COMPARISON OF BONE HEALTH STATUS, MUSCULAR PERFORMANCE AND ANAEROBIC CAPACITY BETWEEN PHYSICALLY ACTIVE HIKERS AND SEDENTARY INDIVIDUALS

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COMPARISON OF BONE HEALTH STATUS, MUSCULAR PERFORMANCE AND ANAEROBIC CAPACITY BETWEEN PHYSICALLY ACTIVE HIKERS AND SEDENTARY INDIVIDUALS

BY

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CERTIFICATE

This is to certify that the dissertation entitled "COMPARISON OF BONE HEALTH STATUS, MUSCULAR PERFORMANCE AND ANAEROBIC CAPACITY AMONG HIKERS AND SEDENTARY INDIVIDUALS" is the bona fide record of research work done by Ms. NUR SYARA AFIQA BINTI ZARIAN during the period from March 2020 to June 2021 under my supervision. I have read this dissertation and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation to be submitted in partial fulfillment for the degree of Bachelor of Health Science (Honours) (Exercise and Sport Science).

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DECLARATION

I hereby declare that this dissertation is the result of my investigation, except where otherwise stated and duly acknowledged. I also declare that it has not been previously or currently submitted as a whole for any other degrees at Universiti Sains Malaysia or other institutions. I grant Universiti Sains Malaysia the right to use the dissertation for teaching, research, and promotional propose

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NUR SYARA AFIQA BINTI ZARIAN

DATE: 22 June 2021

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LIST OF ABBREVIATIONS

SOS	Speed of Sound
PT	Peak Torque
BW	Body Weight
BMD	Bone Mineral Density
DXA	Dual-Energy X-Ray Absorptiometry
HA	High Altitude
%BF	Percentage Body Fat
HR	Heart Rate
PCR	Phosphocreatine
ATP	Adenosine Triphosphate
CP	Creatine Phosphate
BMI	Body Mass Index
FFM	Fat-Free Mass
MP	Mean Power
PP	Peak Power
AC	Anaerobic Capacity
AP	Anaerobic Power
FI	Fatigue Index
IQR	Interquartile Range
SD	Standard Deviation
AVG.P	Average Power
PT/BW	Peak Torque Per Body Weight

PERBANDINGAN STATUS KESIHATAN TULANG, PRESTASI MUSKULAR DAN KEUPAYAAN ANAEROBIK DI ANTARA KUMPULAN PENDAKI DAN KUMPULAN SEDENTARI

ABSTRAK

Kajian ini dilakukan untuk mengetahui perbezaan status kesihatan tulang, prestasi otot dan kapasiti anaerobik di antara kumpulan pendaki yang aktif secara fizikal dan individu tidak aktif. Seramai 32 peserta (N=32) yang terdiri daripada 16 pendaki yang aktif secara fizikal (kumpulan pendaki, n=16) dan 16 individu yang tidak aktif (kumpulan sedentari, n=16) yang berumur 20-25 tahun dengan nilai BMI normal (18-24.9 kg/m^2) telah direkrut untuk kajian ini. Semua peserta dikehendaki melakukan penilaian fizikal seperti berikut: antropometri dan komposisi badan yang diukur menggunakan skala stadiometer dan analisis komposisi badan, kapasiti anaerobik diukur menggunakan Ergometer kitar, kekuatan otot isokinetik diukur menggunakan dynamometer BIODEX dengan 3 pergerakan halaju yang berbeza iaitu $60^0.s^{-1}$, $180^0.s^{-1}$ dan $300^0.s^{-1}$ pada tangan dan kaki dominan dan bukan dominan serta kekuatan pegangan tangan yang diukur melalui Dinamometer tangan. Selain itu, sonometer tulang digunakan untuk mengukur kelajuan bunyi (SOS) tulang yang dapat menggambarkan kepadatan mineral tulang pada tulang radius dan tibia. Hasil-hasil kajian menunjukkan terdapat nilai yang lebih besar yang signifikan secara statistik untuk tork puncak per berat badan (PT/BW) pada halaju $300^0.s^{-1}$, extensi bahu isokinetic tork puncak (PT) pada halaju $300^0.s^{-1}$, fleksi bahu isokinetik PT / BW pada halaju $300^0.s^{-1}$ dan flexi bahu isokinetik PT pada halaju $180^0.s^{-1}$ pada kumpulan pendaki daripada kumpulan sedentari. Walau bagaimanapun, perbezaan yang signifikan secara statistik tidak diperhatikan

dalam parameter lain antara kumpulan pendaki dan kumpulan kawalan sedentari. Daripada keputusan yang diperolehi, ia menunjukkan bahawa penglibatan dalam mendaki dapat meningkatkan kekuatan otot dibandingkan dengan gaya hidup yang sedentari dan menunjukkan faedah ketika mendaki di peringkat rekreasi berbanding gaya hidup tidak aktif.

