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An Investigation Of The Association Between Perceived Exertion And Heart Rate During Aerobic Training In Individuals Post-Stroke

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AN INVESTIGATION OF THE ASSOCIATION BETWEEN PERCEIVED EXERTION AND HEART RATE DURING AEROBIC TRAINING IN INDIVIDUALS POST-STROKE

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A dissertation submitted in partial fulfilment for the degree of MSc in Neurology and Gerontology.

School of Physiotherapy,
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September 2016

Supervisor: Professor Marie Guidon
DECLARATION

I declare that this thesis, which I submit to RCSI for examination in consideration of the award of a M.Sc. in Neurology and Gerontology is my own personal effort. Where any of the content presented is the result of input or data from a related collaborative research programme this is duly acknowledged in the text such that it is possible to ascertain how much of the work is my own. I have not already obtained a degree in RCSI or elsewhere on the basis of this work. Furthermore, I took reasonable care to ensure that the work is original, and, to the best of my knowledge, does not breach copyright law, and has not been taken from other sources except where such work has been cited and acknowledged within the text.

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RCSI Student Number _14117495________________________________________

Date 17/08/2016________________________________________________________
SUMMARY

Introduction

The addition of aerobic exercise to standard rehabilitation can improve functional outcomes and reduce the chance of secondary stroke. Measurement of exercise intensity can be difficult in clinical practice due to lack of specialised equipment often resulting in insufficient intensities to induce cardiopulmonary strain. Intensity may be assessed by proxy measures such as the Borg Scale of Rate of Perceived Exertion (RPE). However, there is a lack of research investigating the relationship between the Borg RPE scale and objective measures of exercise intensity such as heart rate reserve in the stroke population.

Aims and Objectives

The primary aim of this research was to investigate whether there was a relationship between perceived exertion and heart rate in a sub-acute stroke population during aerobic exercise. The secondary aim was to determine whether guiding exercise intensity using the Borg RPE scale, was an effective way of achieving recommended target heart rate reserve (HRR) levels of at least 40%.

Methods

A cross-sectional, observational study was undertaken using a sample of convenience. A total of 23 participants in the sub-acute stage post stroke were recruited from an acute stroke unit. Participants underwent exercise testing on a lower limb ergometer for 15 minutes with
increasing resistance until their exertion level was rated at 14 on the Borg RPE scale. Heart rate reserve and Borg levels were recorded at the end of every minute of testing. Correlation between Borg RPE and heart rate reserve was analysed using a Spearman Rank Correlation. The level of HRR achieved was analysed descriptively and univariable linear regression was used to determine the strength of relationship between baseline characteristics (age, sex, stroke severity, number of medications, number of comorbidities, smoking history, physical activity prior to stroke and time since stroke) and HRR level achieved.

**Results**

The mean (SD) age of participants was 67.17 (14.00) years and 61% were male. Mean (SD) NIHSS score was 4.09 (2.88) and median time since stroke was 5.00 (14.00) days. The majority of participants (n=13) achieved a mean HRR between 10%-19%. Five participants achieved a maximum value of > 40% HRR at one-time point during the exercise test. One participant achieved a mean HRR > 40% for the duration of the exercise test. Participants who achieved > 40% HRR had higher physical activity levels prior to stroke, lower stroke severity and carried out the exercise test sooner post-stroke than those who did not achieve >40%HRR. A weak correlation was found between mean HRR and mean Borg RPE values R=0.32 and this was not significant (p<0.14). Mean (SD) HRR achieved was 19.72 (12.19). Mean (SD) Borg RPE score reported was 13.10 (1.24). The relationship between baseline characteristics and HRR levels achieved was not significant when analysed using univariable linear regression.
Conclusions

This study found a weak relationship between reported values on the Borg RPE scale and HRR during aerobic exercise, in a sub-acute stroke population. Therefore, the Borg RPE scale does not accurately indicate the level of exercise intensity in the sub-acute stroke population. The results also indicated that use of the Borg RPE scale to rate exertion up to a level of somewhat hard (level 14) during exercise, did not result in the achievement of recommended heart rate reserve levels between 40%-70% HRR.

Implications of Findings

This research suggests proxy measures such as the Borg RPE scale should not be used in a sub-acute stroke population. Clinicians should use objective measures such as heart rate monitors when measuring exercise intensity.
ACKNOWLEDGEMENTS

I would sincerely like to thank Professor Marie Guidon for her guidance and support throughout the research process. I would also like to thank the lecturers in RCSI for all their help over the past two years.

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To my mum for her constant encouragement and supply of frozen home cooked meals at the busy times. To my dad for his excel knowledge, proof reading skills and generosity of his time.

Finally, to my husband Aaron, for your patience, cups of tea and constant support throughout the duration of the course. I could not have completed the process without you.

Now for our next project.
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<td>12MWT</td>
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<td>ADLS</td>
<td>Activities of Daily Living</td>
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<td>FIM</td>
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<td>SPSS</td>
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<td>STROBE</td>
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INTRODUCTION

Stroke is the leading cause of acquired major physical disability in Ireland (Irish Heart Foundation National Audit of Stroke Care, 2015). As a consequence of physical impairment, stroke survivors are often deconditioned and predisposed to a sedentary lifestyle, limiting performance of activities of daily living. Reduced physical activity and low aerobic fitness has been related to an increased risk of various forms of cardiovascular disease in adults (Warren et al, 2010). Recurrent stroke and cardiac disease are the leading causes of mortality in stroke survivors (Billinger et al, 2012). Evidence of low cardiovascular fitness post stroke underlines the need to introduce aerobic exercise for optimal recovery and secondary prevention.

Exercise combined with pharmacological treatment can reduce the risk of a second stroke by 80% (Hackman et al, 2007). There is also strong evidence that aerobic exercise is beneficial for enhancing aerobic fitness, walking speed and walking endurance post stroke (Pang et al, 2013). Recently published guidelines state that all individuals should participate in aerobic training as soon as possible post stroke unless there are contraindications unrelated to stroke, and this should be included as part of their inpatient rehabilitation programme (Billinger et al, 2014).

The intensity of exercise during stroke rehabilitation has been shown to be insufficient to induce aerobic challenge (Koopman et al 2013, MacKay-Lyons et al 2002). Guidelines recommend a moderate intensity exercise of 40%-70% heart rate reserve
during the sub-acute stage post-stroke (Billinger et al, 2014). The gold standard measurement of exercise intensity is maximum oxygen uptake (VO₂ max), however, use of objective measures such as VO₂ max or heart rate to measure intensity are not commonly used in clinical practice. During rehabilitation, intensity of exercise is often guided by subjective report with use of proxy measures such as the Borg Scale of Rating of Perceived Exertion (RPE). It is not known whether use of subjective reports of exertion results in sufficient aerobic challenge for individuals to achieve recommended heart rate levels.

The Borg RPE Scale has been found to be a valid measure of exercise intensity in a healthy population (Chen et al, 2010) with a strong correlation found between RPE and VO₂ max. Less is known about the use of the Borg RPE scale in the stroke population. Sage et al (2015) found that RPE was appropriate for prescribing low to moderate intensity exercise, but not high intensity exercise in a sub-acute stroke population, whereas Koopman et al (2013) found a weak relationship between heart rate reserve and RPE values. The use of a simple scale such as the Borg RPE to measure exercise intensity could aid exercise prescription in the in-patient setting. The aim of the current study was to determine whether there was a relationship between perceived exertion and heart rate in a sub-acute stroke population. A secondary aim was to determine whether use of the Borg RPE scale during aerobic exercise resulted in achievement of recommended heart rate reserve levels. Use of the Borg RPE scale could offer a pragmatic approach to exercise prescription and provide a way for individuals to monitor their own exercise intensity and progression, on discharge from physiotherapy treatment.
CHAPTER 1 LITERATURE REVIEW

1.1 Post Stroke Sequelae

Stroke is the most common cause of acquired physical disability and there are approximately 30,000 stroke survivors in Ireland (Irish Heart Foundation, 2015). Despite being an acute event, the effects of a stroke are often chronic and many stroke survivors have to live with residual disability and activity limitations. Commonly treated symptoms post stroke include impairments of the neuromuscular system such as weakness, balance and gait deficits. There is now increasing research demonstrating that cardiorespiratory fitness is greatly impacted and also contributes to reduced functional capacity post stroke (Mead & Bernhault, 2011). Cardiovascular comorbidities are present in 75% of stroke survivors and are associated with greater mortality and risk of secondary stroke (MacKay-Lyons et al, 2006). Cardiac disease and ischemic stroke share many of the same predisposing risk factors, therefore adaption of a cardiac rehabilitation model of care in stroke survivors, including aerobic training is of increasing interest to clinicians and researchers alike (Lennon et al, 2009). Aerobic exercise programmes combined with medical management of stroke, has been found to reduce the chance of secondary stroke by 80% (Gordon et al, 2004). There is now a growing body of research investigating the effect of aerobic exercise and its prescription in the post stroke population which will be outlined in the current review.

