EFFECTS OF LOAD CARRYING TRAINING ON CORE STRENGTH, BALANCE AND JUMPING MECHANICS OF FEMALE RESERVE OFFICER TRAINING UNIT CADETS

by

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CERTIFICATE

This is to certify that the dissertation entitled

EFFECTS OF LOAD CARRYING TRAINING ON CORE STRENGTH, BALANCE AND JUMPING MECHANICS OF FEMALE RESERVE OFFICER TRAINING UNIT CADETS

is the bona fide record of research work done by

SITI HAWA ZULAIKHA BINTI JAAPAR

during the period from September 2016 to May 2017 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, Exercise and Sports Science.

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated and duly acknowledged. I also declare that it has not been previously or concurrently 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 purposes.

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Date: .....

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KESAN LATIHAN MENGGUNAKAN BEBAN KEPADA KEKUATAN TERAS, KESEIMBANGAN DAN MEKANIK LOMPATAN KADET PASUKAN LATIHAN PEGAWAI SIMPANAN WANITA.

Abstrak

Membawa beg galas mengenakan tekanan pada bahagian belakang badan dan kaki. Dalam Pasukan Latihan Pegawai Simpanan (PALAPES), membawa bebanan dalam bentuk beg galas adalah satu kemestian kerana ia termasuk di dalam latihan yang telah dirangka oleh Angkatan Tentera Malaysia (ATM). Kajian ini mengkaji kesan-kesan latihan bebanan kepada kekuatan teras, keseimbangan dan juga mekanik lompatan pada 20 kadet wanita PALAPES (kumpulan Backpack = 10; Kumpulan Kawalan = 10). Kedua-dua kumpulan telah menjalani latihan fizikal selama 6 minggu, dua sesi seminggu, di mana mereka telah melakukan larian sejauh 2.4 km, 3 set lompat bintang (20 ulangan setiap set) dan 3 set latihan *squat* (10 ulangan setiap set). Kumpulan Backpack telah membawa beg galas yang diisu oleh ATM dengan bebanan berjumlah 8 kg, manakala kumpulan Control tidak membawa bebanan. Empat ujian telah dilakukan sebelum dan selepas enam minggu sesi latihan, iaitu; Modified Plank Test untuk menilai kekuatan teras; Balance Error Scoring System (BESS) untuk menilai keseimbangan statiK; Star Excursion Balance Test (SEBT) untuk menilai keseimbangan dinamik dan ujian Drop Vertical Jump (DVJ) untuk mengkaji mekanik lompatan melalui nilai Frontal Plane Projection Angle (FPPA) pada sendi lutut. Tidak terdapat perbezaan statistik yang signifikan dalam kekuatan teras, keseimbangan static dan FPPA apabila membandingkan di antara kedua-dua kumpulan pada sebelum dan selepas latihan. Terdapat perbezaan statistik yang signifikan dalam keseimbangan dinamik antara kedua-dua kumpulan pada pra-latihan, tetapi tiada perbezaan statistik yang signifikan pada akhir latihan. Dapatan kajian ini mencadangkan bahawa latihan bebanan seberat 8 kg tidak membawa kesan yang besar kepada kekuatan teras, keseimbangan statik dan dinamik, dan mekanik lompatan pada kadet PALAPES wanita.

EFFECTS OF LOAD CARRYING TRAINING ON CORE STRENGTH, BALANCE AND JUMPING MECHANICS OF FEMALE RESERVE OFFICER TRAINING UNIT CADETS

Abstract

Carrying a backpack imposes stress to the back of the body and lower limbs. In Reserve Officer Training Unit (ROTU), carrying a backpack with load is a must as it was included in the training drafted by the Malaysian Armed Forces. This study examined the effects of weight training on the core strength, balance and jumping mechanics in 20 female ROTU cadets (Backpack group = 10, Control group = 10). Both groups undergone 6 weeks with twice a week of physical training, performing a 2.4 km run, 3 sets of jumping jacks (20 reps each set) and 3 sets of squats (10 reps each set). The Backpack group carried a military issue backpack with a total weight of 8 kg while the Control group carried nothing. Four tests were done prior and after the training sessions which were, Modified Plank Test to assess core strength; Balance Error Scoring System (BESS) to assess static balance; Star Excursion Balance Test (SEBT) to assess dynamic balance and Drop Vertical Jump test to assess the jumping mechanics through the evaluation of Frontal Plane Projection Angle (FPPA) of the knee joint. There were no statistically significant differences in the core strength, static balance and FPPA when comparing between the two groups at pre- and post-training. There was statistically significant difference in the dynamic balance between the two groups at pre-training, but no statistically significant difference at post-training. These results suggest that training with backpacks with a load of 8 kg does not have any major effects on the core strength, static and dynamic balance, and jumping mechanics of female ROTU cadets.