COMPARISON OF BONE HEALTH STATUS, MUSCULAR PERFORMANCE AND ANAEROBIC CAPACITY BETWEEN PHYSICALLY ACTIVE HIKERS GROUP AND SEDENTARY INDIVIDUALS

ABSTRACT

This study was carried out to determine the differences in bone health status, muscular performance, and anaerobic capacity among physically active hikers and sedentary individuals. A total of 32 participants (N=32) consists of 16 physically active hikers (hikers group, n=16) and 16 sedentary individuals (sedentary group, n=16) with ages between 20-25 years old with normal BMI values (18-24.9 kg/m^2) were recruited in this study. All participants were required to perform the following physical assessments: anthropometric and body composition was measured by stadiometer scale and body composition analyzer, anaerobic capacities were measured by Cycle ergometer, isokinetic muscle strength and power were measured using BIODEX dynamometer with 3 different angular velocities of movement, i.e. $60^0.s^{-1}$, $180^0.s^{-1}$ and $300^0.s^{-1}$ on both dominant and non-dominant arm and leg. Handgrip strength was measured via a Hand dynamometer. Moreover, a bone sonometer was used to measure the bone speed of sound (SOS) which can reflect the bone mineral density of radius and tibia bone. The result showed that there were statistically significantly greater values ($p<0.05$) of isokinetic knee flexion peak torque per body weight (PT/BW) at $300^0.s^{-1}$ angular velocity, shoulder extension peak torque (PT) at $300^0.s^{-1}$ angular velocity, shoulder flexion PT/BW at $300^0. s^{-1}$ angular velocity and shoulder flexion PT at $180^0.s^{-1}$ angular velocity in the hiker group than the sedentary group. However, statistically,

significant differences were not observed in other parameters between the hiker group and sedentary group. From the results, it can be concluded that involvement in hiking can improve muscular strength compared to a sedentary lifestyle and implying the benefits of hiking at the recreational stage compared to a sedentary lifestyle.

CHAPTER 1

INTRODUCTION

1.1 Background of The Study

An active lifestyle is considered the best lifestyle for an individual. A lot of benefits of a healthy lifestyle can be found in the literature (Farhud, 2015). Some of the benefits of a healthy lifestyle can be compared directly between two different groups, including bone health status, muscular performance and anaerobic fitness. These parameters influence directly or indirectly the effectiveness and efficiency of our daily tasks. The type of daily activities or exercise will influence certain fitness components.

Different sports give different advantages and develop parts of the muscle differently. For example, taekwondo practitioners build up a lower limb strength through their practice and gymnasts build their flexibility and balance through their training. Normal individuals can achieve minimum requirements for a healthy lifestyle easily as many jogging tracks are available around the housing area or they can walk easily around the housing area.

Hiking is a long, vigorous walk, usually on trails or footpaths in the countryside. Walking for pleasure is developed in Europe during the 18^{th} century (Amato and Joseph, 2004). Hiking and walking in nature are recreational activity especially among those with sedentary occupations. Hiking is also a natural exercise that promotes physical fitness which is economical and convenient. It also requires no special equipment because hikers can walk as far as they want.

Nowadays, hiking is getting popular because of the pandemic. Since travel to another region is not allowed, people are exploring nature near to their places. To date, limited studies are done on the benefits of hiking to the bone health status and physical fitness parameters, and previous studies mostly focused on the psychological benefits of hiking. Even we know that the benefits of hiking can be related to the health benefits, most of the previous studies describe the benefits qualitatively.

Exercise can give a direct effect on bone health status and muscular performance for the specific part involved in the exercise. According to Haapasalo *et al.* (1994), loading exercises are applied to enhance bone mass and, it is necessary to apply more weight on bones than common weights that occur in daily activities. The osteogenic responses by their tensions on the skeleton are specific to the region of mechanical stress, and the responses are triggered by exercises, and resulting in an increased rate of osteogenesis and subsequently increased bone mineral density (BMD), which is indirectly reflected by bone health status measurement (Norsuriani and Ooi, 2018). To date, studies on hikers in Malaysia are very limited, so this study was proposed to compare between two groups, i.e. physically active and healthy hiker groups and sedentary individuals. It is hoped that the findings can increase the awareness of the benefits of an active lifestyle. This study focused on the comparison of bone health status, the muscular performance of the upper and lower limbs and anaerobic fitness between physically active and healthy hikers and sedentary individuals.

In early adulthood, BMD peaks, and it declines after menopause in women. Bone mineral density is also influenced by genetics (Brown *et al.*, 2005). However, starting in utero, BMD can be affected where maternal nutrition and medications can affect the fetal skeleton. Moreover, there are a few varieties of other modifiable factors affecting bone health, such as exercise, diet, smoking, alcohol, medications and calcium intake.

During 18 years old, nearly 90% of peak bone mass can be gained by an individual (Whiting *et al*., 2004). It is known that adolescence and young adulthood are the most critical times for increasing BMD. Furthermore, eating disorders, poor nutrition, hypoestrogenism, and inadequate calcium intake can cause negative consequences for bone health. Physical activity is important and acts as a key role as benefits of bone loading in childhood and adolescence continue into adulthood to maintain bone mass. Fracture risk can be reduced by maintaining bone mass between 50% to 80% bone mass (Johston *et al.,* 1994 and Kanis *et al*., 2001).

Bone mineral density can be measured by dual-energy x-ray absorptiometry (DXA) with the amount of mineral measured per unit area or volume of bone tissue (Johston and Slemenda, 1994). Ultrasound bone sonometer can also be used to determine the bone health status of an individual via measurement of the bone speed of sound, which can reflect bone mineral density. Bone sonometer is easy to be used and cheaper compared to DXA. This study will be used a bone sonometer to detect the bone health status of the participants.