1.2 Factors Contributing to Low Cardiovascular Fitness Post Stroke

The reasons for a reduction in cardiorespiratory fitness post stroke remain uncertain. Possible factors include premorbid fitness levels, direct effect of the stroke and poor post stroke physical activity levels. The concomitant presence of other cardiovascular
diseases in the majority of stroke survivors is a major explanatory factor of poor cardiorespiratory fitness (Billinger et al, 2014). Modifiable risk factors for stroke include smoking, obesity, diabetes mellitus and physical inactivity, consequently stroke survivors are often deconditioned and predisposed to a sedentary lifestyle (Goldstein et al, 2011). These factors combined with resultant sequelae of stroke, such as hemiparesis, further confound a stroke survivor’s ability to exercise. Physical activity levels of stroke survivors, compared to age and sex matched individuals with other chronic diseases have been shown to be much lower (Ashe et al, 2009). Direct changes from a stroke that may impact cardiorespiratory fitness include changes in muscle composition, impaired blood flow to the paretic limb, muscle atrophy, increased pro-inflammatory markers, impaired glucose tolerance and impaired autonomic control of cardiac function (Mackay-Lyons et al, 2006). The exact physiological mechanisms causing reduced cardiorespiratory fitness are unknown, however Billinger et al (2012) suggested that a reduction in lean muscle tissue, and an increase in proportion of fast twitch fibres in the paretic limb results in a more rapidly fatiguing muscle. A reduction in lean tissue has also been linked to a reduction in cardio-respiratory fitness and maximum oxygen uptake (VO₂ max) (Ryan et al, 2000). Autonomic control of cardiac function has also been found to be impaired as a direct result of a stroke, especially if the stroke occurs around the parietal and insular cortex (Jin et al, 2013). Central mechanisms such as reduced cardiac output can result in increased anaerobic metabolism during exercise which causes more rapid fatigue of relevant muscle groups (Mackay-Lyons, 2006). Respiratory function may also be directly impacted post stroke due to weakness of respiratory muscles, poor postural control, co-morbidities such as chronic obstructive pulmonary disease, and secondary complications such as respiratory tract infections (Billinger, 2012). It is likely that a combination of these factors affect the extent of cardiorespiratory function and consequent fitness levels post stroke. Using
peak oxygen consumption as an indicator of aerobic capacity, Mackay-Lyons et al (2004) found that stroke survivors had a 60% lower peak oxygen consumption than age and sex matched peers. These findings are significant at a functional level as low aerobic capacity has been found to impact performance of activities of daily living in stroke survivors (Billinger, 2012). Given the extensive impact of a stroke on fitness levels, the post stroke period is an important time to implement secondary prevention interventions such as aerobic exercise (Furie et al, 2011).

1.3 Effects of Aerobic Training Post Stroke

Several systematic reviews and meta-analyses provide evidence for the beneficial effect of aerobic training on various outcomes post-stroke (Billinger et al 2010, Saunders et al 2013, Stoller et al 2012, Tang et al 2013). A Cochrane review and meta-analysis demonstrated strong evidence that aerobic exercise is effective in improving cardiorespiratory fitness post-stroke (Pang et al, 2006). The addition of aerobic training on a cycle ergometer to standard stroke rehabilitation demonstrated significantly greater improvements in VO₂ peak and six minute walk test distance (Tang et al, 2009). Despite the heterogeneous nature of ability levels post stroke, aerobic exercise training has been shown to improve fitness levels in mild (Billinger et al, 2010) and moderately impaired individuals, however information on how to influence aerobic capacity in severely affected individuals is lacking (Billinger et al, 2014). Evidence supports aerobic training in the sub-acute and chronic stages post stroke (Pang et al, 2013). There is less evidence to support aerobic training in the acute stage as a safe level of physical activity for this population is unknown (Cumming et al, 2011). However, aerobic exercise introduced as early as possible post stroke may improve participation in therapies such as gait training or motor learning activities due to improved endurance.
Furthermore, improved aerobic fitness has been associated with improved walking ability, performance of activities of daily living (ADLs), depression and cognition (Brogardh et al., 2012). Conversely in a review of 25 articles, Pang et al. (2013) found no significant effect on performance of ADLs with aerobic training programmes, however this may have been because the majority of studies measured function using the Functional Independence Measure (FIM) which includes tasks such as eating, swallowing and bowel and bladder movement which would not be affected by aerobic capacity. Use of a different functional outcome measure may have resulted in alternative findings. Despite the high level of cardiac co-morbidities seen in stroke survivors, studies investigating aerobic exercise regimes have reported low levels of adverse effects of training (Billinger et al., 2014). It is clear from the evidence that aerobic training has beneficial effects at an impairment, functional and participation level post stroke, and the risk of adverse events is low. Introduction of aerobic exercise protocols in clinical practice is therefore essential for implementation of evidence based treatment of all patients post stroke.

1.4 Exercise Prescription Post Stroke

Given the extensive evidence surrounding aerobic exercise post stroke, a growing number of studies have investigated the optimal prescription parameters to guide clinical practice. The treatment parameters used in exercise interventions often vary between studies and a gold standard of prescription is unknown. Exercise prescription should be specific in its frequency, intensity, time and type (FITT) to ensure efficacy and ease of transferability to the clinical setting. Lack of reporting of FITT parameters used in intervention protocols has led to uncertainty about the best prescription parameters post stroke. Various reviews have found that these principles were inconsistently reported, with only 59% of studies reviewed reporting the intensity of the
exercise training (Ammann et al 2015, Garveth et al 2015, Ingrid et al 2015). Lack of detailed, specific protocols used means it is unknown whether results obtained may have been due to lack of adequate prescription of the treatment, or a true reflection of the efficacy of the treatment. Reasons for lack of reporting may be the difficulty in measuring the intensity of an exercise due to lack of equipment. Intensity of exercise is reported to be the primary factor responsible for change in peak oxygen consumption, therefore, for aerobic training to be beneficial a stroke survivor must be exerted to the appropriate level to gain the benefits (Billinger et al, 2015).

There is emerging evidence that intensity of physical activity may be a greater determinant of stroke prevention than duration. A growing number of studies have investigated the use of short burst of high intensity training showing positive effects on fitness levels (Mattrage et al, 2013). The American College of Sports Medicine (ACSM, 2009) guidelines for persons with chronic diseases and disabilities, including people after stroke, recommend exercising large muscle groups at a frequency of 3-5 times a week, for a duration of 20-60 minutes (or multiple 10 minute sessions) at an intensity of 40-70% heart rate reserve (HRR). Recent specific guidelines for stroke survivors also recommend a target of 40-70% HRR or working to an intensity level of 11-14 on the Borg Scale of rate of perceived exertion (RPE) (Billinger et al, 2014). Studies have shown that routine physiotherapy results in only three minutes of adequate exertion that exceeded recommended aerobic levels (Koopman et al, 2013). Also, heart rate values were found to be less than 20% HRR in stroke patients over the course of a day in an inpatient rehabilitation setting (Prajapati et al, 2013). Development of prescription protocols to ensure patients reach the adequate intensity of exercise during aerobic training in clinical practice are required.
1.5 Exercise Testing in the Stroke Population