Chapter 1

INTRODUCTION

1.1 Introduction

Reserve Officer Training Unit (ROTU) or known as *Pasukan Latihan Pegawai Simpanan (PALAPES)* is a voluntary force that trains university students to become an officer of *Rejimen Askar Wataniah* of the Malaysian Armed Forces. The community was prompted to join the force as to help defend the nation's strategic assets and the sovereignty of the country. So, ROTU is considered as a platform of the community to serve the country as a volunteer.

This study focuses on female USM ROTU cadets, with a total of 20 cadets. The field of interest in this research was to study biomechanics of an after-effect of training with weights. The study of effects of training with weights (carried as a backpack) is not extensively done. So, this study was done to fill the gap of knowledge.

1.2 Problem Statement

The problem was to investigate the effects of weight training on the core strength, balance and jumping mechanics of female ROTU cadets. This study was designed to determine the relationship between the training and the biomechanical characteristics of the cadets. The present study was designed to identify those characteristics which differentiate between cadets who trained with weights and those cadets who did not. The problem of the study was to determine is there a relationship between the weight training and biomechanical characteristics of female ROTU cadets.

1.3 Significance of the Study

This study investigated the effect of physical training with backpacks on the core strength, balance and jumping mechanics. It will provide insights on the pros and cons of using a backpack while training. If the results are negative, then a modification can be done to the existing method, so as to provide a better way to improve performance. Besides that, if the results are positive, it can also be used in athletic functions as a method of training to provide variability in exercise methods.

1.4 Research Objectives

General objectives

To study the effects of load carrying training on core strength, balance and jumping mechanics of female Reserve Officer Training Unit cadets.

Specific objectives

1. To study the effect of load carrying training on core strength of female Reserve Officers Training Unit cadets.

2. To study the effect of load carrying training on static balance of female Reserve Officers Training Unit cadets.

3. To study the effect of load carrying training on dynamic balance of female Reserve Officers Training Unit cadets.

4. To study the effect of load carrying training on knee joint Frontal Plane Projection Angle during landing from drop vertical jump of female Reserve Officers Training Unit cadets.

1.5 Research Hypotheses

1. Null hypothesis (H_0): There is no significant difference in core strength test duration in female Reserve Officer Training Unit cadets following load carrying training.

Alternative hypothesis (H_a): There is significant difference in core strength test duration in female Reserve Officer Training Unit cadets following load carrying training.

2. Null hypothesis (H_0): There are no significant difference in Balance Error Scoring System (BESS) test scores in female Reserve Officer Training Unit cadets following load carrying training.

Alternative hypothesis (H_a): There are significant difference in Balance Error Scoring System (BESS) test scores in female Reserve Officer Training Unit cadets following load carrying training.

3. Null hypothesis (H_0): There are no significant difference in Star Excursion Balance Test (SEBT) test scores in female Reserve Officer Training Unit cadets following load carrying training.

Alternative hypothesis (H_a): Thereare significant difference in Star Excursion Balance Test (SEBT) test scores in female Reserve Officer Training Unit cadets following load carrying training.

4. Null hypothesis (H_0): There is no significant difference in the knee joint Frontal Plane Projection Angle during landing from Drop Vertical Jump in female Reserve Officer Training Unit cadets following load carrying training.

Alternative hypothesis (H_a): There is significant difference in the knee joint Frontal Plane Projection Angle during landing from Drop Vertical Jump in female Reserve Officer Training Unit cadets following load carrying training.

Chapter 2

Literature Review

2.1 Introduction to ROTU and *Askar Wataniah Malaysia*

2.1.1 History of Askar Wataniah Malaysia

Askar Wataniah Malaysia (AW) is a volunteer force unit in the Malaysia Armed Forces (*Angkatan Tentera Malaysia*), that aids in the national defence. The involvement of the citizen in AW is a noble contribution, responding to the call of motherland which matches the concept of HANRUH (*Pertahanan Menyeluruh* or Overall Defence) that was specified in the National Defence Policy. As a developing country, the involvement of citizens is required for the development and national defence.

The volunteer forces had existed in Malaya since 1861 with the establishment of a voluntary group which was named Penang Volunteer. The participation of Malaysian citizens in Peninsular Malaysia started since 1902 during the reign of English Government. The Federated Malay States (FMS) or *Negeri-Negeri Melayu Bersekutu* which consisted of Perak, Selangor, Negeri Sembilan and Pahang had established their own volunteer force which is known as Malay State Volunteer Rifles (MSVR). The force continued to grow and several other forces were established with the name of Federated Malay States Volunteer Force (FMSVF), Unfederated Malay States Volunteer Force (UFMSVF) and Straits Settlement Volunteer Force (SSVF).