The definition of muscular performance is the capacity of a muscle or a group of muscles to generate forces in maintaining, sustaining and modifying certain postures and movements that are prerequisites to functional activity (Heidi *et al.,* 2014). There are a few components of muscular performance that can be classified into strength, power, and endurance. Strength is the muscle force exerted to overcome resistance under a specific set of circumstances. Next, Power is the work produced per unit of time or the product of strength and speed. The definition of endurance is the ability of muscles to sustain force repeatedly or to generate forces over a while. The maximum extensibility of a muscle-tendon unit is referred to as length.

Besides, muscle strength can be measured isotonically. The muscle can be loaded only to its capability at the point of the range due to muscle performance. According to Moffroid *et al.* (1969), the total picture of muscle function throughout the range can be reflected by an isokinetic contraction that is the same as the maximal load being applied at each point of the arc of joint motion. Furthermore, exercise muscular patterns movement at selected angular velocities can be tested by isokinetic devices such as isokinetic dynamometer. The isokinetic device can also be used to measure moment (torque) work, power, endurance and range of motion. The isokinetic devices begin to register force when the force threshold is applied by the subject. Based on Winter *et al.* (1981), the value of the force depends on limb weight, either or not the movement is against gravity on the angular velocity setting. The safety of the subject using this method is efficient for those who have pre-existing pain. However, the machines will respond by reducing the resistance proportionately if the subject reduces contraction or feel the pain. Injury can be prevented while using this equipment.

Health-related fitness tests are the measurements related to cardiorespiratory, musculoskeletal fitness, motor fitness and body composition (Bouchard and Sheppard,1994). The level of physical fitness can be assessed by a selected fitness test. For example, the Wingate anaerobic test can assess anaerobic fitness, the handgrip strength test can assess musculoskeletal fitness. Body composition could be used as a marker of health.

Anaerobic capacity is the ability of the muscles to adapt to workouts in the form of very short duration, maximal and supramaximal physical activities. Anaerobic workouts mean the use of explosive power and a load that exceeds an anaerobic threshold and is a form of physical activity that is fatigued. Anaerobic activity cannot be maintained for extended periods because the skeletal muscles function well above the metabolism of steady-rate oxygen and through anaerobic metabolism (Sözen & Akyıldız, 2018).

1.2 Problem Statement

To date, studies carried out on bone health status and physical fitness components of hikers in Malaysia are limited. This study was warranted as a preliminary study for obtaining baseline data of bone health status and physical fitness components of hikers in Malaysia.

1.3 Research Objective

1.3.1 General objective

To compare bone health status, muscular performance and anaerobic capacity between physically active hikers and sedentary individuals.

1.3.1 Specific objectives

1. To compare the bone health status between physically active hikers and sedentary individuals.
2. To compare the muscular performance and power measurement between physically active hikers and sedentary individuals.

3. To compare the anaerobic capacity between physically active hikers and sedentary individuals.

1.4 Research Hypotheses

H_{O1}: There is no significant difference in bone health status between physically active hikers and sedentary individuals.

H_{A1}: There is a significant difference in bone health status between physically active hikers and sedentary individuals.

H_{O2}: There is no significant difference in muscular performance between physically active hikers and sedentary individuals.

H_{A2}: There is a significant difference in the muscular performance between physically active hikers and sedentary individuals

H_{O3}: There is no significant difference in anaerobic capacity between physically active hikers and sedentary individuals.

H_{A3}: There is a significant difference in anaerobic capacity between physically active hikers and sedentary individuals.

1.5 Significance of The Study

According to the Sedentary Behaviour Research Network (SBRN), a sedentary lifestyle is defined as any activity involving sitting, reclining, or lying down that has very low energy expenditure and which is known to promote lifestyle diseases such as diabetes, obesity and heart attacks. Physical activity such as hiking has the potential to encourage an individual to stay active. Sedentary individuals are suggested to stay active by exercising. Bone health, muscular and anaerobic fitness are vital components for an individual to maintain general health status. Health benefits can be obtained directly and indirectly through practicing one sport. However, information on the direct or indirect effects of hiking activities on these features is not studied especially among hikers in Malaysia. We hope that the findings of this proposed study can add new information in the field of exercise and sports science, and the information can be used to promote active and healthy living in the sedentary population.

CHAPTER 2

LITERATURE REVIEW

2.1 Anthropometric and Body Composition Adaptations to High Altitude

Bodyweight (BW) loss and body composition modifications are the most common adaptations to high altitude (HA) exposure in non-acclimatized humans, observed both in experimental studies in hypobaric chambers and field studies on mountaineering. BW loss relies on several variables, the primary one being the marked distinction between energy intake and energy expenditure, which is elevated through hypoxia. The magnitude of BW loss has been suggested to be linked to the altitude reached (Martin *et al.*, 2010) for the period of HA disclosure (Hamad and Travis, 2006). The nature or absence of altitude-related disease, to the level of physical activity and the level of consumption of food (Fulco *et al.*, 1992), and perhaps gender, losing less for women (Boyer and Blume, 1984; Kayser, 1994).

