EFFECTS OF NEUROSTIMULATION AND MOTIVATING PATRIOTIC MUSIC ON RESERVE OFFICER TRAINING UNIT CADETS RUNNING PERFORMANCE AND MOOD STATES

by

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July 2018

CERTIFICATE

This is to certify that the dissertation entitled

EFFECTS OF NEUROSTIMULATION AND MOTIVATING PATRIOTIC MUSIC ON RESERVE OFFICER TRAINING UNIT CADETS RUNNING PERFORMANCE AND MOOD STATES

is the bona fide record of research work done by

SITI HAWA ZULAIKHA BINTI JAAPAR

during the period from February 2018 to July 2018 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 masters degree of Master of Science (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 masters 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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Table of Contents

List of Tables

List of Figures

KESAN NEUROSTIMULASI DAN LAGU PATRIOTIK YANG MEMOTIVASI TERHADAP PRESTASI LARIAN DAN MOOD PEGAWAI KADET PASUKAN LATIHAN PEGAWAI SIMPANAN

Abstrak

Neurostimulasi transkranial dapat meningkatkan fungsi badan melalui latihan otak dan sistem saraf pusat. Selain itu, terdapat juga bukti-bukti bahawa muzik yang "betul" dapat meningkatkan prestasi sukan. Kajian ini mengkaji kesan neurostimulasi dan muzik patriotik yang memotivasi dalam terhadap prestasi dan keadaan mood 22 kadet PALAPES lelaki. Semua peserta mengambil bahagian dalam ketiga-tiga keadaan penyelidikan iaitu, tanpa rangsangan, neurostimulasi dan muzik patriotik yang memotivasi, tetapi pada masa yang berlainan dengan satu minggu berehat di antaranya. Setelah menerima rangsangan, para peserta melakukan Multistage Fitness Test (MSFT) untuk mengukur prestasi larian. Mood para peserta telah diambil sebelum rangsangan, selepas rangsangan dan selepas melakukan MSFT dengan menggunakan borang soal selidik Brunel Mood Scale (BRUMS). Tidak ada perbezaan statistik yang signifikan dalam prestasi larian di antara tanpa rangsangan, neurostimulasi dan muzik patriotik yang memotivasi. Untuk rangsangan dengan menggunakan muzik patriotik yang memotivasi, kami mendapati bahawa terdapat perbezaan statistik yang signifikan dalam keletihan, ketegangan dan keadaan mood semangat. Bagi neurostimulasi, kami mendapati terdapat perbezaan statistik yang signifikan dalam kesemua enam item yang kami nilai. Kami menyimpulkan bahawa neurostimulasi dan memupuk muzik patriotik tidak meningkatkan prestasi kadet PALAPES. Kedua-dua neurostimulasi dan mendengar muzik patriotik yang memotivasi dapat meningkatkan keadaan mood sebelum ujian prestasi berjalan. Memotivasi muzik patriotik ditunjukkan untuk memberikan respons mood yang lebih baik jika dibandingkan dengan neurostimulasi.

EFFECTS OF NEUROSTIMULATION AND MOTIVATING PATRIOTIC MUSIC ON RESERVE OFFICER TRAINING UNIT CADETS RUNNING PERFORMANCE AND MOOD STATES

Abstract

Transcranial neurostimulation can improve bodily function through training the brain and the central nervous system. Besides that, there are also increasing evidence that the “right” music can increase performance. This study examined the effects of neurostimulation and motivating patriotic music on running performance and mood states of 22 male ROTU cadets. All the participants participated in all three research conditions which were no stimulation, neurostimulation and motivating patriotic music, but at different times with one week of rest in between conditions. Upon receiving the stimulation, the participants did Multistage Fitness Test (MSFT) to measure their running performance. Mood states of the participants were taken before stimulation, after stimulation and after performing MSFT by using Brunel Mood Scale (BRUMS) questionnaire. There were no statistically significant differences in the running performance between no stimulation, neurostimulation and motivating patriotic music. For stimulation by using motivating patriotic music, we found out that there were statistically significant differences in fatigue, tension and vigour mood states across the three times. As for neurostimulation, we found out that there were statistically significant differences in all six BRUMS items that we assessed. We conclude that neurostimulation and motivating patriotic music did not increase the running performance of ROTU cadets. Both neurostimulation and listening to motivating patriotic music can enhance mood states before a running performance test. Motivating patriotic music was shown to give greater mood responses when compared to neurostimulation.