When the World War 2 started, all volunteer forces that existed had worked together hand in hand with the Armed Forces to oppose the Japanese Army in Malaya. During the emergency (*darurat)* period in Malaya in 1948, a volunteer force which is known as Home Guard (*Pasukan Kawalan Kampung*) was established. The Home Guard played a vital role throughout the emergency.

Figure 2.1 The Home Guard

In 1958, when the safety of the country was stabilised, the Home Guard was dissolved. Considering the fact that a number of members of the Home Guard wanted to continue their voluntary service, the Malay Federal Government (*Kerajaan Persekutuan Tanah Melayu*) decided to revive and arrange the volunteer force so it will be more effective and functional. Hence, The Territorial Army Ordinance 1958 was drafted. With the power of the Ordinance, the new volunteer force, now known as *ASKAR WATANIAH* was established on 1st June 1958 (*Bahagian Pasukan Simpanan, Tentera Darat Malaysia)*

2.1.2 Involvement of Women in Askar Wataniah

In 1964, women get to officially involve in the Armed Forces. It was from the effort of Tan Sri Zainun bte Sulaiman, which was a parliament member at that time, where she proposed the government to establish female soldiers. She gained support from the members of *Pergerakan Wanita UMNO*. In November 1964, 150 women of *Barisan Tentera Sukarelawan Wanita* which was led by Datin Fatimah Abdul Majid, were trained by the military in Kem Majidee, Johor Bahru. The training was conducted every Wednesday for one and a half hours.

In the following year, recruitment from women was officially done. Many women were interested in joining *Pasukan Askar Wataniah Wanita*, and thus *Pasukan Semboyan Wanita* (PSW) was established. PSW was created to train women to be operators ranging from telephone, printer and cipher. They were also trained to be clerks, typist, drivers and also nurses. Before they undergone specified training, all of the women was sent to recruitment training.

When ROTU (Reserve Officer Training Unit) was formed in Higher Education Institutes such as Universiti Kebangsaan Malaysia, Universiti Sains Malaysia and Institut Teknologi Mara, many female students joined the unit. They were trained and exposed with military lessons for three consecutive years, and had the same standard and function as Royal Military College (RMC). (*Bahagian Pasukan Simpanan, Tentera Darat Malaysia).*

2.1.3 History of Reserve Officer Training Unit

Reserve Officer Training Unit (ROTU) or known as *Pasukan Latihan Pegawai Simpanan* (PALAPES) is a training unit that was formed in Higher Educational Institutes. It functions were to produce high quality military reserve officers. The syllabus of military knowledge and the training that was used in ROTU was the same as the training conducted in Royal Military College (*Maktab Tentera DiRaja*). Upon completing the military training, ROTU would be commissioned by Seri Paduka Baginda Yang Dipertuan Agoing as Second Lieutenant in AW.

The history of the establishment of ROTU started from 3rd April 1965, parallel to the formation of the first branch of Armed Infantry (*Angkatan Infantri*) of reserve forces in Universiti Malaya (UM). Its formation responded to the uneasiness and fear of the university's staffs and students during the Malaysian-Indonesian Confrontation in 1963.

In the early formation of the unit, 30 students from various faculties in Universiti Malaya underwent the recruit training programme at Kem Latihan Seputih, Batu Gajah, Perak during semester break. Starting from the event of 13th May 1969, the branch of reserve forces had expanded with 'A' Company in Institut Teknologi Mara (ITM), 'B' Company in Universiti Putra Malaysia (UPM) and 'C' Company in Universiti Kebangsaan Malaysia (UKM), while UM maintained as the Battalion Headquarters.

With the fighting spirit shown by the Higher Educational students, the Director of Reserve Forces, Brigadier General Dato' Abul As bin Ismail had discussed with the Vice Chancellor of all universities to form ROTU in their respective universities. At present, there are a total of 14 ROTU that was formed in the following universities:

1. Universiti Malaya ROTU
2. Universiti Kebangsaan Malaysia ROTU
3. Universiti Putra Malaysia ROTU
4. Universiti Sains Malaysia ROTU
5. Universiti Teknologi Malaysia ROTU
6. Universiti Utara Malaysia ROTU
7. Universiti Teknologi Mara ROTU
8. Universiti Malaysia Sabah ROTU
9. Universiti Malaysia Sarawak ROTU
10. Universiti Pendidikan Sultan Idris ROTU
11. Universiti Tun Hussein Onn ROTU
12. Universiti Malaysia Perlis ROTU
13. Universiti Pertahanan Nasional Malaysia ROTU
14. Universiti Islam Antarabangsa ROTU

Basically, the objective of ROTU is to expose IPTA students to the ways of the military and also to build self-esteem in themselves. Other than that, ROTU functions by supplying military-trained university graduate officers as a workforce for Malaysian Armed Forces (ATM) to strengthen our country's defence.