The components of BW loss at HA are not clear, however. Some researchers have mainly attributed BW loss to fat reduction in mass (Armellini *et al.*, 1997; Boyer and Blume, 1984; Butterfield *et al.*, 1992; Ermolao *et al.*, 2011; Guilland and Klepping, 1985; Surks, 1966) some to body fluid loss (Consolazio *et al.*,1968), or fat-free mass (FFM) reduction (Fulco *et al.*, 1985). Rose *et al.* (1988) claimed that the loss of BW in a simulated climb was from both fat mass and fat-free mass within the hypobaric space, where the temperature was maintained continuously. Some anthropometric and body composition characteristics are more suitable for sports practice at high altitudes, as in mountain climbing (Barbieri *et al.*, 2012)

Watts *et al*. (1993) concluded that climbing performance is best predicted by percentage body fat (%BF) and strength to body mass ratio in elite sport climbers. Grant *et al.* (1996) found that elite climbers differ from recreational climbers and active non-climbers on measures of leg span, %BF, flexibility, and muscular strength and endurance.

2.2 Physical Fitness Components

There are 4 components of health-related fitness, i.e. cardiorespiratory fitness, musculoskeletal fitness, motor fitness and body composition that have relationships with health (Bouchard *et al.,* 1994). Fitness tests can be carried out to test the overall health and physical status of individuals, and through this test, all components that contribute to the overall health can be measured and compared. Suggestions for the improvement in a specific component can then be made in the future to improve the overall health status of the participants.

Assessing levels of physical fitness can be done by selected fitness tests such as the Wingate test to assess anaerobic fitness, and handgrip strength test to assess musculoskeletal fitness.

Ruiz *et al.* (2009) reported that there is strong evidence that a healthier cardiovascular profile is associated with higher levels of cardiorespiratory fitness, and muscular strength improvement is negatively associated with changes in overall adiposity among childhood and adolescence. Also, healthier body composition is positively associated with a healthier cardiovascular profile later in life and with a lower risk of death among childhood and adolescence.

Outdoor activity such as hiking has a preparedness increased with experience and fitness levels. Hikers planning trips of less than 12 hours are less prepared compared with hikers planning longer trips. In general, the uphill part of the hike showed increasing cardiorespiratory values that peaked towards the end. Oxygen uptake and heart rate reached 75% to 80% of the individual's VO_2 peak and HR max. In comparison, similar peak values have been reported in a 160-km backpacking trip (Burtscher., *et al* 2001) as well during marathon racing (75%-85%) highlighting the exertion of this hike (Bassett and Howley, 2000; Costill and Winrow, 1970).

2.2.1 Anaerobic Capacity

Hiking is an aerobic activity of vigorous intensity. Aerobic exercises can become anaerobic exercises if performed at a level of intensity that is too high. From this statement, hiking maybe increase anaerobic capacity if performed at high intensity. One study demonstrated significant improvement in Wingate anaerobic power in 11 days of altitude training in an adolescent runner (Bahenský *et al.,* 2020).

Physical activity has been proven to be favorable to reduce cardiovascular morbidity and mortality (Morris *et al.,* 1953; Paffenbarger *et al.,* 1986; Blair *et al.,* 1989; Belardinelli *et al.,* 1999; Myers *et al.,* 2002; Oguma *et al.,* 2002; Piepoli *et al.,* 2004; Thompson, 2005). Several studies have shown that persons with and without cardiovascular disease can acclimatize well and tolerate exercise at moderate altitude (Roach *et al.,* 1995; Levine *et al.,* 1997; Erdmann *et al.,* 1998; Burtscher *et al.,* 2001). Burtscher *et al.* (2001) have revealed that present CVDs and physical activity are related to sudden cardiac death risk during mountaineering and downhill skiing. However, a prior myocardial infarction (MI) was associated with increased risk whereas regular exercise led to a reduced risk. Hypertension is one of the prevalence of CVD for both hikers and skiers. Ledderhos *et al.* (2002), reported that these persons might have increased cardiovascular responses when performing sports activities like skiing or hiking at altitude when compared to normotensives.

Contemporary sports can be divided into those with the endurance character of motor activities (long-term exercise), sports with strength and speed character (exercise with very high intensity and short duration), and mixed sports, where the exercise is of both speed and mixed strength and speed character (e.g. team sports) (Spieszny *et al.,* 2012)**.** Muscle power is described as the capacity to generate large amounts of force (Bompa *et al.,* 2013). The high level of anaerobic muscle strength is calculated by muscle fiber ratio (a higher level of power is associated with a higher content of fast-twitch fibers) and bioenergy human body skills (Czuba *et al.,* 2007 and Gabry's *et al.,* 2004). Phosphocreatine (PCr), which accounts for roughly 70% of the ATP resynthesis needed for muscle function during the supramaximal exercise of up to 5 seconds is the primary source of ATP resynthesis (Driss and Vandewalle, 2013; Sahlin *et al.,* 2014). As the exercise is prolonged for more than 5 seconds, the value of anaerobic glycolysis increases, while the contribution of the creatine phosphate (CP) system decreases (Sahlin, 2014).

