EFFECTS OF ROWING TRAINING ON AEROBIC CAPACITY AND AVERAGE POWER OF STROKE SURVIVORS

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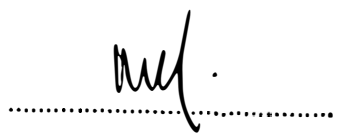

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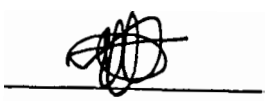

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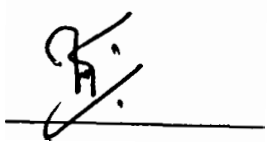

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ABSTRACT

This study was conducted to study the effect of rowing training on peak oxygen uptake (VO_2peak), resting stroke volume (RSV), and average power (AVGPWR) of stroke survivors. A pilot study, a test-retest study was conducted to develop a rowing-ramp protocol (RRP) as cardiopulmonary exercise testing (CPET) before a real test was performed to test the effectiveness of rowing training on VO_2peak of 11 stroke participants. The retest study was conducted to study its reliability as CPET in this study AVGPWR, peak heart rate (HRpeak), Modified Borg Dyspnoea Scale (MBDS), and respiratory exchange ratio (RER) were measured during RRP test. Both tests showed excellent reliability, $r = 0.946$, $p < 0.001$ for VO_2peak, $r = 0.915$, $p < 0.001$ for AVGPWR, HRpeak, $r = 0.964$, $p<0.001$, MBDS, $r = 0.659$, $p<0.027$, and RER, $r = 0.838$, $p<0.001$. Reliability coefficient, r showed excellent reliability of all the variables. Thus, RRP was reliable as CPET to measure VO_2peak of the stroke survivors. Sixteen patients (nine male; seven female), age (47.69 ± 14.225 years), weight (70.04 ± 14.623 kg), and height (162.15 ± 9.748 cm) underwent a 12-week rowing training which consisted of both high-intensity interval training (HIIT) and moderate rowing (MR) types of training. RRP was conducted after every five weeks of training to measure VO_2peak and AVGPWR. Electrical bioimpedance measurement using Biopac System (MP36) noninvasive method applied to measure RSV value before and after 12 weeks rowing intervention was applied. Mean ± SD of VO_2peak (17.544 ±8.749 ml/min/kg to 22.619 ± 9.003ml/min/kg), AVGPWR (28.173 ± 15.093 W to 45.209 ± 21.226 W), and RSV (93.315 ± 42.482 ml to 121.560 ± 84.126 ml) showed an improvement from pre to post test 3. F values showed a statistically significant value for VO_2peak and AVGPWR, $F (3, 45) = 8.056$, $p = 0.001$ and $F (3, 45) = 19.059$, $p = 0.001$ respectively. The results of paired t-test, $t = -3.538$, $p = 0.003$; $t = -6.021$, $p = 0.001$; and $t = -1.343$, $p = 0.206$ respectively showed VO_2peak and AVGPWR showed a significant p value ($p < 0.05$). In this study, a regression test was performed to study the relationship between VO_2peak and AVGPWR. VO_2peak was expected to increase 0.373 ml/kg/min for a unit of increased in AVGPWR. Hence, there was a positive linear relationship recorded between VO_2peakand AVGPWR ($\beta_1 = 0.373$, 95% CI: 0.118, 0.628, $p = 0.007$). Therefore in this study, it could be concluded that 12-week rowing training would improve aerobic capacity (VO_2peak and RSV) and power output of the stroke survivors.