Prescription of exercise is often based on results of a maximal or submaximal cardiopulmonary exercise test (CPET) in healthy individuals. Gas exchange analysis is used to obtain VO₂ max levels to indicate aerobic capacity, and is quantified during exercise to complete exhaustion. Many studies have investigated the use of such tests in a stroke population in order to aid exercise prescription. Studies of exercise testing protocols have highlighted the difficulty in using these tests to ascertain peak aerobic capacity post stroke as peripheral symptoms such as muscle fatigue often are the cause of test cessation (Bosch et al 2006, Lennon et al 2012, Marzolini et al, 2012, Ovando et al 2011, Tang et al, 2006). Use of CPET may therefore underestimate aerobic capacity post stroke. These findings were corroborated in a review by Ingrid et al (2015) which found that during exercise testing, most of the defined criteria such as a plateau in oxygen levels, were not met. Therefore, it is questionable whether criteria defined in aerobic exercise guidelines are applicable to stroke survivors. Submaximal tests are often administered in elderly and stroke populations as they are considered safer and better tolerated. However, their ability to predict VO₂ peak may not be as accurate (Lennon et al, 2012). Lennon et al (2012) investigated the use of submaximal testing on a cycle ergometer in stroke survivors to aid exercise prescription. As in previous studies, VO₂ max estimation was only possible in 35% of all patients due to failure to achieve heart rate criteria during testing. Ovando et al (2011) measured VO₂ peak in eight individuals with chronic stroke using a submaximal test on a treadmill. All of the tests were terminated due to limb fatigue rather than plateauing of maximal oxygen consumption. A larger study by Marzolini et al (2012) involving 98 participants post stroke found that CPET was feasible with 68% of participants achieving critical levels of oxygen uptake and heart rate to determine exercise prescription. The conflicting results between studies may be due to differing sample sizes and also differing
participant characteristics and protocols used. A chronic stroke population was investigated in the Ovando and Lennon studies, whereas Marzolini included sub-acute stroke patients. This suggests a possible deconditioning effect in the chronic phase of stroke that may have affected the participant’s ability to achieve required levels. Due to the heterogeneity of the studies it is difficult to conclude whether submaximal or maximal exercise tests reliably determine adequate exercise intensity for prescription. The ability to accurately set exercise training intensities based on VO₂ max to avoid over or undertraining of stroke patients remains uncertain (Lennon et al, 2008). The studies to date do not reveal a protocol that is preferable in the stroke population. CPET results are often used to assess the effects of stroke interventions as well as development of exercise interventions, therefore the methods of conducting and reporting exercise parameters after stroke need to be improved. Due to the heterogeneity of studies and protocols used in exercise testing in the stroke population, there are no stroke specific guidelines for maximal or submaximal exercise testing.

1.6 Measuring Exercise Intensity Post Stroke

In the clinical setting cardiorespiratory exercise tests are not routinely carried out prior to commencing an exercise regime after stroke and consequently exercise is often prescribed without an objective assessment of capacity (Marzolini et al, 2012). Other measures used in clinical practice include prescription based on age predicted maximum heart rate. As previously discussed, cardiac autonomic function may be impaired after stroke, with previous studies finding heart rate levels can be up to 20% lower post stroke, therefore proxy calculations may over-estimate target heart rate (Raimundo et al, 2013). During routine physiotherapy activities, Wu et al (2015) found that heart rate and VO₂ max were moderately correlated and concluded that heart rate could be used as a
reliable measure of exercise intensity in stroke survivors. Proxy measures to ascertain intensity, such as the Borg scale of Rate of Perceived Exertion (RPE) may also be used, as it may provide a fairly good estimate of actual heart rate during physical activity (Ammann et al, 2014). The relationship between heart rate and the Borg RPE Scale in the stroke population is unclear. Use of the Borg RPE scale may provide a simple and easy to administer method of determining exercise intensity when specialised equipment is not available.

1.7 Use of the Borg RPE Scale in the Stroke Population

The Borg RPE scale was developed in the 1960’s by Gunnar Borg to quantify perceived exertion. The Borg scale is a 15-point scale ranging from 6-20 with word anchors ranging from very very light to very very hard. The scale has been found to be strongly related to physiological measures of exercise intensity such as heart rate, blood lactate concentration and oxygen consumption in healthy adults (Dunbar, 1992). The Borg RPE scale is practical, easy to administer and cost-effective (Morrison et al, 2008). It continues to be used widely as a subjective measure of exertion particularly in cardiovascular rehabilitation. Less is known about the relationship between perceived exertion and physiologic markers in a stroke population.

A small number of studies have investigated ratings of perceived exertion in sub-acute stroke survivors. A moderate correlation between VO₂ peak and RPE was found during exercise on a cycle ergometer at 60% and 70% VO₂ peak, but not at greater intensities, indicating that RPE may be appropriate for prescribing moderate intensity exercise (Sage et al, 2013). Wu et al (2015) found a stronger correlation between heart rate and VO₂ max, than RPE and VO₂ max, suggesting heart rate is a better predictor of exercise
intensity than RPE in stroke survivors. Due to the wide range of RPE reported at each intensity, adjunctive use of heart rate monitoring was suggested to ensure target exercise intensity was achieved. Eng et al (2002) compared perceived exertion during six minute (6MWT) and twelve minute walk (12MWT) tests in a chronic stroke population. Despite a plateau in heart rate levels in the last six minutes of the 12MWT, perceived exertion rose by two points indicating exertion was more related to peripheral muscle fatigue than heart rate. Exercise testing on a cycle ergometer compared to a walking test may have contributed to the conflicting findings in these studies suggesting differing choices of exercise modality may affect the level of perceived exertion. During walking, impairments such as lower extremity weakness and balance deficits may increase peripheral muscular discomfort and be perceived as requiring more exertion (Eng et al, 2002). It may therefore be prudent to record RPE on the same treatment modality that exercise will be prescribed on. Koopman et al (2013) found weak correlations between heart rate reserve and Borg ratings during different rehabilitation therapies. Participants in the study included patients post stroke, lower limb amputation and spinal cord injury and the differing severity of impairments, may have caused the large variation in outcome measures. Tang et al (2013) also found considerable inter-individual variability in stroke exercise programme responses. Participants who were not able to achieve age-predicted maximal heart rate reported higher levels of perceived exertion, suggesting a mismatch between reported and actual exertion. One study has found that individuals post stroke were able to distinguish between different levels of perceived exertion, and there was no significant difference in participants who had a stroke and those who did not (Hampton et al, 2014). The study investigated use of RPE during isometric force production by contraction of small muscle groups therefore results may not be transferrable to aerobic training which stresses the cardiorespiratory system and requires use of large muscle groups.
It is inconclusive whether using rate of perceived exertion to guide exercise prescription in a stoke population results in achieving recommended intensity. Current guidelines suggest stroke survivors in the sub-acute stage should exercise to an intensity of Borg 11-14 (Billinger et al, 2014), however it is not known whether this induces a sufficient amount of cardiorespiratory strain to provoke an aerobic training effect and reach target heart rate reserve levels between 40% and 70%. Studies have tested the use of the Borg to guide exercise intensity in cardiac rehabilitation. Ilaraza et al (2004) found patients were able to gauge their own exercise intensity when asked to exercise to Borg level 13, and also increased their exercise capacity significantly using this method. In contrast, Aamot et al (2013) found that use of RPE resulted in an exercise intensity below target level during high intensity interval training. Tang (2015) investigated the use of the Borg in everyday clinical practice and demonstrated that patients were able to change their response to training using RPE levels. The results indicated that a change in score of one point on the Borg scale was equal to a heart rate change of 6-7 beats per minute. The same has not been investigated in the stroke population and no study has identified whether the Borg scale is effective in achieving recommended exercise intensities.

The aim of the current study was to investigate whether there was a relationship between subjective reports of exertion using the Borg RPE Scale and heart rate values in a sub-acute stroke population. Furthermore, the study also aimed to establish whether prescription of exercise intensity based on the Borg RPE would result in achieving target exercise intensities measured by heart rate.
CHAPTER 2 METHODOLOGY

2.1 Aims and Objectives

Aim

The aim of this study was to investigate whether there was a relationship between perceived exertion and heart rate reserve in a sub-acute stroke population during aerobic exercise.

Objectives

To determine if heart rate reserve (HRR) levels were correlated with ratings of perceived exertion (RPE) on the Borg Scale.

To determine whether guiding exercise intensity using the Borg RPE Scale, was an effective way of achieving recommended target HRR levels of at least 40% HRR.
2.2 Study Design

The study involved collection of data at one-time point and observation of one group of participants, therefore the study design used was a cross-sectional, observational study design. The STROBE statement for observational studies was adhered to in the design of the current study (Vandenbroucke, 2007).