2.3 Muscular Performance

Muscles grow and develop through exercise movements. The process is known as muscle hypertrophy (Russell, 2000). Muscle hypertrophy occurs when the fibers of the muscles sustain damage or injury during exercise. The body repairs damaged fibers by fusing them, which increases the mass and size of the muscles, this can be measured through the muscular performance of the specific body segment. Muscle performance can be determined by muscle strength. Muscle strength is a major factor in athletic success. The definition of strength is the force or peak torque developed during a maximal voluntary contraction (Sale, 1991). Torque can be defined as the force measured about a joint's axis of rotation, while 'peak torque' is defined as the point in the range of motion when the greatest torque is produced (Perrin,1993). The measurements of torque can be performed under isokinetic conditions which are eccentrically at angular velocities of $60^{o}.s^{-1}$ and $120^{\circ}.s^{-1}$. By using an isokinetic dynamometer, the measurements of torque can also be performed isometrically at five different joint positions and concentrically at angular velocities of $60^{o}.s^{-1}$, $120^{o}.s^{-1}$, $180^{o}.s^{-1}$ and $240^{o}.s^{-1}$. However, to measure the muscle strength isotonically, the muscles perform the overall work done is less than maximum capacity due to muscle can be loaded only to what it is capable of at the point of the range, where the skeletal lever system is least efficient. The total picture of muscle function throughout the range can be reflected by an isokinetic contraction that is the same as a maximal load being applied at each point of the arc of joint motion (Moffroid *et al.*, 1969). Also, it has the same principle that permits optimal muscle strengthening.

Isokinetic devices act to test exercise muscular patterns of movement at selected angular velocities. Isokinetic devices can also be used to measure moment (torque), work, power, endurance and range of motion. The unit of the moment is newton-metres (Nm) or foot-pounds (ft/lbs), the calculation can be performed by the software itself, it can calculate the ratio of the moment to bodyweight for inter-subject comparisons. There are a few brand names of isokinetic dynamometers which are Kin-Com, Cybex, Lido and Orthotron.

When the force threshold has been applied by the subject, the isokinetic devices will begin to register force. The value of the force is dependent on limb weight, either or not the movement is against gravity on the angular velocity setting (Winter *et al.*, 1981). Isokinetic methods are safe, especially for subjects who have pre-existing pain. Furthermore, the machines will respond by reducing the resistance proportionately if the subject reduces contraction or feel the pain. So injury can be prevented.

Moreover, there are some studies on the reliability of the isokinetic equipment, which have shown positive results (Barbee, 1984: Farrell, 1986). However, the results for the reliability of peak torque data are not in agreement (Pentland, 1989).

In a recent study carried out by Norsuriani and Ooi (2018) which investigated bone health status, isokinetic muscle strength and power, and body composition in Malay adolescent female silat and taekwondo practitioners, it was found that silat and taekwondo groups had statistically significant higher values of the muscular peak torque and power measurements compared to the sedentary control group. Their study finding implies that involvement in silat and taekwondo could enhance muscular strength and power compared to a sedentary lifestyle. BIODEX isokinetic dynamometer was used as a device to measure muscular peak torque and power measurement in their study.

The increased popularity of wilderness activities such as recreational hiking (Gretchen, 2004) implies that injury and illness among participants (Bently *et al.*, 2004) are becoming relevant to a larger demographic group. Activity such as hiking with prolonged duration and varying intensities can be physically demanding on participants, and as a result, injuries have become an increasing concern for recreational hiking (Twombly and Schussman, 1995; Elliott *et al.,* 2003; Leemon and Schimelpfenig, 2003; Lobb, 2004). Strains, and sprains and other soft tissue injuries in the lower limb are examples of hiking injuries (Twombly and Schussman, 1995; Elliott *et al.,* 2003; Leemon and Schimelpfenig, 2003; Lobb, 2004). Outdoor education research has found that female hikers suffer significantly higher injury rates than their male counterparts participating in the same hiking activities (Twombly and Schussman, 1995; Leemon and Schimelpfenig, 2003). Reducing backpack mass has been suggested as one prevention strategy to reduce hiking-related injuries (McIntosh *et al.,* 2007). Based on the previous study, there are changes to stride length, stride frequency, double and single support time, ankle and knee joint motion, joint moments and vertical and horizontal ground reaction forces in response to variations in backpack load (Kinoshita, 1985; Harman *et al.,* 2000; Quesada *et al.,* 2000; Simpson *et al.,* 2011). Analysis of lower limb muscle activity during load carriage can provide a better understanding of a potential mechanism or contributing factors to the development of load carriage injuries in recreational hikers. Previous studies have examined lower limb muscle activity with increasing load mass. As loads are carried by recreational hikers for extended periods, covering many kilometers a day assessing lower limb muscle activation over longer distances is imperative to ensure results are relevant to the activities undertaken by recreational hikers (Lobb, 2014). The study by Roberts *et al.* (1996) provided the first systematic investigation of lower limb muscle activity during prolonged load carriage, the study only investigated the muscles surrounding the ankle during treadmill walking. Given the whole body interaction of walking and the high number of ankle and knee injuries sustained by recreational hikers (Bentley *et al.,* 2004), particularly female hikers (Twombly and Schussman,1995), and the paucity of research conducted on female recreational hikers, it is important to examine how the muscles that control knee and ankle motion during load carriage function over distances commonly traversed by this population.

2.4 Bone Health

There are a few factors that influence bone health status which include endogenic factors such as ethnicity, heredity, gender and endocrine status, as well as exogenic factors such as physical activity and nutrition (Javaid & Cooper, 2002: Rizzoli *et al.,* 2010). Furthermore, muscular strength was a factor that influenced bone health, and there was a link between muscular strength and bone health, Ahedi *et al.*

(2014) investigated the relationship between muscle strength and bone mineral density (BMD) of the hip and and spine in 321 Tasmanian older adults and reported that BMD was positively related to the muscular strength and authors conclude that higher muscular strength is associated with BMD of the hip in elderly women.