ABSTRAK

KESAN LATIHAN ROWING TERHADAP KAPASITI AEROBIK DAN MIN KUASA PESAKIT STROK

Kajian ini dijalankan untuk melihat kesan latihan rowing terhadap penggunaan oksigen puncak (VO_2peak), isipadu strok (RSV), dan min kuasa (AVGPWR) pesakit strok. Kajian rintis, kajian berulang telah dijalankan untuk merangka sebuah ujian rowing-ramp protocol (RRP) sebelum kajian yang sebenar dijalankan untuk menguji kesan latihan rowing terhadap VO_2peak 11 pesakit strok. Kajian berulang dijalankan untuk menguji tahap kebolehpercayaan ujian RRP sebagai ujian kardiopulmonari (CPET) untuk pesakit strok. Min kuasa rowing (AVGPWR), kadar denyutan jantung puncak (HRpeak), Modified Borg Dyspnoea Scale (MBDS), dan nisbah pertukaran respirasi (RER) turut diuji dalam RRP. Kedua-dua ujian menunjukkan tahap kebolehpercayaan yang tinggi, $r = 0.946$, $p < 0.001$ (VO_2peak), $r = 0.915$, $p < 0.001$ (AVGPWR), $r = 0.964$, $p<0.001$ (HRpeak), $r = 0.659$, $p<0.027$, dan RER, $r = 0.838$, $p<0.001$. Ini menunjukkan RRP adalah sesuai dan boleh digunapakai sebagai CPET dalam kajian ini. Enam belas pesakit strok (sembilan lelaki; tujuh perempuan), umur (47.69 ± 14.225 tahun), berat (70.04 ± 14.623 kg), dan tinggi (162.15 ± 9.748 cm) mengikuti 12 minggu latihan rowing yang merangkumi kedua-dua latihan iaitu high-intensity interval training (HIIT) dan moderate rowing (MR). Ujian RRP dijalankan selepas setiap lima minggu latihan rowing dijalankan. Mean ± SD VO_2peak (17.544 ±8.749 ml/min/kg kepada 22.619 ± 9.003ml/min/kg), AVGPWR (28.173 ± 15.093 W kepada 45.209 ± 21.226 W), dan RSV (93.315 ± 42.482 ml kepada 121.560 ± 84.126 ml) menunjukkan peningkatan sebelum dan selepas 12 minggu latihan. Dalam ujian analisis RPM ANOVA, ujian F menunjukkan kadar signifikan untuk parameter VO_2peak, $F (3, 45) = 8.056$, $p = 0.001$ dan AVGPWR, $F (3, 45) = 19.059$, $p = 0.001$. T-test menunjukkan, $t = -3.538$, $p = 0.003$; $t = -6.021$, $p = 0.001$; dan $t = -1.343$, $p = 0.206$ untuk VO_2peak, AVGPWR, dan RSV. VO_2peak dan AVGPWR menunjukkan kadar yang signifikan $p < 0.05$. Dalam kajian ini, ujian regrasi (single regression) telah digunakan untuk menguji hubungan di antara VO_2peak dan AVGPWR. VO_2peak dijangka akan meningkat sebanyak 0.373 ml/kg/min untuk satu unit peningkatan AVGPWR. Justeru, dapatan ujian regrasi (single regression) antara AVGPWR dan VO_2peak mempunyai hubung kait positif yang linear ($\beta_1 = 0.373$, 95% CI: 0.118, 0.628, $p = 0.007$). Dalam kajian ini, pengkaji menyimpulkan bahawa 12 minggu latihan rowing akan meningkatkan kapasiti aerobik (VO_2peak dan RSV) dan AVGPWR pesakit strok.

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LIST OF ABBREVIATIONS

AE	Aerobic Capacity
AVGPWR	Average Power
BG	Blood Glucose
BP	Blood Pressure
BPbase	Baseline Blood Pressure
CHF	Chronic Heart Failure
CIMT	Constraint-Induced Movement Therapy
CO	Cardiac Output
CPET	Cardiopulmonary Exercise Testing
CVA	Cerebrovascular Accident
CVD	Cardiovascular Disease
CVI	Cerebrovascular Insult
ECG	Electrocardiographic
FES	Functional Electrical Stimulation
HIIT	High Intensity-Interval Training
HR	Heart Rate
HRbase	Baseline Heart Rate
HRmax	Maximal Heart Rate
HRpeak	Peak Heart Rate
MBDS	Modified Borg Dyspnoea Scale
METS	Metabolic Equivalent of Task
MI	Myocardiac Infarction
MR	Moderate Rowing
NASAM	National Stroke Association of Malaysia
QEH	Queen Elizabeth Hospital