There are many benefits in participating in ROTU. Cadets will receive free meals and allowances depending on their attendance. The incentives are RM6.00 per hour for Localised Training, RM27 – RM32 per day (depends on the cadet's level) for Continuous Training, Annual Camp Training and Passing-Out Parade Training. In addition to that, they will also receive annual bounty, complementing from the total hours of training they attend.

Being commissioned as a Second Lieutenant in AW will enable them to receive privileges same as officers from Regular Armed Forces. The system and procedure of the commission does not differ from the system that was practicable to Cadet Officers from Regular Forces, fully emphasizing the customs, regimental traditions in any branches of ATM. This means that they are of the same level as Cadet Officers from Regular Forces, but their abilities, competencies and their posts are what makes them different from each other. Officers from the Reserved Forces must continue training and acquire technical and military tactical knowledge so as to gain maximum impact in the military field (*Majalah Perajurit,* 2012, *Bahagian Pasukan Simpanan, Tentera Darat Malaysia*).

Figure 2.2 Commission Parade of Reserve Officer Training Unit Cadets

2.2 Training of ROTU

The Armed Forces had outlined three types of training for ROTU, which are Localised Training or *Latihan Tempatan* (240 hours a year, 10 hours per day), Continuous Training or *Latihan Berterusan* (14 days maximum per year) and Annual Camp Training or *Latihan Kem Tahunan* (15 days maximum per year). The training conducted includes Field Training Exercises (FTX), marching, shooting exercises and compass marching.

Localised training is training conducted in the University, and the syllabus included learning how to read maps, learn how to use weapons and their components, and marching. For Continuous Training, it is a training that is conducted for more than 72 hours. The training included compass marching and shooting exercises. While for Annual Camp Training, it includes Field Training Exercises (FTX) that comprises of four phases of battle which are a) Advancing, b) Attacking, c) Defense and d) Retreat. During Annual Camp Training, the cadets are also needed to undergo tests of technical and tactical knowledge that they had learnt.

Figure 2.3 A cadet undergo Map reading test

All these training need endurance and strength, thus everyday it is a must to do physical training at least for 45 minutes during Localised Training. The physical training constitutes of running and bodyweight exercises such as push ups, squat jumps, mountain climbers, and jumping jacks.

In USM ROTU, sometimes the cadet officers are needed to carry backpacks that are filled with sand which weighted about 8 kg. The reason is that the cadets will be accustomed to the heavy weight of the backpacks that they will carry throughout FTX. The cadets will run with the backpacks, and also do some weight training with the backpack such as isometric lift and doing push ups while wearing the backpack.

Figure 2.4 ROTU Cadets running while carrying backpacks

As a requirement for the cadet officers to be commissioned after the completion of three years of training, they need to pass a fitness test (*Ujian Kecergasan Asas, UKA*). The test comprises of 2.4 km run to evaluate cardiovascular endurance, and push up and sit up test to evaluate muscular endurance. In order to pass the test, the cadets will have to do extra training because the 45 minutes of physical training allotted during Localised Training was not enough to maintain their fitness.

2.3 Effects of Carrying Loads

2.3.1 Acute Effects

Carrying weights at the back are associated with back pain with 50% of adolescents reporting links of back pain to bag carriage (Dockrell et al., 2006.) The back pain may be resulted in the increased activity of the back muscles (Elfving et al., 2003) which will cause muscular fatigue (Ibrahim, 2012). Female adolescents have higher risk to back pain compared to male adolescents (Dockrell et al., 2006) which may be resulted from lower strength of the upper body in females (Haselgrove et al., 2008).

A study conducted in male military training students showed that weight distribution influenced static body balance (Park et. al., 2014). The research studied the effect of weight distribution on armour wore by the subjects, on body balance. They found that an even weight distribution tends to decrease the centre of pressure (COP) area and its medial-lateral trajectory despite a considerable weight difference, which helps to achieve better static balance. Soldiers and climbing enthusiasts should know that carrying uneven heavier loading on the front torso and the back will cause limitations to static and dynamic body balance.

Brown et al. (2014) conducted a study to compare lower limb biomechanics between heavy, medium and light load carrying. They found out that the stance time was significantly longer during heavy load carrying compared to medium and light loads. Besides that, there was a decreased peak stance knee flexion angle and a greater hip adduction moment during heavy load compared to medium and light loads. Hence, lower limb biomechanics was important in identifying the modifications needed by the lower limbs, such as hip and knee flexion, as to enable good body balance.