Chapter 1

INTRODUCTION

1.1 Background of the Study

Over the past decade, the technology of transcranial neurostimulation has been widely researched and better understood. Transcranial neurostimulation is where rapidly changing magnetic fields that are delivered to the scalp. The magnetic field produces a weak electrical current that excites the neural tissue underlying the scalp, which causes activity in specific parts of the brain with little or no discomfort (Goodall, Howatson, Romer & Ross, 2014). Due to its ability to induce neuroplasticity in motor regions and also modulate corticospinal excitability, transcranial neurostimulation has been deemed a useful technique in clinical neuroscience in the past 20 years (Halo Neuroscience, 2016c).

Traditionally, athletes train to have stronger and more efficient muscles through improving the body. However, there is also another way to improve bodily function, which is through training the brain and the central nervous system (CNS) to optimise the neural activity associated with movement (Halo Neuroscience, 2016a). Such popular method of known as the transcranial neurostimulation, also named as the transcranial direct current stimulation (tDCS), has shown promising results in enhancing the performance of athletes.

Music is an art form and cultural activity. Music is very subjective, as it affects every individual differently. Faster tempo music was associated with happier responses and can elevate mood while slow tempo music was associated with sad responses (Webster & Weir, 2005). During the 2012 London Olympics, the Organising Committee of the Olympics developed a playlist of more than 2000 tracks, using popular music to manipulate athletes' psychophysiological state (Bishop, Wright & Karageorghis, 2014). The playlist was to provide the most appropriate soundtrack to each of the Olympic sports. Various studies have shown that music can act as an ergogenic aid and can affect psychological states of athletes during exercise (Karageorghis & Terry (2006), Bishop, Wright & Karageorghis (2014) and Eliakim, Meckel, Nemet & Eliakim (2007)). Besides, there is also increasing evidence suggesting that the "right" music can enhance sports performance (Karageorghis & Priest, 2012). Thus, the present study attempts to investigate the use of motivating patriotic music to enhance running performance of the Reserve Officer Training Unit (ROTU) cadets from Universiti Sains Malaysia.

Both neurostimulation and music had its effects on an athlete's performance. Thus, the present study attempts to compare the psychological effects between neurostimulation and music on running performance. The study of using neurostimulation before running is not yet extensively conducted. The use of motivating patriotic music towards running performance is also not extensively studied. So, this study was designed to fill the gap of knowledge. This study focused on male USM ROTU cadets, with a participation of 22 volunteered cadets.

1.2 Problem Statement

This study aimed to examine the effects of using neurostimulation before performing a running test among the male ROTU cadets. Neurostimulation and music have been shown to enhance the performance of an athlete whether in endurance or power sports. However, between the two medium, we do not know which one will enhance the running performance better. Thus, this study was designed to differentiate the effects of using neurostimulation and motivating patriotic music on ROTU cadets' running performance.

1.3 Significance of the Study

This study attempts to examine the effects of using neurostimulation before a running performance. It will provide insights on the pros and cons of using stimulation prior to exercise or a performance test. Besides, the study also attempts to investigate the effects of adding motivating patriotic music to enhance the motivation of the ROTU cadets further, leading to the enhancement in the running performance among the ROTU cadets. If the results are positive, it can be used as a method of training to increase sporting performance and also can improve the psychological states of the athletes and for the military personnel.

1.4 Research Questions

1. Does neurostimulation enhance running performance?

2. Does motivating patriotic music to improve the running performance better than neurostimulation?

3. Does neurostimulation or motivating patriotic music enhance mood states?

1.5 Objectives of Study

General Objectives

To examine the effect of neurostimulation and motivating patriotic music on running performance and mood states among male Reserve Officer Training Unit cadets.

Specific Objectives

1. To examine the effect of neurostimulation on running performance among the Reserve Officer Training Unit cadets.

2. To examine the effect of motivating patriotic music on running performance among male Reserve Officer Training Unit cadets.

3. To examine the effect of neurostimulation on mood states in male Reserve Officer Training Unit cadets.

4. To examine the effect of motivating patriotic music on mood states in male Reserve Officer Training Unit cadets.

1.6 Hypotheses of Study

1. Null Hypothesis (H_0): There is no statistically significant difference in running performance among the Reserve Officer Training Unit cadets between neurostimulation and listening to motivating patriotic music.