2.3 Subjects

Subjects were a convenience sample, consecutively recruited from the Acute Stroke Unit in Tallaght Hospital. Participants were recruited in the sub-acute stage post stroke, defined as medically stable and less than three months post stroke (Baisin et al 2014, Lennon et al 2009, Sage et al 2013, Tang et al 2006). The majority of aerobic exercise programmes for individuals post stroke have focused on the chronic phase post stroke, however participation in aerobic exercise may be critical at the sub-acute stage (Baisin et al, 2014). There is no clear definition of how long post stroke a person is deemed to be in the sub-acute phase, therefore no minimum time point after the occurrence of the stroke was defined, in order to include as many medically stable participants as possible.

2.3.1 Sample Size

One study has investigated the correlation between the Borg RPE and heart rate reserve values during rehabilitation (Koopman et al, 2013). Data on a small sample (n=10) of sub-acute stroke patients was collected as part of a larger study involving patients with spinal cord injury and below knee amputation. In the participants post stroke, a moderate (r=0.5) correlation was found between heart rate reserve and Borg RPE ratings during
various different rehabilitation activities. Therefore, sample size estimation was based on a minimum correlation co-efficient of 0.5 (moderate correlations ranging from 0.5 to 0.69), a 5% significance level ($\alpha=0.05$), and a power of 80% ($\beta=0.2$) (Hicks, 2004). This gave a resultant sample of $n=23$. To allow for a 20% attrition rate, as seen in previous similar studies using aerobic exercise on a cycle ergometer (Baisin et al, 2014, Sage et al, 2013) the total target sample size was $n=29$.

2.3.2 Subject Recruitment

The participants were consecutively recruited from the Acute Stroke Unit in Tallaght Hospital. Participants were screened for suitability for inclusion by a gate keeper (the Senior Stroke Physiotherapist). Each participant was then provided with an information pack containing a participant information leaflet and consent form (Appendix 1). Participants were given a time of their own determination to think about their decision and then approached by the gatekeeper to obtain consent or otherwise. All participants who met the inclusion criteria for the study outlined below were given the opportunity to take part in the study. Participants were also given the option to withdraw from the study at any point.

2.3.3 Inclusion Criteria

- Hospital dwelling patients who were admitted with stroke (confirmed by CT or MRI scan)
- Medically stable to participate in aerobic exercise (Appendix 2) and <3 months post stroke
• Medically cleared by their treating physician to participate in the study.
• Cognitive and communication functions adequate to understand study participation (ability to repeat back what he/she understood about the study after education provided)
• All levels of mobility were eligible to participate

2.3.4. Exclusion Criteria

• Medical instability including, oxygen dependence, angina, unstable cardiac conditions, un-controlled diabetes mellitus, major medical conditions, claudication, febrile illness.
• Prescribed Beta-Blocker medication as this would affect heart rate achieved
• Modified Rankin Score >5 (Appendix 3) This would indicate severe disability and would inhibit participation in the study as patients in this category would be bed ridden and would be unable to complete the cycle ergometry programme.

2.4 Ethical Considerations

Ethical approval for the study was gained from the Tallaght Hospital Ethics Committee (Appendix 4) and the RCSI Research Ethics Committee (Appendix 5). The management and lead Physician (Dr Ronan Collins) of the Stroke Unit was notified for approval to conduct the study. The inclusion criteria stated that participants must have the ability to give informed consent. It was explained verbally and in writing on the participant information leaflet that participants had the right to refuse to participate and that did not affect their standard of care. Participants were given a time period of their own determination between receiving information about the study and deciding whether to participate, in order to make an informed decision. Participant data was collected in a
coded format so that participants would remain anonymous. Names and details that may have identified participants were removed.

2.5 Procedure

2.5.1 Demographic Details

Baseline characteristics and demographic details were collected from the participant’s medical charts. Demographic details were collected on participants who consented to take part (Appendix 6). Demographic details included age, sex, stroke location (left or right), stroke classification as per the Oxford classification (Bamford et al, 1991), time since stroke, National Institutes of Health-Stroke Scale (NIHSS) score (Appendix 7), Modified Rankin Score (Appendix 3), pre-stroke activity levels measured by the Physical Activity Scale for the Elderly (PASE) (Appendix 8) pre-stroke mobility status, co-morbidities and smoking history.

2.5.2 The Aerobic Exercise Protocol

Participants underwent familiarisation trials on the cycle ergometer if they were not already familiar with the cycle ergometer through prior standard physiotherapy treatment sessions. During the study two cycle ergometers (Moto-med Viva 2) were available for use in the Physiotherapy gym. During the test procedure the principal investigator observed each participant and completed the data collection form (Appendix 6). Patients admitted to the stroke unit routinely use the cycle-ergometer as part of their post stroke rehabilitation programme. After familiarisation, participants
then took part in the testing procedure for the purpose of the study. The testing protocol (Appendix 9) was adapted from a previous study investigating the feasibility of using submaximal exercise testing to determine maximal exercise capacity in an inpatient setting in sub-acute stroke patients (Baisin et al, 2014). That protocol differed from the current study protocol as testing was carried out on a semi-recumbent stepper. In the current study, participants were asked to work until they reached a moderate level of exertion (level 14 of the Borg) and to maintain that level for the duration of the test, to replicate regular clinical practice. The aerobic exercise procedure complied with the ACSM guidelines for sub-maximal aerobic exercise testing (Appendix 10). Participants had their resting heart rate recorded prior to testing and this value was used to calculate their heart rate reserve values of 40%-70%. The Karvonen formula was used for this calculation (Appendix 11). During the exercise test, participants had their heart rate recorded using a POLAR heart rate monitor. The testing comprised of a three minute warm up, ten-minute exercise test and two-minute cool down. At the end of every minute of testing, heart rate was recorded and participants were asked to rate their exertion levels using the Borg RPE Scale (Appendix 12).

2.5.3 Time Scale

Ethical approval was obtained from the Tallaght Hospital Ethics Committee in September, 2015 and by the RCSI Research Ethics Committee in October, 2015. Data collection took place from October 2015 until March 2016. Data analysis and write up was carried out from February until April 2016. With over 300 people admitted to Tallaght Hospital with stroke every year (The Adelaide and Meath Hospital, 2015) and
allowing for inclusion criteria and attrition rate, a six month data collection time period was deemed sufficient to obtain the target sample size.

2.5.4 Resources/ Costs

Submission to the Tallaght Ethics Committee was charged at a nominal fee of €100. Other costs included printing of data collection forms, patient information leaflets and consent forms. All costs were covered by the Principal Investigator. All equipment required for the testing procedure was readily available for use in the Physiotherapy department of Tallaght Hospital. No external funding was sought for this study.

2.6 Research Instruments

2.6.1 National Institute for Health Stroke Score

The NIHSS score (Appendix 7) is a systematic assessment tool that provides a quantitative measure of stroke-related neurologic deficit. The scale is widely used as a clinical assessment tool to evaluate acuity of stroke patients, determine appropriate treatment, and predict patient outcome (Kasner, 2006). On admission to Tallaght Hospital the admitting Physician completed the NIHSS score and this was available to view in the participant’s medical chart.
2.6.2 Modified Rankin Score

The Modified Rankin Score (MRS) (Appendix 3) is used to categorise the level of functional independence with reference to pre-stroke activities and has been found to have excellent test-retest, inter and intra-rater reliability (Wolfe et al, 1991). The MRS is a quick and easy to administer measure, consisting of a seven-point scale (0-6), that is routinely scored by the admitting physician to the hospital. A score of 0 is no disability and a score of 6 is death. This score was obtained from the participant’s medical chart.

2.6.3. Physical Activity Scale for the Elderly

Physical activity levels prior to stroke were assessed using the Physical Activity Scale for the Elderly (PASE). This information was collected as pre-stroke physical activity levels have been found to impact cardiovascular fitness post stroke. The PASE is a 12 item questionnaire measuring the level of self-reported physical activity in individuals aged 65 years or older scored from 0-600. It is comprised of items regarding occupational, household, and leisure activities. The PASE has been found to be easily administered and scored, and is valid in the assessment of physical activity in studies of older people (Washburn et al, 1993). In people with ischemic stroke moderate correlations between PASE and the Senior Fitness Test (SFT) scores were found (Lindahl et al, 2008). The PASE was chosen because the majority of people with stroke presenting to hospital are over 65 years old (Irish Heart Foundation, 2015).
2.7 Primary Outcome Measures

2.7.1 Borg Scale of Rate of Perceived Exertion

The Borg RPE scale is a subjective measure of exertion and was developed to rate the degree of heaviness or strain experienced during exercise (Borg, 1982). The Borg scale has been validated in healthy individuals, however less is known about perceived exertion compared to physiologic measures such as heart rate and VO$_2$ max in a stroke population (Sage et al, 2013). The original Borg Scale is rated from 6-20 with word anchors to facilitate subjective rating. More recently a 0-10 scale has been developed that is mainly used for measuring pain and dyspnoea. Studies comparing the two scales indicate that both have similar correlations with physiologic markers of exertion (Borg and Kaijser, 2006). For the purpose of the current study the Borg 6-20 scale was used as the 6-20 scale was referenced in recent Stroke Guidelines (Billinger et al, 2014) and this scale was utilised in similar sub-maximal training studies (Koopman et al 2013, Wu et al 2015, Murray et al 2012). Use of the 6-20 scale therefore allowed for easier comparability of results to previous studies.