As for muscle activation during carrying loads at the back, it was found that there are significant muscle activities of the abdominis muscles during standing when compared unloaded standing with loaded standing, (Al-Khabbaz et al., 2008). The right rectus abdominis muscles showed more activity when compared to the left side of the

muscle. In the same study, it was also shown that there are inclination of the trunk posture, trunk rotation and also side flexion during loaded standing. The study concluded that as the backpack heaviness increased, the activities of the rectus abdominis muscle will increase progressively and disproportionally.

Performing double-legged landing while carrying loads resulted in higher peak Ground Reaction Forces (GRF) compared to unloaded landing (Hamzah & Siti Zubaidah, 2012). The greater the load, the larger the force generated. According to Coventry et al. (2006), the hip has the greatest joint moment and powers during double-legged landing, while the knee has the greatest joint excursion and perform the greatest amount of work.

All the studies that were cited in this subsection are the acute effects of carrying loads on lower limb biomechanics.

2.3.2 Prolonged Effects

Regular load carriage activities are a key feature of military training programmes. Soldiers relied on their musculoskeletal system to support their body and additional load during movement (Brown et al., 2014). It is important for soldiers to have good locomotion in the battlefield, because any decrease in the capacity to walk and run can decrease their survivability.

Rice et al. (2016) conducted a study on the effects of military load carriage activity on lower limb gait mechanics and muscle activities. The subjects are needed to complete a 12.8-km course activity, in a duration of approximately 150 minutes, while carrying a Bergen (large rucksack), webbing (worn like a belt to carry additional military kit) and a weapon. The total mass that was carried by the subjects was 35.5 kg. The study concluded that there were increase in ground contact time and altered sagittal plane lower limb mechanics during loaded military training activity. They also observed

peroneus longus muscle fatigue and it may be resulted from greater contribution of the plantar flexor muscles while knee extensor moments were reduced.

In another study by Knapik et al. (1990), they demonstrated the effects of frequency of loaded road march training and performance on a loaded road march. The soldiers carried a total load of approximately 46 kg, and needed to march on a measured 20 km course as a pre- and post-training test. There are four groups of different training prescription, a) Group 0 (GP0) performed no road marching, b) Group 1 (GP1) road marched once per month, c) Group 2 (GP2) road marched twice a month and d) Group 4 (GP4) road marched four times a month. The study resulted in loaded road march training conducted at least twice a month resulted in faster 20 km road march times than a loaded road march training once a month or not at all.

Knapik et al. (1990) also found out that performance in marksmanship and grenade throw decrease after performing the 20 km road march. This was caused by an increase in body tremors due to fatigue or an elevated post exercise heart rate. While firing the weapon, the butt of the rifle was supported by the shoulders. Subjects in the study reported some pain and discomfort in the area and this could have effected marksmanship ability.

Researches in the past done to assess physiological and traditional biomechanical gait parameters, but it was limited in quantifying lower limb kinematics for less than 3 steps (Almosnino et al., 2014). It is of interest to know the long term effects of load carrying training on balance and core strength.

2.4 Tests to Evaluate Biomechanical and Physiological Changes from Carrying Loads

2.4.1 Drop Vertical Jump (DVJ) Test

The greater dynamic knee valgus in women is one of the factors suggested to explain the higher incidence of patellofemoral pain syndrome and anterior cruciate ligament (ACL) tear in female athletes compared to men (Hewett et al., 2005). In addition to valgus collapse, Boden et al. (2000) reported that most ACL injuries occur with the knee near full extension (e.g. reduced knee flexion) during a sharp deceleration while landing a jump.

Hewett et al. (2005) reported that female athletes who landed from a drop vertical jump (DVJ) with a maximal knee flexion of 10.5^0 less than other female athletes went on to injure their ACLs. Further researches showed that the drop jump test has been linked to predict anterior cruciate ligament injury in female athletes and the test was shown to be sensitive to changes in training (Hewett et al., 2005, Noyes et al., 2005).

It was shown that 2D kinematic analysis of knee in frontal and sagittal planes during DVJ was reliable and valid assessment (Munro et al., 2012). 2D analysis may be useful for evaluating the value of training and intervention programmes in reducing frontal-plane projection angle (FPPA) values. Positive FPPA values reflected knee valgus while negative FPPA values indicated knee varus.

Normative 2D FPPA values for the drop-jump have been reported previously (Herrington & Munro, 2010). The authors of that study suggested that 'average' performance resulted in values of 7° to 13° for the drop-jump in women. It was also suggested that subjects who demonstrate valgus FPPA values in excess of these normal values may be demonstrating kinematics that are detrimental and may increase the risk of injury to the patellofemoral joint or ACL (Herrington & Munro, 2010).