Bone mineral density (BMD) peaks during early adulthood and decreases after menopause in women, and is also influenced by genetics. Maternal nutrition and medications can affect the fetal skeleton which is starting in utero where bone health can be affected. Moreover, other factors that can affect the bone health status of an individual include exercise, diet, smoking, alcohol, medications, and calcium intake. Nearly 90 percent of peak bone mass can be gained by age 18 years for adolescence, thus young adulthood is the most beneficial time for gains a high level of bone density (Whiting *et al,* 2004). However, eating disorders, poor nutrition, hypoestrogenism and inadequate calcium intake are the factors for negative consequences that can occur. Physical activity or bone loading activities act as key roles in maintaining bone mass process during childhood and adolescence continues into adulthood. To reduce fracture risk later in life, physical activities are important for maintaining bone mass (Johnston, 1994; Kam, 2000; Kahn, 2000; Kanis, 2001). Knowledge of the bone composition, formation and adaptation is important in understanding the benefits of exercise on bone health.

Weight-bearing athletes have an approximately 10% higher BMD than nonathletes (Marci *et al.,* 2017). Athletes participating in high-impact sports have a higher BMD compared with medium or low-impact sports (Torstveit, 2005). The effects of exercise on the bone are such as increasing bone mass and strength and reducing the risk of falls (Manske *et al.,* 2009). Exercise should be dynamic, not static, achieve adequate strain intensity, consists of discrete and intermittent bouts, involving variable loading patterns, supported by optimal nutrition such as adequate intake of calcium and vitamin D to achieve maximum benefit. (Borer, 2005). A 5.4% increase in BMD is equal to a 64% increase in ultimate force and a 94% increase in energy (Robling, 2002). High improvement in BMD and bone strength can be caused by exercise.

Fractures caused by low bone mass can lead to morbidity and mortality. According to Looker (2005), 52% of adults older than 50 years have low bone mass at the femoral neck or lumbar spine in the United States. There are 9% of them met the diagnostics criteria of osteoporosis at one or both sides. Based on a previous study by Howe (2011), there are benefits of a variety of different types of exercises. For example, cardiovascular exercises and resistance training. Resistance strength training is an example of high-force exercise. This type of exercise is focusing on the lower limb that has the most impact on femoral neck BMD. A combination of the exercise is effective in enhancing BMD at the spine.

Adaptive changes can improve bone architecture through increasing bone density caused by sports participation (Tenforde & Fredericson, 2011). Different strain demands on the skeletal bones can be created by different types of physical activity (Heinonen *et al.*, 1995). Martial arts such as taekwondo, judo, tai-chi and karate are examples of physical activities that impose high and unusual strains on bone and subsequently increase bone health (Creigthon *et al.*, 2001). Based on a previous study carried out by Andreoli *et al.* (2001), sports involvement elicited beneficial effects on bone density and muscle mass in highly trained male athletes.

DXA in the clinical setting can be used for measuring BMD of an individual. High resolution peripheral quantitative computed tomography (HR-pQCT) can be also used to distinguish healthy microarchitecture of bone from suboptimal bone by 3-

dimensional information to provides estimates of bone geometry (LeBlanc, 2007: MacNeil, 2007). In addition, a bone sonometer can also be used to measure the bone speed of sound which can reflect the bone mineral density of an individual.

The most significant medical issue that arose with long-distance backpacking such as during hiking was "gynecologic abnormalities". It has been reported that 22% of female backpackers have significant experience amenorrhea (Boulware, 2004). Complications of intense exercise include low estrogen and progesterone with the risk of loss of trabecular bone and early osteoporosis (Prior and Vigna Y., 1985; Drinkwater *et al.*, 1984). The observed prevalence of amenorrhea in the athlete is 5% to 66% compared with 1% to 5% in the general population (Bachman and Kemmann, 1982; Singh, 1981). In a study of adult female athletes, 72% of amenorrheic women were either osteopenic or osteoporotic (Renckens *et al.,* 1996). The duration of amenorrhea and body weight are predictors of BMD.

Weight-bearing exercise does not offset the negative effect of decreased estrogen on the skeleton of amenorrheic athletes (Renckens *et al.*, 1996). Although the incidence of long-distance backpacking and amenorrhea may be only temporary, the BMD loss may be irreversible despite a resumption of menses (Otis *et al.,* 1997; Drinkwater *et al.,* 1986; Jonnavithula *et al.,* 1993). This raises concern over a possible later increased risk for premature osteoporotic fractures. Moreover, amenorrheic athletes using estrogen in doses used for menopausal women have shown maintenance but no gain of BMD (Hergenroeder, 1995).