2.7.2 Heart Rate

Heart rate was used as a physiologic measure of exercise intensity in participants. VO$_2$ max is seen as the gold standard in measurement of exercise capacity to determine exercise intensity, however this equipment was not readily available or feasible to use in the time scale of the current study. Gas exchange analysis is not routinely carried out in clinical practice, whereas heart rate and the Borg RPE can be more easily measured. Therefore, the findings of this study could offer practical information on exercise
prescription that would be easily replicated in the clinical setting. Heart rate values were converted to heart rate reserve values using the Karvonen formula (Appendix 11).

2.8 Statistical Methods

All data was analysed using the Statistical Package for Social Sciences (SPSS) (version 22, IBM Corporation 2012) for Windows. Normality of the variables was analysed using the mean, median, mode and standard deviations. Normality of data was further analysed on a distribution curve and the Shapiro-Wilks test was carried out. Demographic characteristics and baseline data were summarised in tables and baseline comparability of participants was examined. Heart rate and perceived exertion scores are quantitative measures on a continuous scale and therefore were classified as continuous data for the purpose of descriptive and inferential statistics. A scatterplot was used to visually display the relationship between HRR and Borg RPE. HRR and Borg RPE values were not normally distributed therefore the association between Borg RPE level and Heart Rate Reserve was determined using non-parametric analysis (The Spearman Rank correlation coefficient). A significance level of $p \leq 0.05$ was set for data analysis. Univariable linear regression was then carried out to determine whether the level of HRR achieved was associated with baseline characteristics of participants including age, sex, stroke severity, number of comorbidities and pre-morbid physical activity levels. Secondary analysis was carried out to determine if there was a difference between participants who did and did not achieve a minimum level of 40% HRR and baseline demographic details of these groups was displayed in a table.
CHAPTER 3 RESULTS

The primary aim of this study was to investigate whether there was a relationship between perceived exertion and heart rate in a sub-acute stroke population during aerobic exercise.

The specific objectives were:

- To determine if heart rate reserve (HRR) levels were correlated with ratings of perceived exertion (RPE) on the Borg RPE Scale.
- To determine whether guiding exercise intensity using the Borg RPE Scale, was an effective way of achieving recommended target HRR levels of at least 40% HRR.

3.1 Participant Flow

Participants were recruited between October 2015 and March 2016. In total, 81 people were admitted to the Acute Stroke Unit in Tallaght Hospital and referred for physiotherapy. Patients were screened for eligibility for the study and the reasons for exclusion are displayed in Figure 3.1. Of the 81 admissions, 30 were deemed suitable (37%). Reasons for exclusion included cognitive impairment, medical instability, language barrier, aphasia, unconfirmed diagnosis of stroke, diagnosis of transient ischemic attack, death and medicated with beta blockers. Of the 30 participants who were eligible, three declined to take part and four people were inpatients for less than three days and therefore did not have an admission long enough to take part in the study protocol. There were no dropouts from the 23 participants who consented to take part in the study.
3.2 Baseline Demographic Data

Baseline data collected included sex, age, stroke classification, stroke location, mobility status prior to stroke, number of comorbidities, smoking history, number of medications, Modified Rankin Scale, National Institute for Health Stroke Scale (NIHSS) on admission and Physical Activity Scale for the Elderly score (PASE) (Table 3.1). Mean (SD) values were reported for normally distributed data. Median (IQR) were reported for data that was not normally distributed. There were 9 females and 14 males in the group with a median (IQR) age of 67.17 (14.00) years. Prior to stroke 83% of participants were independently mobile (n=19), 13 % were mobile with a walking stick (n=3) and 4% were mobile with a rollator (n=1). Median (IQR) of the Modified Rankin
Scale on admission was 2.00 (3.00). Mean (SD) PASE score was 113.26 (69.50). Mean NIHSS score on admission was 4.09 (2.88). Participants required a median (IQR) number of 5.00 (6.00) medications. Median (IRQ) time since stroke was 5.00 (14.00) days. Six participants (26%) had a lacunar stroke (n=6), 13% had a total anterior circulation stroke (n=3), 44% had a partial anterior circulation stroke (n=10) and 17% had a posterior circulation stroke (n=4). Of the 23 participants 70% (n=16) were smokers and 30% (n=7) were non-smokers. Mean (SD) number of comorbidities was 3.22 (2.43). A description of the co-morbidities is displayed in Table 3.2.

3.3 Physiotherapy Interventions

All participants were referred for physiotherapy by their treating consultant, and received standard physiotherapy treatment. Therapy intervention was individualised by the treating therapists. All participants underwent aerobic exercise on a cycle ergometer as part of their treatment. All participants were invited to take part in the study as soon as they were deemed medically stable (Appendix 2).
Table 3.1 Baseline Demographic Data

<table>
<thead>
<tr>
<th>Age</th>
<th>Median (IQR)</th>
<th>67.17 (14.00) years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Female</td>
<td>39% (n=9)</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>61% (n=14)</td>
</tr>
<tr>
<td>Mobility Status</td>
<td>Independent</td>
<td>83% (n=19)</td>
</tr>
<tr>
<td></td>
<td>Walking Stick</td>
<td>13% (n=3)</td>
</tr>
<tr>
<td></td>
<td>Rollator</td>
<td>4% (n=1)</td>
</tr>
<tr>
<td>Stroke Classification</td>
<td>LACS</td>
<td>26% (n=6)</td>
</tr>
<tr>
<td></td>
<td>TACS</td>
<td>13% (n=3)</td>
</tr>
<tr>
<td></td>
<td>PACS</td>
<td>44% (n=10)</td>
</tr>
<tr>
<td></td>
<td>POCS</td>
<td>17% (n=4)</td>
</tr>
<tr>
<td>Smoker/Previous Smoker</td>
<td>Yes</td>
<td>70% (n=16)</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>30% (n=7)</td>
</tr>
<tr>
<td>Time Since Stroke</td>
<td>Median (IQR)</td>
<td>5.00 (14.00) days</td>
</tr>
<tr>
<td>Number of comorbidities</td>
<td>Mean (SD)</td>
<td>3.22 (2.3)</td>
</tr>
<tr>
<td>Modified Rankin Score</td>
<td>Median (IQR)</td>
<td>2.00 (3.00)</td>
</tr>
<tr>
<td>NIHSS Score</td>
<td>Mean (SD)</td>
<td>4.09 (2.88)</td>
</tr>
<tr>
<td>PASE Score</td>
<td>Mean (SD)</td>
<td>113.26 (69.50)</td>
</tr>
<tr>
<td>Number of medications</td>
<td>Median (IQR)</td>
<td>5.00 (6.00)</td>
</tr>
</tbody>
</table>

LACS=lacunar stroke TACS=total anterior circulation stroke PACS=partial anterior circulation stroke POCS=posterior circulation stroke NIHSS=National Institute for Health Stroke Scale PASE=Physical Activity for the Elderly Scale
Table 3.2 Comorbidities

<table>
<thead>
<tr>
<th>Comorbidities</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>13</td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>2</td>
</tr>
<tr>
<td>Atrial Fibrillation</td>
<td>2</td>
</tr>
<tr>
<td>COPD</td>
<td>2</td>
</tr>
<tr>
<td>Previous stroke/TIA</td>
<td>4</td>
</tr>
<tr>
<td>Type 2 Diabetes Mellitus</td>
<td>2</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>7</td>
</tr>
<tr>
<td>Previous Cancer</td>
<td>3</td>
</tr>
<tr>
<td>Mental Disorders</td>
<td>4</td>
</tr>
<tr>
<td>Alcoholism</td>
<td>2</td>
</tr>
<tr>
<td>Parkinson’s Disease</td>
<td>1</td>
</tr>
<tr>
<td>Vertigo</td>
<td>1</td>
</tr>
<tr>
<td>Cardiac Disease</td>
<td>4</td>
</tr>
<tr>
<td>No comorbidities</td>
<td>2</td>
</tr>
</tbody>
</table>
3.4 Heart Rate Reserve and Borg RPE Values