2.4.2 Modified Plank Test

Core strength is important in athletic function. It provides local strength and balance, and can also decrease risk of back injury (Kibler et al., 2006). The core is a muscular box with the abdominals in the front, paraspinals and glutes in the back, the diaphragm as the roof, and the pelvic floor and hip girdle musculature at the bottom. These muscles are located at the centre of the body and provide proximal stability that the body required for the distal segments' function and mobility.

Core activity involved in almost all extremity activities such as running and kicking. It is considered the most important component in ensuring good performance in athletes. Therefore, position, motion and contributions of the core must be evaluated and treated as part of the evaluation and treatment of lower extremity injuries (Kibler et al., 2006).

Mackenzie (2005) developed a sport-specific core muscle test due to the need for a means of monitoring the development of core muscle function in athletes. The core test requires the subjects to hold a plank position with their arms and legs lifted up alternatively for 10 s in each stage for eight stages, over a total of two minutes. This test was proven to be valid and reliable for assessing the endurance capacity of the global core muscle in a functional manner (Tong et al., 2014).

2.4.3 Balance Test

For balance, the core muscles provide postural control during static and dynamic position. Static balance is defined as the ability to maintain a base of support with minimal movement, while dynamic balance is defined as the ability to perform a task while maintaining a stable position (Bressel et al., 2007).

Factors that influence balance includes sensory information obtained from the somatosensory, visual, and vestibular systems and motor responses may affect coordination, joint range of motion (ROM), and strength (Bressel et al., 2007). Thorpe and Ebersole (2008) demonstrated that female soccer players with regular training have better dynamic balance, lower extremity strength and neuromuscular control across both limbs, when compared to non-soccer players.

2.4.3.1 Balance Error Scoring System

To objectively measure balance, clinicians used instrumented testing devices which are considered the gold standard of balance testing (McKeon & Hertel 2008). However, public usually do not have access to the instruments (Bell at al., 2011). Hence, the Balance Error Scoring System (BESS) was created as a standardised, objective assessment test for the clinical side line assessment of postural control (Riemann et al., Shields 1999). It was found that BESS has a moderate to good reliability in clinical evaluation of static balance (Bell et al., 2011).

2.4.3.2 Star Excursion Balance Test

Star Excursion Balance Test (SEBT) is a clinical test to measure dynamic balance in the lower extremities. In this test, the lower extremity have to reach out in eight directions that challenges a subject's postural control, strength, range of motion and motion on the contralateral stance limb (Hertel et al., 2006). Bastien et al. (2014) found that visual estimation of the maximal reach distance is a valid and accurate measurement.

Chapter 3

Methodology

3.1 Study Design

This was an interventional study with pre- and post- intervention tests. There were two groups of participants: (1) the experimental group that undergone physical training wearing backpacks (n=10), and (2) the control group that undergone similar physical training without wearing backpacks (n=10). The participants were weight-matched to the two groups. The duration of participants' involvement was 6 weeks. All phase of the study were conducted in the vicinity of Universiti Sains Malaysia, Health Campus. The protocol of this study was approved by USM (**USM/JEPeM/16090319**).

3.2 Participants

3.2.1 Sample Size Calculation

A priori sample size calculation of two-way ANOVA showed that a total of 24 participants (e.g., 12 participants per group) are sufficient to yield 0.8 power of the study with small effect size of 0.3. Effect size was based on Cohen, 1988. A total of 20 subjects were recruited, with 10 subjects each for the two groups. Sample size was calculated using G*Power Software version 3.1.9.2 (Heinrich Heine Universitat Dusseldorf, Germany).

