeson *et al.* (2004) mentioned that dietary deficiencies of energy, protein and specific micronutrients are correlated with depressed immune function and increased susceptibility to infection. According to Pike and Chandra (1995), supplementation with micronutrients can play an important role in the maintenance of normal immune function in the elderly. Furthermore, based on Nieman (2011), nutrition has the vital influence on immune function and almost all nutrients provide support for the immune system in its work against viruses and bacteria.

According to Chandra (1997), the simultaneous assessment of nutritional status and immune responses and subsequent correlation analysis have suggested that impaired immunity in the elderly may be due in part to associated nutritional deficiencies. Furthermore, to improve immune function, vitamins, minerals and micronutrient are very important for elderly. According to Kuroiwa *et al.* (2004), there are beneficial effects of traditional Japanese herbal medicine on immunological capacity in elderly people.

2.3 OAT BRAN

Oats are a uniquely nutritious food as they contain high amounts of soluble fibre (Decker *et al.*, 2014). Oat (Avena sativa) is different among the cereals due to its multifunctional characteristics and nutritional profile. It is a good source of dietary fibre especially β-glucan, minerals and other nutrients (Butt *et al.*, 2008). Oats can be processed into oat bran and fibre to obtain high-fibre-containing fractions that can be used in a variety of food products. Besides, the outer layer of the groat in oat is an important source of protein, neutral lipids, β-glucan, phenolics and niacin, and is sometimes separated from the groat to produce oat bran (Decker *et al.*, 2014). Oat bran is produced by grinding clean groats or rolled oats for separating the resulting flour by sieving. It has total β-glucan and dietary fibre not less than 5.5 and 16.0% respectively with at least one-third of total dietary fiber is soluble fiber (American Association for Clinical Chemistry, 1989). Oat BG22™ oat bran powder produced by Biogrow Company provides 20% β-glucan per sachet. Please refer to **Table 2.1** for the nutrition facts of Biogrow Oat BG22™ oat bran powder.

Table 2.1: Nutrition facts of Biogrow Oat BG22™ oat bran powder

Serving Size: One sachet contains ≈ 9g

	Per Serving (1 scoop/ sachet ≈ 9g)	*Per 100 g*
Energy Calories	114 kJ 27 kcal	1274 kJ 303 kcal
Total Fat *Monounsaturated Fat* *Polyunsaturated Fat* *Saturated Fat* *Trans Fat*	0.3 g 0.1 g 0.1 g < 0.1 g 0.0 g	3.2 g 1.4 g 1.2 g 0.6 g 0.0 g
Carbohydrate *Total Sugars*	2.7 g 0.3 g	30.5 g 3.2 g
Total Dietary Fiber *of which* ***beta-glucan*** *soluble fiber*	3.7 g 1.8 g	40.7 g 20.0 g
Protein Magnesium (Mg) Iron (Fe) Zinc (Zn) Sodium (Na)	1.7 g 23 mg 0.8 mg 0.5 mg < 1 mg	18.6 g 260 mg 8.4 mg 5.5 mg 7 mg

The recommended dose for an individual is 2 sachets (18 gram) per day, which can provide 3.6g soluble fibre β-glucan (Biogrow Company, 2015). According to Queenan *et al.*, (2007), six grams concentrated oat β-glucan per day for six weeks significantly reduced total and LDL cholesterol in participants with elevated cholesterol in their study.

2.3.1 Oat bran and immune function

The association between oat bran and the immune system is related to the content of β-glucan, especially water-soluble β-glucan. This soluble fibre can improve the activities of both the innate and specific immune system components through direct activation of specific receptors on macrophage, neutrophils, and NK cells (Donatto *et al.*, 2010). Volman *et al.* (2008) mentioned that immune response can be modulated by nutrients like β-glucans, which are glucose polymers that are major structural components of the cell wall of yeast, fungi, bacteria and cereals like oat and barley. In their study, it was observed that β-glucans can enhance the immune response in leukocytes and epithelial cells in animals. The authors speculated that it might be practicable to modulate immune function by increasing the dietary β-glucan intake. Davis *et al.* (2004) mentioned that β-glucan exerts its effects through direct stimulation of macrophage, neutrophil, and natural killer cells through β-glucan-specific receptor sites on their cell surface membranes, such as complement receptor 3 (CR3) a dectin-1. When attached, β-glucan activates these cells and activates a cascade of immune defenses that protect the organism from various viral, bacterial, and fungal challenges. According to Yun *et al.* (2003), immune functions may be upregulated by both oral and parenteral administration of oat β-glucan, and these enhanced responses may play an important role in providing resistance to bacterial and parasitic infections. According to Daou and Zhang (2012), oat β-glucan enhances resistance to microbial infections through cellular and antigen-specific humoral immunity, and immune functions can be upregulated by both oral and parenteral administration of oat β-glucan. Therefore, oat β-glucan plays an important role in providing resistance to bacterial and

parasitic infections. A study carried out by Murphy *et al.* (2009) found that oral feedings of oat β-glucan for 10 consecutive days significantly decreased symptoms of morbidity and revealed a trend toward a decrease in mortality following three consecutive days of exercise stress.