Alternative Hypothesis (H_A): There is a statistically significant difference in running performance among the Reserve Officer Training Unit cadets between neurostimulation and listening to motivating patriotic music.

2. Null Hypothesis (H_0): There is no statistically significant difference in mood states of male Reserve Officer Training Unit cadets between neurostimulation and listening to motivating patriotic music.

Alternative Hypothesis (H_A): There is a statistically significant difference in mood states among the Reserve Officer Training Unit cadets between neurostimulation and listening to motivating patriotic music.

1.7 Operational definition

Neurostimulation - Neurostimulation is a purposeful modulation of the nervous system's activity using non-invasive means (e.g. transcranial direct electric stimulation). In this study, we used transcranial direct electric current (tDCS) to provide the neurostimulation, by using the Halo Neurostimulation System (Halo Sport).

Motivating Patriotic Music - In this study, the song that we applied was Negaraku by Faizal Tahir ft Joe Flizzow. We chose the song based on the results of Brunel Music Rating Inventory-3 (refer Appendix F), which were given to all of the participants.

Reserve Officer Training Unit (ROTU) cadets - Reserve Officer Training Unit (ROTU) is a training unit that formed in Higher Educational Institutions. It is a volunteer force unit in the Malaysian Armed Forces. The cadets who enrolled in this training unit will go through training throughout the three years, which every year they are required to complete 240 hours of localised training, 14 days of continuous training and 14 days of annual camp training.

Running Performance - In this study, running performance is quantified through the Multistage Fitness test (also known as Leger test, beep test or bleep test). The test is commonly used to assess an individual's aerobic capacity. We can obtain the individual's predicted $\dot{V}O_2max$ through this test. We expressed running performance as predicted $\dot{V}O_2max$.

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 as the 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 known as the 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 of the 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, the volunteer force which is known as the 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 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 Agong as Second Lieutenant in AW (Bahagian Pasukan Simpanan, Tentera Darat Malaysia) .

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 13^{th} 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 at 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

The objective of ROTU is to expose IPTA students to the ways of the military and also to build self-esteem in themselves. Besides, 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 to 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 the annual bounty, complementing from the total hours of training they attend.

Being commissioned as a Second Lieutenant in AW will enable the officer to receive privileges same as officers from Regular Armed Forces. The system and procedure of the commission do not differ from the system that was practicable to Cadet Officers from Regular Forces, fully emphasising 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 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

2.1.3 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 at 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.

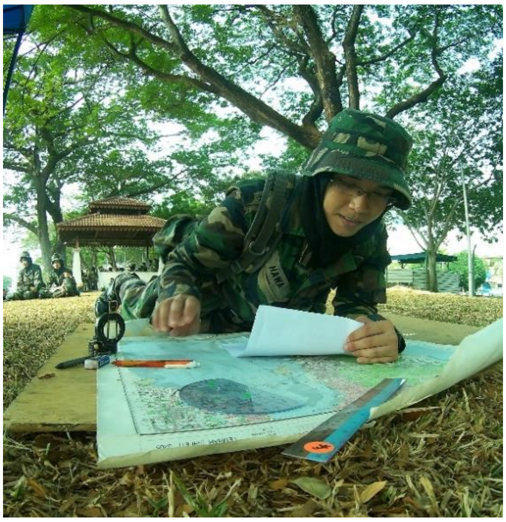

Figure 2.3 A cadet undergo Map reading test

All these training need endurance and strength, thus every day 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. 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 tests to evaluate the 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.

2.2 Transcranial Direct Current Stimulation

Transcranial direct current stimulation (tDCS) is a non-invasive technique that alters human cortical excitability via electrodes (Halo Neuroscience, 2016). Distal muscular contraction and sufficient neural drive are required in motor exertion. Neural drive refers to electrical signals that are sent from the central nervous system to the muscle. This in turns will drive the recruitment of motor units and causes the muscle to generate force (Folland et al., 2014). In supplying continuous neural input to muscles and maintaining maximal force exertion, the primary motor cortex (M1) plays a key role (Halo Neuroscience, 2016). It is shown that tDCS can increase the excitability of M1 through the induction of weak intracerebral ionic current between a positively charged anode and a negatively charged cathode (Nitsche et al., 2005).