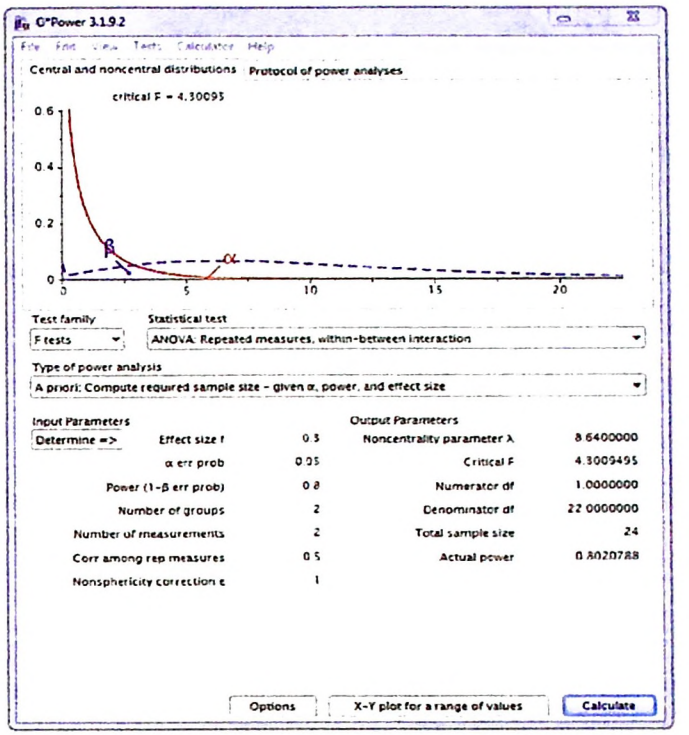

Figure 3.1 Sample Size calculation

3.2.2 Inclusion and Exclusion Criteria

The participants comprised of ROTU cadet officers, with age ranged between 19 – 25 years old, with normal body mass index and free from any lower limb and back injuries at the time of data collection. Those who were unable to complete 85% of the training programme, or have any injuries, pregnant or suspected pregnancy, were excluded from the research.

3.2.3 Recruitment of Participants

Participants were recruited voluntarily through words of mouth. Participants were provided with details regarding the study methodology. Upon agreement, their consent form was collected.

3.3 Study Protocol

3.3.1 Training Programme

This was an interventional study with pre- and post-intervention tests that compare the effects of physical training with weighted backpack across control and intervention groups. The participants went through a series of tests before and after the physical training. The training was conducted twice a week for six weeks. Duration of each session was averaged 20 minutes. Both groups went through similar physical training, however only the intervention group carried a military issue backpack with a total weight of 8 kg during the training. The flowchart of the study are shown in Figure 3.2.

Figure 3.2 Military Issue Backpack

The training that were done by the participants are as follows:

- 2.4 km walk / run
- 3 sets of Jumping Jacks (20 reps per set)
- 3 sets of squats (10 reps per set)

Jumping Jacks and squats exercises were done after they completed the 2.4 km run.