2.4 EXERCISE RECOMMENDATION AND BRISK WALKING EXERCISE

According to American College of Sports Medicine (ACSM)'s guideline for exercise testing and prescription (2010), exercises can be divided into three main types, i.e. aerobic or cardiovascular endurance exercise, resistance exercise for muscular fitness and flexibility exercise. 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, and at least 5-10 minutes with low to moderate intensity activities as a 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 (American College of Sports Medicine, 2010).

Walking is one of the simplest and least expensive options to increase one's physical activity level and improve overall health. It is a type weight-bearing exercise. According to Chen (2014), brisk walking for 30 minutes/day, 3 times/week may lead to a

drastic decline in the statistics of overweight and obese Malaysians. The author also mentioned that brisk walking is an ideal way to begin an exercise programme since it can be performed with minimal instruction or equipment and is low in cost. Walking at a brisk pace for 30 minutes or more per week enables an individual to meet the criteria for physical activity for health benefits as recommended by the American College of Sports Medicine (2011). According to Hennekens (2000), brisk walking is moderately intense exercise that safe, achievable, and feasible for the majority of the population, including older age groups to improve health.

2.5 EXERCISE AND IMMUNE FUNCTION

Physical exercise training is known to improve functional ability in aging population by improving muscle function and is vital in the prevention of age-associated diseases, such as type II diabetes, atherosclerosis, hypertension and osteoporosis (Bruunsgaard and Pedersen, 2000). Physical exercise brings a challenge to homeostasis throughout the body. The immune system, like many other physiological systems, exhibits substantial perturbations in response to a single bout of exercise (Koch, 2010). In response to acute exercise which is the most frequently studied area of exercise immunology, a rapid interchange of immune cells between peripheral lymphoid tissues and the circulation occurs. The response depends on many factors, including the intensity, duration, and mode of exercise, concentrations of hormones and cytokines, change in body temperature, blood flow, hydration status, and body position (Nieman, 1997). Nieman (1997) also mentioned

that of all immune cells, natural killer (NK) cells, neutrophils, and macrophages appear to be most responsive to the effects of acute exercise, both in terms of numbers and function. The study finding of Nieman (2011) which showed that 25% to 50% reduction in sick days with moderate exercise encouraged individuals to be physically active on a regular basis. The author also mentioned that although the immune system returns to pre exercise levels within a few hours after the exercise session is over, each session represents a boost in immune surveillance that reduces the risk of infection over the long term.

2.5.1 Effect of exercise intensity on immune function

Based on a previous study carried out by Nehlsen-Cannarella *et al.* (1991) on the effects of moderate exercise training on immune response, it was found that moderate exercise training i.e. five 45-min sessions per week, brisk walking at 60 heart rate reserve for 15 weeks is not associated with an improvement in lymphocyte function, but it is associated with little increase in serum immunoglobulins and several small changes in circulating numbers of immune system variables. Their study also observed significant decreases in circulating numbers of lymphocytes, particularly the T-cell subpopulation. Nevertheless, according to Nieman (2011), positive immune changes take place during each bout of moderate physical activity. Moderate exercise elevates the recirculation of immunoglobulins, neutrophils and natural killer cells, 2 cell types that play a major role in innate immune defenses. According to Saito *et al.* (2003), moderate exercise that reaching or exceeding ventricular threshold level acutely affects T cell and natural killer cell subsets. Rogers *et al.* (2008) found that regular moderate exercise may enhance vaccine

efficacy in animals and thus, may be an important lifestyle intervention in humans to couple with immunisation against infectious diseases such as influenza. According to Yan *et al.* (2001), moderate exercise in later life is associated with a lesser age-related decline, in certain aspects of T-cell functions, leading to a better quality of life for the elderly by keeping them in better health.

Based on Pedersen and Toft (2000), after intense long duration exercise, the concentrations of all lymphocyte subpopulations decline, the function of natural killers and T cells are inhibited, whereas the concentration of neutrophils continues to increase. Prolonged bouts of strenuous exercise can cause a temporary depression of various aspects of immune function e.g. neutrophil respiratory burst, lymphocyte proliferation, monocyte antigen presentation that usually last for 3 to 24 hour after exercise, depending on the intensity and duration of the exercise bout (Gleeson, 2007). According to Vahid *et al.* (2009), exercise training in male athletes for 14 weeks may elicit negative effects on immune system and persons who have problems in their immune system should be low intensity trained.