The primary outcome measures recorded in the study were % heart rate reserve (HRR) and Borg RPE. During the cycle ergometry test heart rate values and Borg RPE values were recorded at the end of every minute for ten minutes, after the three minute warm up. Participants then cooled down for two minutes. All participants completed the 15-minute duration of the test as per the protocol described (Appendix 9), and no adverse events occurred. The mean (SD) %HRR value for all participants (n=23) was 19.72 (12.19). The mean (SD) Borg value reported was 13.10 (1.24). The mean %HRR and Borg RPE values over the ten minutes of testing for each participant is displayed in Table 3.3 and outliers are displayed in Figures 3.2 and 3.3. Participant 13 achieved the highest mean % heart rate reserve value (58.4) and participants 10 had the highest mean Borg RPE value (16.9).
<table>
<thead>
<tr>
<th>Participant Number</th>
<th>%HRR Mean</th>
<th>Borg Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30.3</td>
<td>13.4</td>
</tr>
<tr>
<td>2</td>
<td>13.8</td>
<td>14.6</td>
</tr>
<tr>
<td>3</td>
<td>6.5</td>
<td>14.5</td>
</tr>
<tr>
<td>4</td>
<td>11.5</td>
<td>13</td>
</tr>
<tr>
<td>5</td>
<td>39.8</td>
<td>12.8</td>
</tr>
<tr>
<td>6</td>
<td>21.1</td>
<td>12.7</td>
</tr>
<tr>
<td>7</td>
<td>12.5</td>
<td>13.2</td>
</tr>
<tr>
<td>8</td>
<td>13.2</td>
<td>13.4</td>
</tr>
<tr>
<td>9</td>
<td>21.4</td>
<td>13.5</td>
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<td>10</td>
<td>27.3</td>
<td>16.9</td>
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<td>14</td>
<td>18.7</td>
<td>13.5</td>
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<tr>
<td>15</td>
<td>32.1</td>
<td>12.8</td>
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<td>16</td>
<td>10.1</td>
<td>12.8</td>
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<td>17</td>
<td>12.3</td>
<td>12.9</td>
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<td>18</td>
<td>10.5</td>
<td>11.9</td>
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<td>19</td>
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<td>13.4</td>
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<td>20</td>
<td>8.2</td>
<td>12.2</td>
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<tr>
<td>21</td>
<td>10.7</td>
<td>12.6</td>
</tr>
<tr>
<td>22</td>
<td>15.5</td>
<td>10.3</td>
</tr>
<tr>
<td>23</td>
<td>12.5</td>
<td>11.2</td>
</tr>
</tbody>
</table>
Figure 3.2 Mean %Heart Rate Reserve Values

Figure 3.3 Mean Borg Rate of Perceived Exertion Values
3.5 Correlation between Heart Rate Reserve and Borg RPE Values

The correlation between mean HRR and mean Borg RPE values was analysed using a Spearman rank order correlation as the data were not normally distributed. A weak relationship existed between HRR and Borg RPE values $R= 0.32$ and this was not significant $p< 0.14$. The correlation scatter plot is displayed in Figure 3.4.

![Figure 3.4 Scatter Plot of Mean Borg and Mean Heart Rate Reserve Values](image-url)
3.6 Heart Rate Reserve Levels Achieved

The second objective of the study was to determine whether participants would achieve recommended HRR levels of 40-70% during testing. The mean (SD) HRR level achieved was 19.72%(12.19). Of the 23 participants 22% (n=5) achieved a heart rate reserve value of ≥ 40% at one-time point during the ten-minute duration of testing. One participant achieved a mean HRR value of ≥40% HRR over the duration of the test. The majority of participants 57% (n=13) achieved a mean HRR between 10% and 19%. During the 10 minutes of testing the peak HRR achieved at one-time point was also mostly in this bracket 39% (n=9). The mean level of HRR achieved is displayed in Figure 3.5. Maximum HRR achieved is displayed in Figure 3.6. The baseline characteristics of those who did and did not achieve ≥ 40% HRR are displayed in Table 3.4.

![Number of Participants by Mean %HRR Achieved](image)

*Figure 3.5 Mean % Heart Rate Reserve Achieved*
Figure 3.6 Maximum % Heart Rate Reserve Achieved during training

Table 3.4 Baseline Characteristics of Participants who did and did not achieve ≥40% HRR

<table>
<thead>
<tr>
<th>Baseline Characteristic</th>
<th>Did not achieve ≥40%HRR</th>
<th>Achieved ≥40%HRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of participants</td>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td>Male/Female</td>
<td>56%/44%</td>
<td>80%/20%</td>
</tr>
<tr>
<td>Mean Age</td>
<td>67.26</td>
<td>66.75</td>
</tr>
<tr>
<td>Mean TSS</td>
<td>12.11</td>
<td>6.00</td>
</tr>
<tr>
<td>Mean MRS</td>
<td>2.32</td>
<td>2.00</td>
</tr>
<tr>
<td>Mean NIHSS</td>
<td>4.53</td>
<td>2.00</td>
</tr>
<tr>
<td>Mean number co-morbidities</td>
<td>3.37</td>
<td>2.50</td>
</tr>
<tr>
<td>Mean PASE</td>
<td>96.95</td>
<td>190.75</td>
</tr>
<tr>
<td>Mean HRR</td>
<td>15.86</td>
<td>38.05</td>
</tr>
<tr>
<td>Mean Borg</td>
<td>13.06</td>
<td>13.30</td>
</tr>
<tr>
<td>Smoker/History of smoking</td>
<td>77.8%</td>
<td>60.0%</td>
</tr>
</tbody>
</table>

TSS=Time Since Stroke, MRS=Modified Rankin Scale, NIHSS=National Institute for Health Stroke Scale, PASE=Physical Activity Scale for the Elderly, HRR=Heart Rate Reserve.
3.7 Univariable Linear Regression Analysis of Baseline Characteristics and HRR Achieved

Univariable linear regression analysis was performed to determine if there was an association between baseline characteristics of participants and HRR achieved. Results are displayed in Table 3.5. The level of significance for the univariable linear regression analysis was set at $p < 0.15$. None of the baseline characteristics were significantly associated with the level of heart rate reserve achieved.

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Beta Co-efficient</th>
<th>P-Value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
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</tr>
<tr>
<td>Sex</td>
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</tr>
<tr>
<td>MRS</td>
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<tr>
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<tr>
<td>Smoking history</td>
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<tr>
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<tr>
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</tr>
<tr>
<td>NIHSS</td>
<td>-0.93</td>
<td>0.32</td>
<td>Not significant</td>
</tr>
</tbody>
</table>

TSS=Time Since Stroke, MRS=Modified Rankin Scale, NIHSS=National Institute for Health Stroke Scale, PASE=Physical Activity Scale for the Elderly.
3.8 Summary of Results

- There was a weak relationship between Borg RPE levels reported during aerobic exercise and the level of HRR achieved.
- Levels of HRR achieved during the exercise test were low, only five (22%) participants achieved the minimum target of ≥ 40% HRR at one-time point during the test.
- One participant achieved ≥40% mean HRR for the duration of the exercise test.
- Age, sex, severity of stroke, time since stroke, number of medications, number of co-morbidities, smoking history and physical activity levels prior to stroke were not significantly associated with the level of HRR achieved during testing.
CHAPTER 4 DISCUSSION

This study investigated the relationship between self-reported exertion using the Borg RPE scale and heart rate reserve (HRR) levels during aerobic exercise in a sub-acute stroke population. Previous studies have found the Borg RPE scale is strongly correlated with heart rate in healthy adults (Dunbar et al, 1992) and can therefore be used to accurately prescribe exercise intensity. This study also investigated whether use of the Borg RPE scale in a sub-acute stroke population resulted in achievement of target HRR values. Unlike studies in the healthy population, the relationship between Borg RPE and HRR was weak in this study, and did not result in achievement of target HRR values. These results will be further analysed in relation to previous literature and the clinical implications will be discussed.