2.5 Health Benefits of Hiking

Hiking is an outdoor activity and cost-effective intervention that encourages people to be physically active while spending time in nature. Hiking is the act of walking for a substantive distance in the outdoors. Encouraging physical activity, such as hiking is a way that health care professionals can promote patient wellness and health in a preventive and curative manner. An activity like hiking can help people meet guidance for regular physical activity and giving health benefits that can be attained by spending time in nature. Time in nature can lead to health benefits through contact with the natural elements as well as restoration of mental and emotional health. Hiking can be considered accessible in terms of the limited skills and equipment needed. Benefits may be immediate, such as decreased blood pressure, decreased stress levels, enhanced immune system functioning, and restored attention, or transpire over time, such as weight loss, decreased depression and overall wellness. Recently, forest bathing or Shinrin Yoku has been a popular activity in Japan and some other Asia countries (Mitten *et al.,* 2018). There are many benefits of spending time in forest or forest bathing such as decreased systolic blood pressure (Lee *et al.*, 2014), decreased stress levels (measured through prefrontal cortex activity and salivary cortisol) (Park *et al.,* 2007), deactivated sympathetic nervous system (measured via urinary adrenaline and noradrenaline) (Li *et al*., 2011) and strengthened immune system (measured via enhanced natural killer cell activity and intercellular anticancer proteins.

Hikers burn more calories than runners or walkers because they tend to spend longer periods outside enjoying nature than they would have if exercising in a different environment (Wolf *et al.,* 2014). Compared to exercise such as going to the gym, many hikers report that hiking does not feel like exercise or working out (Thompson *et al.*, 2011) and it is because physical exercise is often incidental to other goals of hiking, which include sightseeing, socializing or experience nature. Studies have found that exercise conducted outdoors has greater health benefits than comparable exercise conducted indoors. A study by Jelalian *et al.* (2006) randomly assigned 76 overweight adolescents to either a 16-week outdoor wilderness program or an indoor exercise program with comparable amounts of caloric expenditure and caloric intake. At the end of treatment, the older adolescents in the outdoor wilderness group lost 4 times as much weight as the indoor exercise group. The outdoor activity also can increase mental health such as in the systematic review of 11 trials by Thompson Coon *et al.* (2011) which used 13 measures to evaluate the effects of exercise on mental well-being and found that participant self-reports for outdoor exercises included positive effects such as greater feelings of revitalization and positive engagement, decreases in tension, confusion, anger, and depression, as well as increased energy. The same exercises conducted indoors did not elicit reports of these positive effects.

Hiking is an activity to share in families, friendship groups and with pets (Home *et al.,* 2012, D'amore *et al.,* 2015). For example, increased family bonding results from social connections created with others during the time in nature. The natural environment can stimulate social interaction between children (Bixler *et al.*, 2002). Time spent outdoors engaged in activities such as hiking can help individuals complete the developmental challenges faced in each life stage. For example, children who regularly play in natural environments show more advanced motor fitness, including coordination, balance and agility, and are sick less often (Fjortoft *et al.*, 2001). According to Ewert *et al.,* (2014) teens are concerned with body image, sexuality, identity, and their future and encouraging participation in hiking provides teens an opportunity to relax, expend energy, and reflect on their needs and desires (Ferranti *et al.,* 1997). Among middle-aged women in Iran, the "green walking program" demonstrated increased personal growth, positive relations with others, self-acceptance, and sense of purpose in life (Mousavi *et al.*, 2015) Similarly, among older adults in Canada, hiking was linked to active aging in a way that promoted resistance to essentialism (providing a sense of control over the aging body and lessening dependence on medication), increased physical activity and camaraderie.

CHAPTER 3

METHODOLOGY

3.1 Research Design

This study was a comparative study with a cross-sectional study design (Figure 3.1) that has been obtained ethical approval and jepem code (Appendix A).

3.2 Setting and Location

This study was carried out in The Exercise and Sport Science Laboratory and 'red square' of Health Campus, Universiti Sains Malaysia, Kubang Kerian, Kelantan. This location was selected based on the availability of the equipment in the laboratory which was used for the data collection process. The equipment used were a Bone sonometer, Handgrip dynamometer, BIODEX dynamometer and Cycle ergometer. The red square was chosen because its environment settings can be controlled from this location. All the test sessions with the participants were carried out based on their time of availability.

3.3 Sample Size and Sampling Method

In this study, an opportunistic sampling method was used for the recruitment of the participants. The sample size was calculated by using G*power version 3. 1. 9. 2 software with the effect size, d = 0. 9 and power (1-ß err prob) = 0. 8. The total sample size calculated was 32 participants. Since there were two groups in this study, therefore the number of participants per group was 16. The method of participants' recruitment in this studied was through advertisement via poster (Appendix B).