RBP	Resting Blood Pressure
RCO	Resting Cardiac Output
RHR	Resting Heart Rate
RPE	Rate of Perceived Exertion
RPM	Repeated Measures
RRP	Rowing-Ramp Protocol
RSV	Resting Stroke Volume
SCI	Spinal Cord Injury
SPM	Stroke Per Minute
SV	Stroke Volume
THR	Target Heart Rate
UMS	Universiti Malaysia Sabah
VO_2	Oxygen Uptake
VO_2max	Maximal Oxygen Uptake
VO_2peak	Peak Oxygen Uptake
WHO	World Health Organization

LIST OF SYMBOLS

<	Less than
N	Number of subjects
=	Equals to
>	More than
p	Probability value
F	F test for ANOVA test
β	Beta
t	t test
%	Percentage

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CHAPTER 1

INTRODUCTION

1.1 Background of The Study

The leading causes of stroke in Malaysia have been alarming especially in a developing country like Malaysia. Towards 2030, it is estimated that stroke will occur in epidemic proportion, and the number of deaths will rise from 6.5 million in 2015 to 7.8 million in 2030 (Basri, 2010). Stroke is defined and known as one of the cause or factor to disabilities especially among adults and the elderly (age > 65). Though there is no empirical proof that stroke occurred within the senior population, however the risk is higher in this population. Disabilities include hemiparesis or hemiplegia might occurred after a stroke event if rehabilitation process was delayed. Limitation occurs usually on the side or lateral of the body which might limits the patient's daily activities (Glader, Stegmayr, & Asplund, 2002; Helpline, 2012) and routines such as dressing, bathing, and eating. Depending on the affected area of the lobe (site of lesion), stroke could be in various forms which include loss of cognitive function, speech, and physical impairment. Thus, these limitations result in their inefficiency to conduct daily living. Hence leading to cardiac impairment (Francica et al., 2015) which in turn would adversely affect the ability to do exercise (exercise capacity) (Chen, Chen, Chen, & Huang, 2010). Previous study had proved that people after stroke would have a poor cardiorespiratory fitness (Billinger, Boyne, Coughenour, Dunning, & Mattlage, 2014; Tang, Sibley, Bayley, McIlroy, & Brooks, 2006) thus aerobic exercise might be beneficial for this population.

Also, past researcher suggested that earlier rehabilitation after stroke would ensure marked improvement (Hancock, Shepstone, Rowe, Myint, & Pomeroy, 2011). Therefore, immediate rehabilitation is worthwhile for stroke survivors to improve their well-being and reduced mortality rate.

In Malaysia, Stroke Council was formed by The Malaysian Society of Neurosciences in 2003 and its objective is to discuss and plan appropriate stroke programmes for the populations (Basri, 2010). Booklet on managing stroke was distributed all over the country to provide a guideline for doctors to have an organised procedure on stroke victims. The National Stroke Association of Malaysia (NASAM), a non-governmental organisation also was formed to assist stroke survivors in their well-being (Basri, 2010) especially in rehabilitation. It was recorded that there was about 300 to 1000 stroke admissions per year in hospital around Malaysia, which stated a ratio of 1:2000 (Basri, 2010).

Based on previous study, one of the empirical evidence showed that researchers all around the world agreed that constraint-induced movement therapy (CIMT) found to be useful and effective therapeutic modality to assist the stroke survivors (Ishida et al., 2015; Sterr et al., 2002). CIMT is a tool which has become an essential part in facilitating stroke survivors to be independent again. CIMT is a modality to improve or train the upper limb alone where patient is required to wear a sling on the unaffected arm and induced the movement of the affected side based on the non-used principle (Ishida et al., 2015; Grotta et al., 2004). The outcomes of previous research (Grotta et al., 2004) had proven that it was an effective way to force movement from the affective arm. Despite, research on the lower limb is yet to be conducted and there is no empirical evidence from past researches that specifies any modality (s) to train lower limbs. There was a pilot study conducted on stroke survivors to train their hemiparetic lower limb known as single limb exercise (Billinger, Guo, Pohl, & Kluding, 2010) and this study found that oxygen uptake (VO_2) could improve following the particular exercise. Hence, in this study, an assisted whole-body movement therapy for stroke survivors was applied and its benefits were highlighted in terms of cardiorespiratory fitness.