One exciting application in improving brain functionality is the enhancement of motor function. By stimulating specific areas of the motor cortex, fine motor skills and gross motor properties such as fatigue and explosiveness in human subjects can be enhanced (Halo Neuroscience, 2016). Angius et al. (2017) conducted a mini review on studies of tDCS, and found that there are limited studies in this area, showing inconsistent results and often with the suspected flawed methodological design. The studies in the review were divided into two: Whole-body exercise better represents real sporting competition, while single-joint exercise is for exploration of the physiological mechanisms associated with fatigue (Angius et al., 2017).

Currently, for whole-body exercises, previous researchers had tested on the tCDS used for enhancing cycling performance. To our knowledge, there are no studies done on running performance. Okano et al. (2015) conducted a study on the effects of tDCS in performing maximal cycling exercise up to volitional exhaustion and found that maximal power output was improved, and ratings of perceived exertion (RPE) and heart rate were lower compared to control group. Another study conducted by Vitor-Costa et al. (2015) found that there was an improvement in cycling time to exhaustion (TTE) following tDCS. However, they found that there were no changes in mood, physiological or perceptual parameters. In hot conditions, it was found that there were no changes in performance of 20 km cycling trial and a TTE test (Barwood et al., 2016). They also reported there was no reduction in heart rate following tDCS.

2.3 Music in Sports

Music in sports and exercise has a long history and intuitive appeal. It can capture a person' attention, lift spirits, generate emotion, change or regulate mood, evoke memories, increase work output, reduce inhibitions and encourage rhythmic movement (Karageorghis & Terry, 2006). Some of the main benefits that athletes might receive from listening to music would be increased in the positive moods and reduced in the negative moods; activation or relaxation before an event; dissociation from unpleasant feelings such as pain and fatigue; and decrease in the RPE (as cited by Terry & Karageorghis, 2006).

There were more than 100 studies that focused on the main functions of music to enhance performance, where performance preparation (pre-task music) was one of them (Bishop, Wright & Karageorghis, 2014). One of the studies is conducted by Eliakim et al. (2007), studied the effect of arousing music during warm-up on anaerobic performance in elite national level adolescent volleyball players. They found out that with music, the mean heart rate during warm-up is significantly higher than the group without music. The peak anaerobic power was also significantly higher.

Another study conducted by Yamamoto et al. (2003) studied about fast- or slow-tempo music for 20 min before a 45 seconds supramaximal ergometer test. The power output did not differ between fast- and slow-tempo music, but they found that fast-tempo elevates circulating levels of norepinephrine, while slow-tempo music had the reverse effect. Bishop et al. (2014) explored the neural basis related to the effects of pre-task music. They examined the effects of tempo and intensity on brain responses during reactive task performance. They discovered that fast-tempo music produces mild emotional responses, together with an increase in visuomotor activity, suggesting an increase in attentiveness and potential responsiveness as a result. In addition to that, loud intensity music activates the basal ganglia, which it involves in synchronising with external periodicities, effective decision-making and reparation for action in sport (Bishop et al., 2014).

For music to be considered motivational, there are four contributing factors. The first is rhythm response, which is the musical rhythm. Second is musicality, the response to pitch-related elements. Third is cultural impact that is the pervasiveness of the music within society and lastly, association which refers to the extra-musical associations that a piece of music may carry (Priest, Karageorghis & Sharp, 2004). Priest et al. (2004) conducted a study on the effects and characteristics of motivational music in exercise settings. They found that the rhythmical elements of music can increase arousal response. Other than that, they found that the higher the volume of music was delivered, the higher the motivational qualities of music.

Patriotic music was widely used in military settings such as the First World War (WWI) (Heilman, 2009) and the Second World War (WWII) (Maddocks, 2015). In WWI, patriotic music was a crucial component in nineteenth-century European nationalist movements (Heilman, 2009). It was used to identify themselves as a nation, thus promoting nationalism and patriotism to their subjects. In WWII, patriotic music was used to boost the morale and motivation of the US troops which in turn developed combat motivation (Maddocks, 2015). Besides that, they used music to sway enemy soldiers' morale through propaganda (Maddocks, 2015).

By combining motivational and patriotic music components, we proposed to investigate the effects of motivational patriotic music on running performance. The piece of music must have motivational qualities (rhythmic response, musicality, cultural impact and association) and is patriotic in nature.