4.1 Participant Characteristics

This study aimed to include a sample of individuals in the sub-acute stage post stroke that would be representative of the general sub-acute stroke population. However, due to the nature of the exercise test, participants had to be able to communicate verbally and be able to understand how to use the Borg RPE scale. This meant that participants with cognitive impairment, aphasia and those who did not speak English were excluded. Therefore, the generalisability of the results to the whole sub-acute stroke population may be limited and will be discussed further in the limitations section.

Few studies have investigated the relationship between the Borg RPE scale and HRR during aerobic exercise in a sub-acute stroke population. However, five related studies have included participants with similar baseline characteristics to this study (Baisin et al 2014, Eng et al 2002, Koopman et al 2013, Sage et al 2013 and Wu et al 2015). The life
time risk of having a stroke is one in six or higher in people aged from 55 to 75 years (Seshadri et al, 2006). The mean age of participants (66.05 years) in the current study was within this category, similar to previous studies (Baisin et al 2014, Eng et al 2002, Sage et al 2013). However, two of the participants were 45 and 43 years old highlighting that stroke is a condition presenting not only in the elderly.

The current study included participants in the sub-acute stage post stroke, median (IQR) time since stroke was 5 (12) days with a range from 3 to 39 days post stroke. Previous studies have reported time since stroke ranging from a mean of 14 days to 26 days (Baisin et al 2014, Sage et al 2013). The shorter time since stroke in the current study may indicate that commencing aerobic exercise at an early stage post stroke is feasible and safe as no adverse events occurred.

The severity of stroke was measured by the National Institute for Health Stroke Scale (NIHSS), mean (SD) 4.1 (3.0). This indicated that participants were mildly impaired, which was similar to the studies by Sage et al (2013), Baisin et al (2014) and Wu et al (2015). The study protocol involved exercise on a cycle ergometer which allowed participants with greater impairments to take part, however it is likely that participants with higher NIHSS scores may have had communication or cognitive difficulties and were therefore excluded. As a result, the majority of participants had mild strokes only.

Physical activity level prior to stroke was measured by the PASE with a mean (SD) score of 113.26 (69.50) which is comparable to the general over 65 population (Washburn et al, 1993). Although cut off points for the PASE are not available, 52% of participants had a PASE score of less than 100 points which indicates minimal physical
activity levels (Lawrence et al, 2013). This is in line with previous research highlighting physical inactivity as a risk factor for stroke (Billinger et al, 2014).

Number of medications were not recorded in previous studies, however participants prescribed beta blockers were included in the studies by Koopman et al (2013) and Sage et al (2013) which may affect comparability of heart rate levels achieved to the current study. Similar to the study by Wu at et (2015) participants in the current study were excluded if they were taking beta blocker medication. The most common comorbidities reported in the current study included hypertension, hyperlipidaemia and previous stroke or TIA. This is in keeping with previous research highlighting the high presence of concomitant cardiac risk factors in individuals post stroke (Ovando et al, 2011).

Participants of all mobility levels were included in the current study, as the exercise test was carried out on a recumbent bike. This was also the case in the studies by Baisin et al (2013) and Sage et al (2013) but only independently mobile participants were included in the studies by Eng et al (2002) and Wu et al (2015). This resulted in a more heterogeneous sample of participants in the current study, more reflective of the clinical setting. In general, the current study population was similar in age, gender ratio and stroke severity to the previous studies discussed. However, the current study included participants at an earlier stage post stroke and of all mobility levels. Some of the differences in baseline characteristics may be responsible for differing results which will be discussed further in the next section.
4.2 Correlation of Borg RPE with HRR

The primary outcome measures recorded in this study were Borg RPE and HRR. During the testing procedure, participants reported their exertion using the Borg RPE scale at the end of every minute for ten minutes, and heart rate was also recorded at the end of every minute. Heart rate values were then converted to heart rate reserve percentages using the Karvonen formula. The mean %HRR values and mean Borg values were calculated for each participant and a correlation analysis was performed. This was similar to the testing protocol used by Sage et al (2013), however comparison with other studies is difficult due to the heterogeneity of protocols used.

The Borg RPE scale has a well-established relationship with heart rate in an able population (Chen et al, 2015), therefore the current study sought to investigate whether the same was true in a post stroke population. One of the aims of the study was to find a pragmatic way of measuring exercise intensity without the need for equipment such as a heart rate monitor. Exercise intensity has been shown to be the most important factor for improving cardiovascular fitness (Billinger et al, 2015). This study found a weak correlation between the reported RPE values and HRR values in a sub-acute stroke population (R=0.32). The results showed that level of exertion reported by individuals was not related to cardiovascular strain, as often HRR values did not increase as Borg RPE levels increased. This means that in individuals in the sub-acute stage post stroke, self-reported exertion such using a proxy measure such as the Borg RPE scale, cannot be used as to estimate heart rate values. The possible reasons for the lack of correlation will be discussed.
One other study has investigated the direct correlation between HRR and RPE in participants post stroke (Koopman et al, 2013). A stronger correlation (R=0.46) was found than the current study. The current study measured all participants on a lower limb cycle ergometer to allow participants of all levels of mobility to be included, whereas Koopman et al (2013) excluded participants who were unable to walk. Being less physically impaired may have allowed participants to physically exert themselves to a higher level. This was evident in the current study as stroke severity was greater in those who did not achieve recommended HRR values, although the relationship was not found to be significant on univariable linear regression (p<0.32). Mean NIHSS for those who did achieve ≥ 40% HRR was 2.00 compared to 4.53 in those who did not. This indicated that individuals who were more physically impaired had more difficulty in achieving recommended HRR levels. However, the correlation between Borg RPE and HRR remained low in the Koopman study, even though participants were independently mobile, therefore this may not be the only explanation for lack of correlation in the current study.

Other studies have used maximum oxygen uptake (VO₂ max) to measure exercise intensity instead of HR. Wu et al (2015) measured the correlation between heart rate and VO₂ max, and RPE and VO₂ max. Independently mobile participants post stroke were also used and it was reported that heart rate values were more strongly correlated to oxygen consumption than RPE. It was therefore suggested that HR was a better measure of exercise intensity than RPE. This finding concurs with the current study, highlighting the lack of validity of the Borg RPE scale to measure exercise intensity in individuals post stroke.
Similar results were also found by Eng et al (2002) who reported individuals with stroke should not rely on RPE when trying to gauge exercise intensity based on HR. It was reported that RPE could be attributed to the presence of stroke-specific physical impairments such as muscle discomfort causing fatigue, rather than cardiovascular strain. This was also reflected in the current study as individuals with more severe strokes achieved lower HRR values than those with milder strokes. In the current study the reason for exertion was not recorded e.g. leg tiredness versus feeling out of breath. Qualitative information may have added more insight into the reasons for fatigue. Perceived exertion values often increased even though heart rate reserve values plateaued, indicating that reasons other than cardiovascular strain caused exertion. This concurs with Eng et al (2002) who found that the cumulative effect of exercise contributed to increases in perceived exertion.

In contrast to the current study, Sage et al (2013) found that RPE was appropriate for prescribing low to moderate exercise intensities in the sub-acute stage post stroke. The differing results may have been because RPE were measured against VO$_2$ levels and not HRR levels, which may be a more accurate measure of exercise intensity. The majority of participants in the current study achieved low exercise intensity (10%-19% HRR), however ratings of perceived exertion indicated exertion levels of hard to somewhat hard. Sage et al (2013) did observe that higher RPE values were reported among individuals who were unable to achieve maximal effort during exercise tests. This suggests, like the current study that reporting of RPE after stroke may be due to a complex interaction of several factors that may or may not be related to cardiopulmonary function.
Physical impairment post stroke and low aerobic capacity results in elevated energy demands for tasks such as walking and completion of activities of daily living (Baisin et al, 2014). This may provide an explanation as to why the participants in this study report higher RPE during exercise than healthy individuals. Physiological changes post stroke include reduced muscle mass, increased intramuscular fat, autonomic changes, respiratory dysfunction and myopathy (MacKay-Lyons et al, 2006) all of which may lead to higher exertion levels during physical tasks compared to healthy individuals. Moreover, inactivity prior to stroke may also be related to reporting of RPE levels. Individuals post stroke tend to have been inactive and not engaged in regular physical activity (Tang et al, 2013). This inactivity may affect an individual’s ability to judge physical exertion. This was evident in the current study as the mean PASE score for those who did achieve target HRR was 191 compared to 97 in those who did not. This indicates those who achieved target HRR were more physically active prior to stroke. Regression analysis found that PASE score was not significantly associated with the level of HRR achieved. However, the study was powered to investigate the relationship between HRR and Borg RPE and not physical activity levels and HRR. A larger study sample may have revealed a stronger relationship. This result is relevant to clinical practice as practitioners may find it beneficial to target those who were less physically active prior to stroke with a higher intensity of aerobic training.