2.5.2 Exercise and immune function in individual with different age

Older adults exercise less and have lower levels of cardiorespiratory fitness than younger adults and this may lead to immunosenescence (Nieman, 2011). Immunosenescence is an impairment of the immune response associated with aging, is

characterised not only by a defective T-cell response but also by an abnormality in the number and function of other cells of the innate immune system (Kuroiwa *et al.*, 2004).

According to Nieman (2011), elderly persons are more susceptible to vaccine failure and many infections, auto-immune disorders, and cancers when compared with younger adults. However, it was also reported that innate immunity and in particular NK cell activity, is not heavily deteriorated with age (Ginaldi *et al.*, 1999). Bruunsgaard and Pedersen (2000) reported that elderly humans have preserved ability to recruit T lymphocytes and natural killers (NK) cell in response to an acute bout of exercise and training may affect and improve the ability to increase NK cytotoxicity in relation to exercise in elderly humans. Woods *et al.* (1999) reported that 6 months of supervised exercise training can lead to nominal increases in some measures of immune function in previously sedentary elderly. In young population, Saito *et al.* (2003) reported that moderate exercise that reaching or exceeding ventricular threshold level acutely affects T cell and natural killer cell subsets.

According to Gameiro *et al.* (2010), changes in the immune system have been attributed to estrogen deprivation in postmenopausal women. The authors also mentioned that there are decreases in T and B lymphocytes and in the cytotoxic activity of NK cells, thus attenuated immune response and higher susceptibility to microbial invasion and infection are characteristic in postmenopausal women. According to Pompe van der *et al.* (2001), exercise-induced changes in immune system parameters of postmenopausal

women cannot be compared with premenopausal women because of different response of immune function parameters to the exercise.

2.6 COMBINED EFFECT OF NUTRITIONAL SUPPLEMENTATION AND EXERCISE ON IMMUNE SYSTEM

Based on a previous study carried out by Diment *et al.* (2012), it was found that a daily mixed nutritional supplement prevented the decrease in circulating total leucocytes, lymphocytes and monocytes during an eight-week arduous training programme. In another previous study by Liew *et al.* (2013), it was found that six weeks of combined circuit training with chocolate malt drink supplementation and chocolate malt drink supplementation alone elicited more significant effects on immune functions compared to sedentary without supplementation. Mohamed and Ooi (2013) also reported that combination of a circuit training programme with honey supplementation also elicited beneficial effects on immune functions compared to circuit training or honey supplementation alone. Kwon *et al.* (2008) found that regular endurance swimming exercise combined with soybean supplementation improved the immune functions of rats.

Nieman *et al.* (1998) also reported that carbohydrate supplementation had a significant effect in attenuating increases in blood neutrophils and monocytes during exercise. Carbohydrate-containing sports drinks also have well-documented effects as a partial countermeasure for the immunosuppression associated with stressful exercise

(Murphy *et al.*, 2009). However, McFarlin *et al.* (2008) reported that 60 min of high intensity cycling exercise following consumption of carbohydrate does not alter innate immunity of male and female endurances athletes. According to Hirokawa (1997), combined use of different methods such as physical exercise and dietary manipulation would be more effective for reversing or restoring immune functions in the elderly. In other words, regular and moderate exercise combined with other methods, such as dietary manipulation, may thus be beneficial for immune functions in the elderly.

CHAPTER 3

MATERIALS AND METHODS

3.1 PARTICIPANTS

Thirty three women participants were recruited in this study. The inclusion criteria of participants were: Free from any chronic diseases such as cancer, diabetes, allergy, asthma, stroke, heart disease and etc., have regular menses, non-smokers, age between 40 to 50 years old, did not have habit of taking oat bran as daily supplementation prior to the experiment, did not engage in any training programme and did not exercise more than once per week i.e. sedentary. If qualified, the participants proceed to the next stage of this study which was grouping process. (Please refer to **Figure 3.1** for the experimental design of the study). The participants were then age-matched and being randomly assigned into the following three groups with: sedentary without oat bran consumption control group (C), oat bran consumption alone group (Ob) and combined brisk walking exercise with oat bran consumption group (ObEx). Each participant was given a detail explanation about the objectives, procedures, benefits, risks, and possible discomforts experienced in this study. The whole experimental period was 6 weeks. Participants were reminded regarding their participation in this study as being voluntary and they were permitted to stop being a part of this study at any time during the course of the study period. The present study was approved by Human Research Ethics Committee of Universiti Sains Malaysia (USM)