1.2 Definition of Stroke

World Health Organization (WHO) defined disability as "an umbrella term for impairments, activity limitations or participation restrictions" (Turk & Mudrick, 2013). Stroke or its medical term, cerebrovascular accident (CVA) (Bergquist et al., 1994) is recognised as one of the cause of disabilities (Glader et al., 2002; Globas et al., 2012; Mercier, Audet, Hebert, Rochette, & Dubois, 2001) and could lead to various comorbidities. There are two types of CVA which are (i) Ischaemic, and (ii) Haemorrhagic. Ischaemic stroke occurs when there is lack of oxygen delivered to the brain within a specific period of time that damages the brain. This is due to plaque formation within the wall of tunica intima of the blood vessel or also known as atherosclerosis (Powers & Howley, 2012). Haemorrhagic type of stroke is a bleeding of capillaries in the brain (Sims & Muyderman, 2010) occurring due to the thinning of wall of arteries (Powers & Howley, 2012).

Both types of stroke may cause disabilities within its survivors and there is a continuum or severity of stroke (Andersen, Olsen, Dehlendorff, & Kammersgaard, 2009). One of the acute effect of stroke is loss of cardiovascular endurance (Hamzat & Alabi, 2006;Billinger, Taylor, & Quaney, 2012; Potempa, Braun, Tinknell, & Popovich, 1996; Weir, n.d.) as a result of bed-ridden after the attack. It is significant for these people to acknowledge that cardiovascular endurance is important for them (Barfield, Sherman, & Michael, 2003) as it accounts for approximately 80% of daily activities. Physical activities (gardening, cleaning) as well as cardiovascular exercises such as brisk walking, jogging, and cycling are useful for them to keep up their endurance for a better quality of life.

As proven by past research (Stoller, de Bruin, Knols, & Hunt, 2012), cardiovascular endurance could benefit stroke survivors in terms of blood circulation which is beneficial for the paretic side. Cardiovascular exercises or also known as aerobic exercise is defined as any repeated movement of a group of muscles (gross muscles) for a period of time (Powers & Howley, 2012). To add on, the primary element of aerobic exercise is to train the heart to pump more blood especially to the

affected side which should be highlighted by the therapist. Physiologically, Frank-Starling equation states that the amount of blood filling is equal to the amount of blood ejected towards the body (Shiels & White, 2008). Despite, people with disability such as in stroke survivors whom affected in neurophysiological function would be having various obstacles even to conduct the least body movement. Therefore, it is important to screen and prescribe an individualised intervention programme for this population to assist them towards recovery.

1.2.1 Stroke in Malaysia

Stroke is the third largest cause of death in Malaysia. It is considered to be the most common cause of severe disability. Every year, an estimated 40,000 people in Malaysia suffer from stroke and it is possible that anyone can have a stroke, including children but the vast majority of the cases affect adults and elderly people (National Stroke Association of Malaysia, NASAM). According to NASAM, the youngest patient was a six year old girl.

In Malaysia, six new cases of stroke occur every hour (Chua, 2005). According to the Health Minister in 2005, about 52,000 Malaysians suffered strokes annually when it is the most preventable of all life threatening health problems. In 2005, 17,909 stroke victims were admitted into government hospitals alone throughout the country, 3245 of them were fatal. By 2020, this figure is expected to exceed 25,000 per year. He then said the main reason the number increasing is due to leading an unhealthy lifestyle in our country. Obesity, smoking and failure to control hypertension, high cholesterol level and diabetes were found to be the major risks.

According to a senior consultant at the Neurology Clinic of the University of Malaya Medical Centre, said that according to the center's statistics on stroke in 1994, 59% of the patients were male and the patients' average age was 62. He said the

majority of the patients were Chinese, followed by 29% of Malays and 21% of Indians (Borneo Post, Feb 7, 2014).