2.4 Multi-Stage Fitness Test (MSFT)

Multi-Stage Fitness Test (MSFT) is a one of the most popular field tests to assess a person's aerobic capacity (Kavcic, Milic, Jourkesh, Ostojic & Ozkol, 2012). MSFT is also known as Leger's test, beep test or bleep test. Through MSFT, we can estimate the maximal oxygen uptake ($\dot{V}O_2max$) of an individual. $\dot{V}O_2max$ is the ability of the cardiovascular system to deliver oxygen to the working muscles. Individuals with high $\dot{V}O_2max$ values is said to have high "endurance fitness" or "cardiorespiratory fitness" (Ramsbottom, Brewer & Williams, 1988).

To directly determine $\dot{V}O_2max$ of an individual, graded exercise testing (GXT) is usually done. There are many protocols for GXT that include Bruce protocol and Balke protocol, which can be tested by using a treadmill or a cycle ergometer (Krasilshchikov, 2016). These tests are carried out in a lab, which requires sophisticated instrumentation, laboratory time and trained personnel. Not all individuals have access to the facility and equipments, so field tests are developed as an alternative to assess $\dot{V}O_2max$ (Ramsbottom et al., 1988).

The MSFT was developed by Leger and Lambert (1982) and is extensively used among various levels of athletes, from children to elite athletes (Paradisis, Zacharogiannis, Mandila, Smirtiotou, Argeitaki & Cooke, 2014). Many studies showed that there are high correlations (0.90 - 0.93) between MSFT and $\dot{V}O_2max$ (Leger and Lambert, 1982; Ramsbottom et al., 1988; Sproule et al., 1993; Palickza et al., 1987; Wilkinson et al., 1999), but the outcome of MSFT is only the predicted $\dot{V}O_2max$ (as cited by Paradisis et al., 2014). Ramsbottom et al. (1988) then developed a table that depicted the predicted maximal oxygen uptake values for the MSFT, which is used until now as a guidance.

Chapter 3

METHODOLOGY

3.1 Research Design

This is a cross-sectional study with crossover design. We used the crossover study design because all participants experienced three research conditions, namely no stimulation (act as a baseline), neurostimulation and listening to motivating patriotic music.

3.2 Study Setting and Period of Study

The study was conducted at Universiti Sains Malaysia (USM) Main Campus, located in Pulau Pinang. The stimulation phase was done at the USM ROTU headquarters. Then the participants performed the MFST in the vicinity of USM ROTU Headquarters. This study was completed within two months.

3.3 Participants

In this study, we used purposive method to recruit the participants. The reference population of this study was ROTU cadets. It is further refined to only USM ROTU cadets. USM ROTU consisted of the three services which were Army, Navy and Airforce. Then we chose cadets from Army ROTU. The cadets consisted of three strata, which are the senior level, intermediate level and junior level. In this study, we chose male junior level cadets as our study sample. Participants were recruited voluntarily through words of mouth and a poster hung at the ROTU notice board. Prior to participation, each participant signed a consent form approved by the University's Human Research Ethics Committee (USM/JEPeM/17120707).

The participation in this study was entirely voluntary. Therefore no honorarium was given to the participating cadets. The study was not covered by insurance. Participants may refuse to take part in the study or stop participation in the study at any time, without a penalty or loss of benefits to which the participants are otherwise entitled. The participation may also be stopped by the study investigator without the participants' consent.

3.3.1 Participant Inclusion and Exclusion Criteria

a) Inclusion criteria

To be included as a participant of this study, the cadets must

- between the ages of 19 – 21 years old,
- have normal body mass index (BMI) (Normal BMI range: 18.5 to 24.9),
- free from any lower limb and back injuries at the time of data collection, and
- has a normal hearing.

b) Exclusion criteria

Cadets are excluded from the study if

- they are currently injured;
- have any hearing problems;
- have an active, implanted medical devices such as a pacemaker, defibrillator, or other neurostimulator;
- have a skull defect (i.e., plate in the skull or previous reconstructive skull surgery) or any implant in the portion of the skull overlying the brain; and
- have a history of seizures.
- have severe migraine (diagnosed by a medical personnel)

3.4 Sample Size Determination

A priori sample size calculation of one-way ANOVA showed that 9 participants were needed in each group, with a total of 27 participants, which was sufficient to yield 0.8 power of the study with the effect size of 0.55. The sample size was calculated using G*Power Software version 3.1.9.2 (Heinrich Heine Universitat Dusseldorf, Germany).