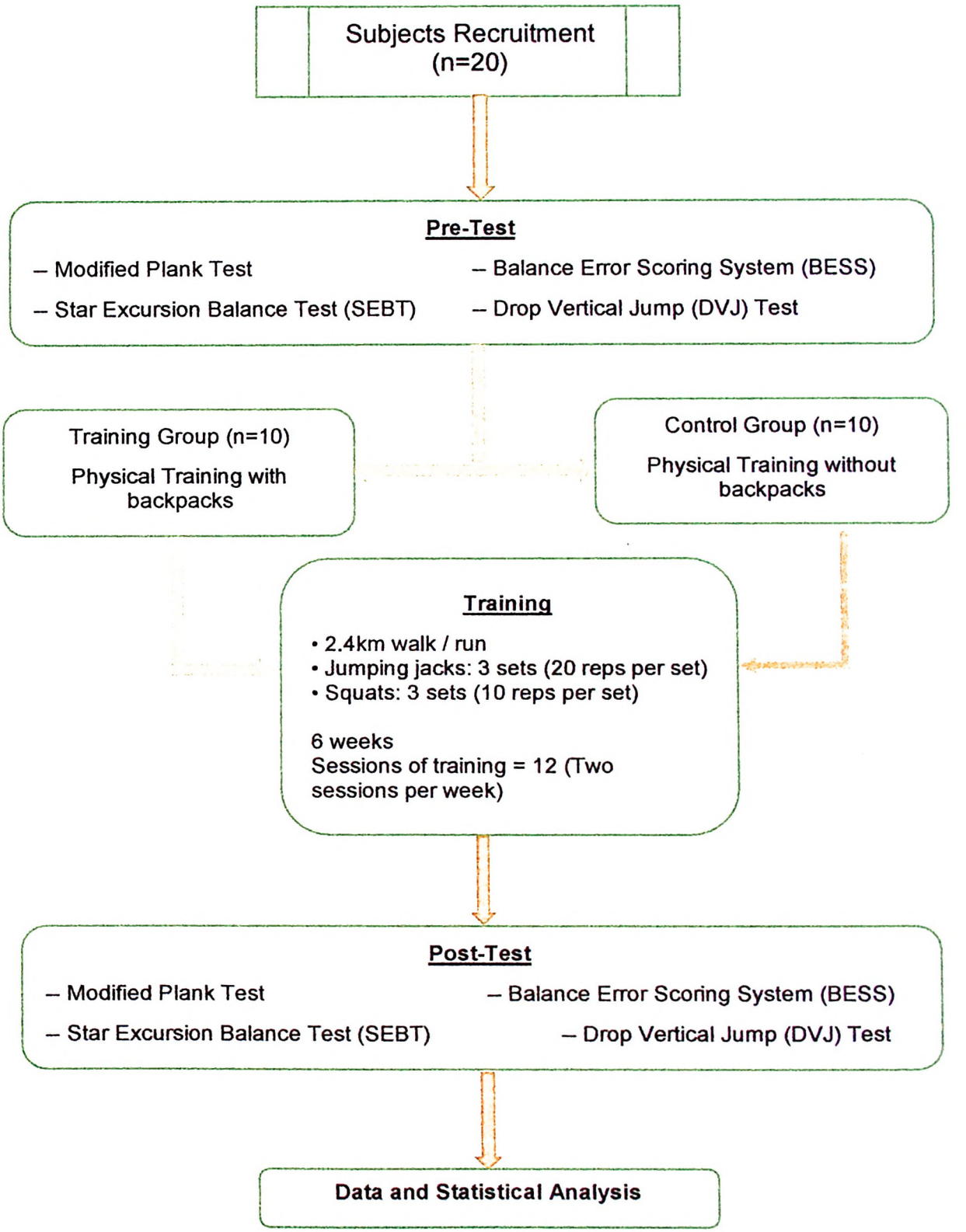

Figure 3.3 Flowchart of the Study

3.3.1 Physical Characteristics of Participants

Demographic data of participants were recorded prior to and post experimental phase. Before data collection, the first meeting was conducted at Sports Science Lab with the participants who were recruited voluntarily. After obtaining their written informed consent, information such as the participant's body weight, height and leg length were measured. The participants were also asked to provide information about their medical history, other medical conditions, and any medications taking.

3.3.2 Grouping of Participants

Participants were divided into two groups namely the Backpack group and Control group. Both groups followed a similar physical training, however only the Backpack group wore a weighted backpack during the training.

3.3.3 Tests Protocol

There were a total of four tests that were done by the participants, which were (1) modified plank test, (2) Balance Error Scoring System (BESS) test, (3) Star Excursion Balance Test (SEBT) Test, and (4) Drop Vertical Jump (DVJ) test. All the tests were done in a total of an hour. The tests were done according to the participants' free time.

The participants were asked to wear tights as it ease the data collection of DVJ test. The participants were also asked to eat an hour before attending the testing session. Consuming caffeine before tests were prohibited, and the tests were done when the participants were not in their menses.

3.3.3.1 Modified Plank Test Protocol

This test measured the core strength of the participants. The duration the participants can hold the plank position was the indicator of the participant's core strength. The participants started the test by holding a basic plank position, with the elbows right beneath the shoulders, the forearms as wide as the shoulders placed on the floor, and the toes on the floor. The scoring is as below:

Stage	Time	Comments
Stage 1	30 sec	Hold this position for 30 seconds
Stage 2	40 sec	Lift R-arm off the ground (hold 10 seconds) Return
Stage 3	50 sec	Lift L-arm off floor (hold 10 seconds) Return
Stage 4	60 sec	Lift R-leg off floor (hold 10 seconds) Return
Stage 5	70 sec	Lift L-leg off floor (hold 10 seconds) Return
Stage 6	80 sec	Lift R-arm & L-leg off floor (hold 10 seconds) Return
Stage 7	90 sec	Lift L-arm and R-leg off floor (hold 10 seconds)
Stage 8	120 sec	Return to beginning position and hold 30 seconds.

Table 3.1 Scoring table for Modified Plank Test

Throughout the test, the participants were needed to maintain proper plank posture without touching the floor. The body must be in a straight line. If the hips were out of position or any other body parts other than the forearms and the toes touched the floor, the test was stopped. The duration was recorded and represent the stage that the participant completed before breaking posture or drop on the floor. Tong et al. (2014) demonstrated that this test is highly reliable with an ICC of 0.97. They also suggested that this test was a valid tool to assess global core muscle endurance.

Figure 3.4 Position of a Plank

3.3.3.2 Balance Error Scoring System (BESS) Protocol

This test measured the static balance of the participants. The error scores from the BESS indicated the participants balance. There are three stance positions in this test, which are (1) double-leg stance with feet together, (2) single-leg stance on the tested limb with the knee on the other leg in approximately 90° flexion, and (3) tandem stance whereby the foot of the tested limb in line and anterior to the foot of the other limb.

The order of the tested stance was double-leg stance, single-leg stance and tandem stance. Each position must be hold with eyes closed and hand on hips for 20 seconds, and stopwatch was used to evaluate the duration of the test. The scoring system was based on the errors done by the participant. There is a minimum score of zero and maximum score of 10. The total score was counted by adding the scores from the three stances (Onate et al., 2007). The errors included were (1) opening eyes, (2) lifting hands from hip, (3) touchdown of non-stance foot, (4) step, hop or other movement of the stance foot or feet, (5) lifting forefoot or heel, (6) moving hip more than 30° of flexion or abduction and (7) remaining out of position for longer than 5 seconds. The reliability of the BESS are reported to be moderate to good.