Women face a higher risk of stroke than men, particularly due to high blood pressure disorders in pregnancy and other hormonal factors (Borneo Post, Feb 7, 2014). Women's unique vulnerability include common pregnancy complications, use of birth control pills, hormone replacement therapy, migraines and heart problems. Risk includes high blood pressure, smoking and diabetes which will lead to various types of stroke. Any woman who has experienced preeclampsia, a dangerous high blood pressure during pregnancy can be double the risk of having a stroke. Older women should be screened for heart beat irregularities known as atrial fibrillation, as this can boost a women's risk of stroke five folds after age 75 (Borneo Post, Feb 7, 2014).

1.3 Problem Statement

Stroke survivors possess impairments and disabilities immediately after a stroke attack which includes hemiparesis or muscle weakness on either side of the body. This situation influenced daily routines of the survivors and in addition their emotional aspect as well. Previous research has proven that stroke made their survivors depressed (Valko, Bassetti, Bloch, Held, & Baumann, 2008) and this might impact the family members as well. Therefore, it is important for this community to acknowledge the existence of exercise therapy and other modalities to improve their physical and psychological well-being.

There were exercise modalities and traditional therapies studied and published in various field from past studies to help this population to improve physical function to ensure they could at least manage to conduct daily routines independently. Traditional therapy such as CIMT uses a different approach to train stroke patients by using an isolated training or also known as learn non-use (Ishida et al., 2015; Sterr et al., 2002). CIMT forces the use of affected arm by limiting and stopping the healthy arm

usage for a duration of time and this method was proven to be benefiting this population significantly (Ishida et al., 2015; Sterr et al., 2002). Question arises in this study whether there is any specific whole-body rehabilitation programme for the stroke survivors who possessed unilateral hemiparesis. To add on it is significant for researchers, therapist, and physicians to understand that other aspects are important as well for the patient to recover in the area of cardiovascular endurance so that stroke survivors' mobility, muscle strength and endurance, balance and coordination would be improved in order to have a better quality of life.

In this study, a whole-body rehabilitation comprising of cardiovascular endurance using rowing ergometer was reported to induce an assisted whole-body movement and was prescribed for the stroke survivors to improve their aerobic capacity and physical functions. With the use of rowing exercise, healthy arm would assist and induced the movement of the paretic side.

1.4 Research Objectives

The research objectives in this study included:

i. To study the effect of rowing training on peak oxygen uptake (VO_2peak) of stroke survivors

ii. To test the reliability of rowing-ramp protocol (RRP) in measuring VO_2peak of stroke survivors

iii. To study improvement of resting stroke volume (RSV) as secondary outcome before and after rowing intervention programme

iv. To study the relationship of VO_2peak and average power output (AVGPWR) in rowing among stroke survivors

1.5 Variables

Sixteen stroke patients were chosen based on the inclusion and exclusion criteria which stated in detail in Chapter 3. They underwent rowing training process for 12 weeks consecutively (not including test). The primary data were as described in the research objectives. Baseline data was taken before the intervention programme started and post data (s) were taken after five weeks. After 12 weeks of rowing training and after completing the whole training programme the assessments was carried out.

1.6 Hypotheses

Based on the above variables stated, there are several hypotheses that could be made based on the theories from previous researches.

Hypotheses 1

H_a There will be a significant effect on VO_2peak after rowing training on stroke survivors

Hypotheses 2

H_a RRP is reliable in measuring VO_2peak in stroke survivors

Hypotheses 3

H_a There will be a significant effect on RSV after rowing training in stroke survivors

Hypotheses 4

H_a There is a significant positive linear relationship between VO_2peak and AVGPWR in rowing among stroke survivors

1.7 Conceptual Framework

Based on the related theories, rowing exercise was used to study its effect on aerobic capacity of stroke survivors. On top of that, there is a need to develop a new RRP for stroke survivors as cardiopulmonary exercise test (CPET) to measure VO_2peak following 12 weeks of rowing training. A pilot study conducted to test the feasibility of the protocol. Then, rowing intervention took place for each patient. Rowing training was prescribed for each individual specifically using target heart rate (THR) method to set their exercise intensity. Two types of rowing training were applied, which are high-intensity interval training (HIIT) and moderate rowing (MR). However, facial expression scale (Modified Borg Dyspnoea Scale) was applied as stroke patients were difficult to achieve THR. Throughout the study, post-tests data were collected to monitor the patients' progress.

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