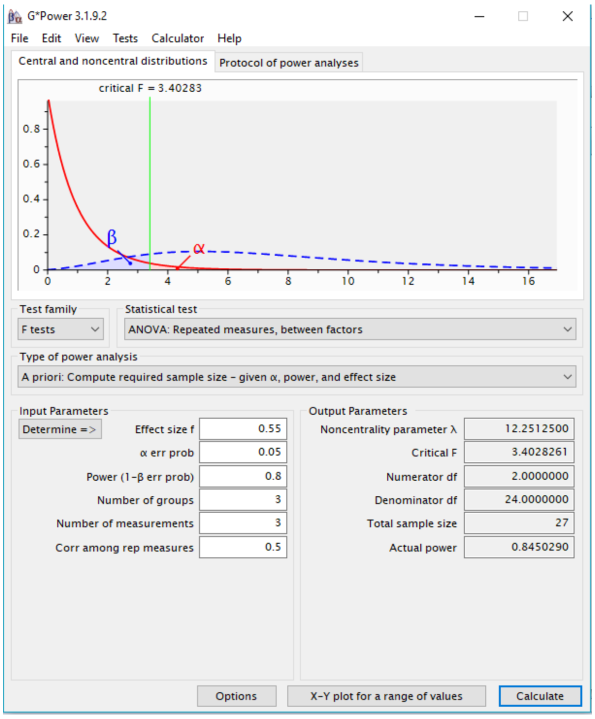

Figure 3.1 Sample size calculation

In this study, we managed to recruit 27 cadets as our participants. We divided the cadets into three research conditions, with nine cadets per group. Along the study, five cadets dropped out because they did not manage to complete all the three tests. At the end of the study, we managed to get the results from a total of 22 cadets.

3.5 Study Instruments

3.5.1 Transcranial direct current stimulation (tDCS)

tDCS was provided using the Halo Neurostimulation system (Halo Sport). The Halo Sport was fitted to the subject as wearing a headphone. The electrodes are 6.4 x 4.4 cm in size, with sponges yielding a nominal contact region of 28 cm^2. Before administering tDCS, the surface of the electrodes was soaked in water. This stimulation was applied for 20 minutes in a single session (Halo Neuroscience, 2016b).

Figure 3.2 Halo Sport

Figure 3.3 Electrodes of Halo Sport

The Halo Sport is controlled via the Halo Sport app. The app is available both for Android phones and iPhones. Through the app, the intensity of the stimulation can be controlled. At the beginning of the stimulation, the intensity was set to 7mA. After 30 seconds, the intensity was increased to 10mA until the end.

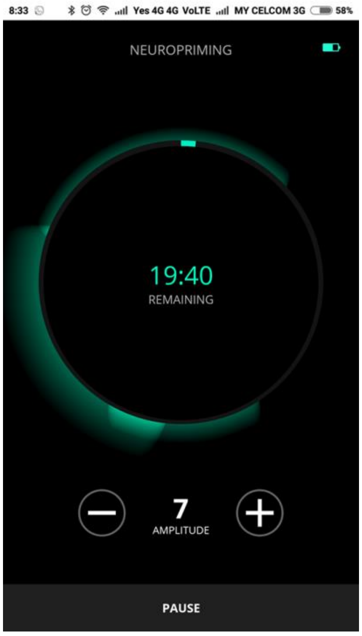

Figure 3.4 The Halo Sport app

3.5.2 Oximeter

The oximeter is a device that can measure heart rate and SpO_2 (peripheral capillary oxygen saturation) (Allwin Digital OLED Fingertip Pulse Oximeter RZ001 SpO_2 Pulse Rate). The oximeter was placed on the index finger to measure both SpO_2 and heart rate. The measurements were taken at the beginning of each trial. The normal values of SpO_2 are between 95% - 100%. We measured the oxygen saturation of participants before conducting MSFT because lower values than 95% indicate hypoxia (Berry & Seitz, 2012).

If the participant had low SpO_2 values, then it will certainly affect the results of MSFT. This is because if oxygen saturation is low, then more O_2 is being released from haemoglobin, as a result, there will be a decrease in oxyhaemoglobin levels in the blood, thus the muscles will receive less oxygen during exercise (Berry & Seitz, 2012). The value of SPO_2 and heart rate was expressed in percentage unit of oxygen (%) and beats per minute (bpm) respectively.