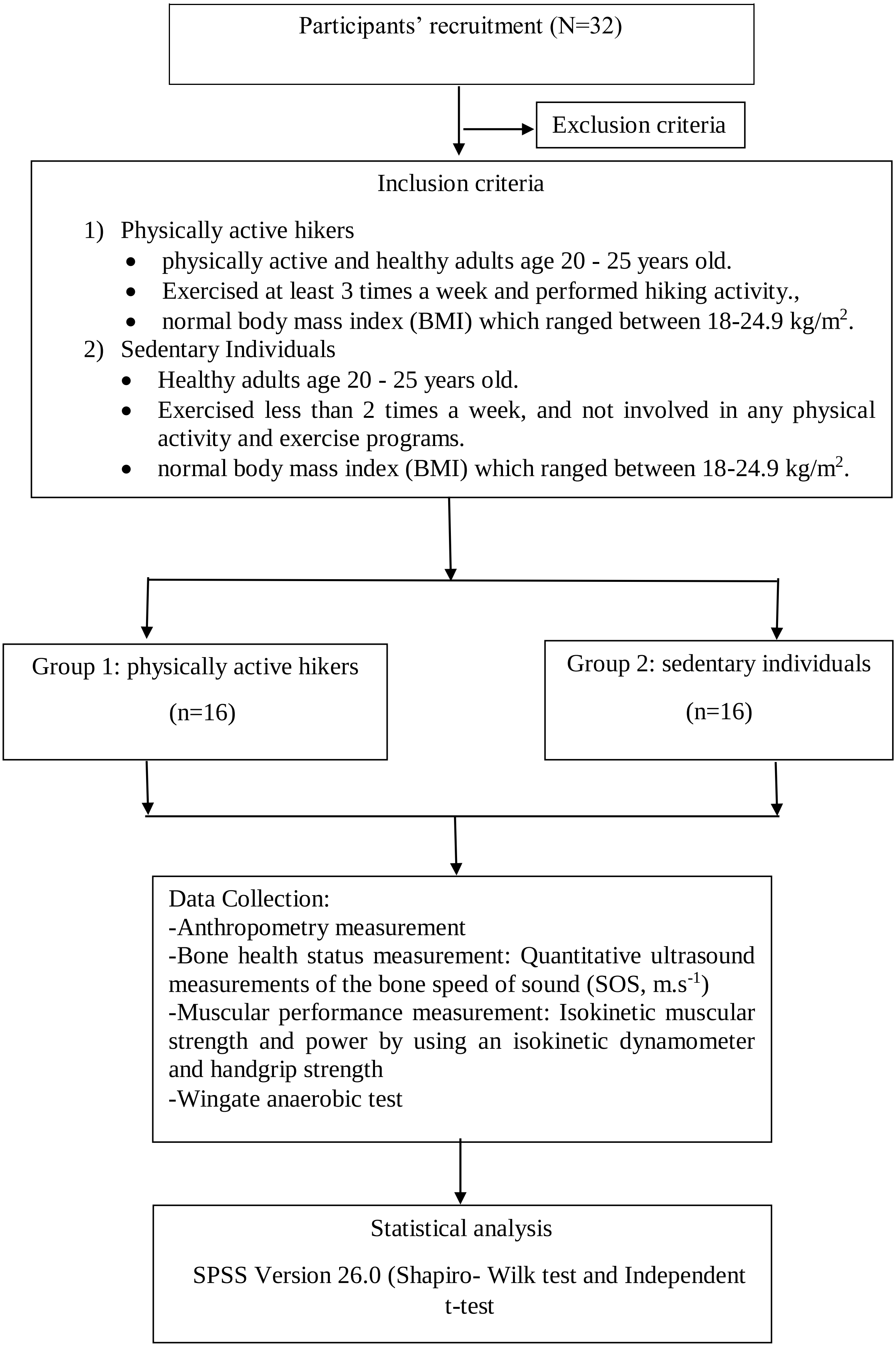

Figure 3.1: Flowchart of the study procedures

3.4 Participants' Recruitment

Participants were recruited from people living in Kota Bharu, Kelantan. A total of 32 participants have enrolled consists of 16 participants in the physically active hiker group (8 males and 8 females) and another 16 participants in the sedentary control group (8 males and 8 females).

Participants were explained and briefed on the aim and importance of the study, test procedures and advantages gained from this study. Simple words were used during the explanation session to ease the communication and gained participants' understanding of the research. The participants could ask any questions whenever they felt doubted about this research before participating.

3.4.1 Inclusion Criteria

a) Physically Active Hikers

The inclusion criteria of the participants were physically active and healthy adults age 20- 25 years old. Exercised at least 3 times a week and performed hiking activity at least once per month and had normal body mass index (BMI) which ranged between 18-24.9 kg/m^2.

b) Sedentary Individuals

The inclusion criteria of the participants were healthy sedentary adults with ages ranging between 20- 25 years old, exercised less than 2 times a week. They were not involved in any physical activity and exercise programs and had normal body mass index (BMI) which ranged between 18-24.9 kg/m^2.

3.4.2 Exclusion Criteria

The exclusion criteria of the participants were having an acute or chronic disease with musculoskeletal diseases and had a serious injury over the past 6 months.

3.5 Study Procedures

In this study, a total of 32 participants were recruited by opportunistic sampling based on the inclusion and exclusion criteria. The participants were recruited among physically active hikers (hiker group, n=16), and sedentary individuals (sedentary group, n=16). The study procedures were explained to all participants to provide an understanding of the study that was conducted. Before the following procedures were conducted consent forms were given to the participants to get their consensus.

3.5.1 Anthropometric Data

The first procedure was anthropometric data measurement. The participants were asked to wear light clothing and be barefooted during the session. The body height and weight of the participants were measured by a stadiometer scale (Seca220, Hamburg, Germany). The height and weight of the participants were recorded nearest to 0.5 cm and 0.1kg respectively.

The body composition of the participants such as percent body fat (% BF) and fat-free mass (FFM, kg) were measured by a body composition analyzer (Tanita, TBF-140 Japan). The data such as body height, gender and age were keyed in before running the measurement. The participants were required to stand in an upright position and breath normally. After a while, the results were displayed on the screen.