Figure 3.5 A Pulse Oximeter

3.5.3 Brunel Mood Scale

Brunel Mood Scale (BRUMS) is a questionnaire that measures mood state. It was administered three times to the participants, which were before stimulation, after stimulation and after performing the MFST. There were six factor with four items in each factors in BRUMS. The six factors are tension, anger, fatigue, vigour, confusion and depression. The items were rated at a 5-point scale from 'Not at all' (0) to 'extremely' (4). (Refer appendix A). BRUMS was previously reported to be valid (Terry et al., 1999; Terry et al., 2003; Hashim et al., 2010).

3.5.4 Multi-stage Fitness Test (MSFT)

This test measured the predicted maximal oxygen uptake ($\dot{V}O_2max$) of the participants. The last level that the participants reached when they were unable to continue the test was the indicator of the participant's running performance. The participants need to run according to pre-recorded beeps, between two points which were 20m apart (Figure 3.6). The participants need to stop at the marked point, turns 180^0 and run in the opposite direction to the other marked point, indicated by the beep.

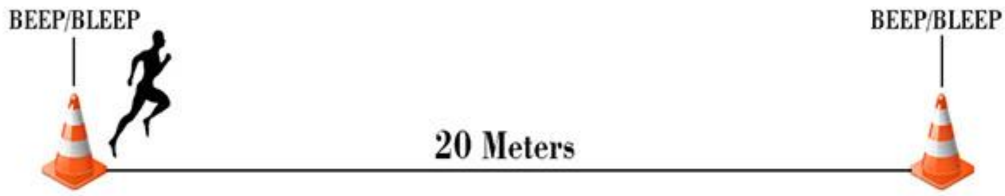

Figure 3.6 Illustration of MSFT set up

The participants were given the first warning if they reach the next point later than the next beep. But if they were able to reach the next point before the next beep, then the warning was lifted. If the participants received two consecutive warnings, and still cannot keep up with the pace dictated by the beep sound, then the test will end for the participant. Table 3.1 is the predicted $\dot{V}O_2max$ that was developed by Ramsbottom et al. (1988). From the table, an equation was derived as follows:

Predicted $\dot{V}O_2max$ = 3.46 x (L+SN / (L x 0.4325 + 7.0048)) + 12.2

Where L is Level and SN is the number of shuttles.

Table 3.1 Prediction of $\dot{V}O_2max$ based on MSFT levels

Level	Shuttle	Predicted VO_{2max}	Level	Shuttle	Predicted VO_{2max}
4	2	26.8	14	2	61.1
4	4	27.6	14	4	61.7
4	6	28.3	14	6	62.2
4	9	29.5	14	8	62.7
			14	10	63.2
5	2	30.2	14	13	64.0
5	4	31.0			
5	6	31.8	15	2	64.6
5	9	32.9	15	4	65.1
			15	6	65.6
6	2	33.6	15	8	66.2
6	4	34.3	15	10	66.7
6	6	35.0	15	13	67.5
6	8	35.7			
6	10	36.4	16	2	68.0
			16	4	68.5
7	2	37.1	16	6	69.0
7	4	37.8	16	8	69.5
7	6	38.5	16	10	69.9
7	8	39.2	16	12	70.5
7	10	39.9	16	14	70.9
8	2	40.5	17	2	71.4
8	4	41.1	17	4	71.9
8	6	41.8	17	6	72.4
8	8	42.4	17	8	72.9
8	11	43.3	17	10	73.4
			17	12	73.9
9	2	43.9	17	14	74.4
9	6	45.2	18	2	74.8
9	8	45.8	18	4	75.3
9	11	46.8	18	6	75.8
			18	8	76.2
10	2	47.4	18	10	76.7
10	4	48.0	18	12	77.2
10	6	48.7	18	15	77.9
10	8	49.3			
10	11	50.2	19	2	78.3
			19	4	78.8
11	2	50.8	19	6	79.2
11	4	51.4	19	8	79.7
11	6	51.9	19	10	80.2
11	8	52.5	19	12	80.6
11	10	53.1	19	15	81.3
11	12	53.7			
			20	2	81.8
12	2	54.3	20	4	82.2
12	4	54.8	20	6	82.6
12	6	55.4	20	8	83.0
12	8	56.0	20	10	83.5
12	10	56.5	20	12	83.9
12	12	57.1	20	16	84.8
13	2	57.6			
13	4	58.2			
13	6	58.7			
13	8	59.3			
13	10	59.8			
13	13	60.6			