Post stroke fatigue is a common phenomenon in the early stages after stroke (Duncan et al, 2012) and may have been a confounding factor in the results found. Higher levels of exertion may have been related to general fatigue leading to higher reported values on the Borg RPE scale. Again, qualitative data regarding reason for fatigue such as a fatigue outcome measure would have added to interpretation of results. Participants may also have been fatigued from other therapies or activity on the ward on the day of
testing, as this was not controlled for in the study. The acute stroke unit in Tallaght hospital is a busy unit with patients often reporting poor sleep, therefore general tiredness may also have affected results. Although these factors may have affected Borg RPE levels reported, they are commonplace during therapy in an acute stroke unit therefore results remain clinically relevant to everyday practice.

Lack of correlation may also be due to the small sample size. All the studies to date including the current study had low participant numbers. Although the target sample size was achieved, it may be possible that the current study was under powered to detect a significant relationship. A larger sample may have revealed a stronger relationship between Borg RPE and HRR.

4.3 % Heart Rate Reserve Values Achieved

Recent guidelines recommend individuals in the sub-acute stage post stroke should exercise at an intensity of 40%-70% HRR or between levels 11-14 on the Borg RPE scale (Billinger et al, 2014). One of the objectives of the current study was to determine whether participants would meet target HRR levels using the Borg RPE scale to guide exercise intensity. Participants were instructed to exercise on a recumbent cycle ergometer with increasing resistance until they rated themselves at Borg level 14, at which point resistance was not increased. The HRR values achieved using this self-pacing method were low and under the recommended 40%-70% value. Use of the Borg RPE scale to self-regulate exercise intensity has been validated in healthy individuals (Dunbar et al, 1992) and in cardiac rehabilitation (Ilarraza et al, 2004). However, in the current study use of the Borg resulted in an exercise intensity below target. The majority of participants reached a maximum of 10%-19% HRR despite rating their exertion up to
level 14 (somewhat hard) on the Borg RPE scale. The contrasting results in the stroke population may be due to impairments such as muscle weakness, spasticity and fatigue that would not be present in healthy individuals or in a cardiac rehabilitation population.

Under achievement of target exercise intensity has been found in previous research involving individuals post stroke. A small study by Prajapati et al (2013) found that only two out of eight participants exercised at an intensity necessary for cardiorespiratory benefit (>40%HRR). Similarly, Koopman et al (2013) measured the cardiovascular strain over three days during a clinical rehabilitation programme in individuals post stroke, spinal cord injury and lower limb amputation. In the individual’s post stroke, the intensity reached was between 10-40% HRR. In the current study the mean HRR achieved varied more ranging from 7%HRR to 58%HRR. This may be because participants of all mobility levels were included in the current study whereas Koopman et al (2013) included independently mobile participants only. The heterogeneity of participants in the current study may account for the greater variability. In the Koopman study, recordings of HRR were high during non-therapy activities. This indicates that in individuals post stroke cardiovascular strain may occur during activities of daily living and not just therapy time. In the current study heart rate was only measured during one bout of exercise therefore it is unknown whether participants may have reached target HRR levels during other activities throughout the day.

The reason that % HRR targets were not met in the current study may be due to the protocol used. Participants were not given feedback to work at a higher intensity or told what heart rate they were achieving. However, studies investigating sub-maximal and maximal exercise tests with feedback, have found similar results. Lennon et al (2012)
found sub-maximal exercise testing was not feasible because the majority of stroke patients were unable to meet HR criteria due to peripheral weakness and fatigue limiting the tests. Similarly, Ovando et al (2010) reported 100% of tests were discontinued due to tiredness especially in the lower limbs. In most studies limb tiredness and generalised fatigue emerges as the main reasons for limiting cardiopulmonary exercise tests, suggesting motor impairment limits peak exercising capacity in this population.

In everyday clinical practice individuals often receive feedback on exercise intensity achieved by their treating physiotherapist. The lack of feedback given in the study protocol may indicate how individuals with stroke might rate their exertion on discharge from therapy, when unsupervised. This highlights the importance of education at an early stage post stroke regarding increasing exercise intensity in order to gain cardiovascular benefit. In a study by Baisin et al (2014) not all participants reached their target exercise intensity due to conservative prescription by practitioners therefore underachievement of exercise intensity may also be due to error of treating physiotherapists. Although intensity was monitored in the current study protocol, it is not always done so in a clinical setting. The results highlight the need for closer monitoring of intensity so that practitioners and patients alike are certain that target intensity is achieved. The results of this study indicate that intensity should be monitored with equipment such as a heart rate monitor as subjective reports from participants did not reliably indicate intensity.

A study by Marzolini et al (2012) found that the ability to reach target heart rate during cardiopulmonary exercise testing (CPET) was lower in a group of individuals with stroke compared to coronary artery disease. The proportion of CPET’s that provided
information sufficient to prescribe exercise intensity for the stroke and CAD groups was 68.4% versus 82.7%. This again suggests that peripheral rather than central physiologic strain affects performance during testing. In the current study many of the participants had cardiovascular comorbidities which may have affected exercise testing however regression analysis did not show a significant relationship between comorbidities and HRR level achieved (p<0.87). In the study by Marzolini, female participants reached significantly lower baseline VO₂ peak than men during testing and were significantly more likely to discontinue the CPET than men due to non-cardiovascular reasons such as discomfort and leg pain. Similarly, in the current study a much higher proportion of men achieved >40%HRR (80%) than women (20%) although sex was not a significant factor in prediction of %HRR achieved (p> 0.28). The Framingham Heart study (Seshadri et al, 2006) showed that post stroke disability and rates of institutionalisation are significantly higher in women than men although the reasons for this are not certain. Age, type of stroke, time since stroke, stage of motor recovery, gait aid requirement and modality of testing were not associated with VO₂ levels achieved in the Marzolini study which was the same in the current study.

Lack of association between baseline characteristics and %HRR level achieved may be due to the small sample size and large variability of the participants in this study. A larger sample may have enabled further sub-group analysis to detect a relationship between baseline characteristics and HRR achieved. Individuals who achieved target HRR had less time since stroke than those who did not. Although this was not significant on regression analysis (p< 0.45), time since stroke was six days in those who achieved target HRR compared with 12 days in those who did not. Previous studies have shown the deconditioning effect of a stroke over time (Ovando et al, 2011) which may account for this finding. However, another explanation may be that individuals
who took part in the study sooner post stroke were likely to be less physically impaired with milder strokes. Individuals who took more time before commencing aerobic exercise were likely to be more medically unstable in the days immediately after stroke with greater impairments.

The choice of exercise modality may also have been a factor in the heart rate level achieved. Koopman et al (2013) reported highest levels of HRR were achieved during hydrotherapy, walking and upper limb ergometry. Lower limb ergometry was chosen in the current study to include participants of all levels, however this may not be the ideal exercise to achieve target intensity. Future studies should compare exercise modalities, however for participants with greater impairments treatment choice is limited. Exerting individuals with greater impairment during therapy is all the more important as it is likely at a ward level they are immobile and spend the majority of the day seated or in bed. Tang et al (2013) investigated training responses in people post stroke and found that lower baseline aerobic capacity was associated with greater training related gains in VO₂. This suggests those with the most compromised fitness levels may gain the greatest benefit from training. The results suggest different exercise models may be required for different cohorts of stroke patients. The same may also be true for prescription of exercise intensity. Although guidelines suggest a target of 40%–70% HRR in the sub-acute population, there is little evidence to guide optimal exercise intensity post stroke. Although participants in the current study exercised at low intensities, it is unknown whether this was enough to induce a training effect. It may be possible that for those who were more physically inactive prior to stroke, low exercise intensity training was enough to induce a training effect due to poor baseline fitness levels. Future research should investigate the optimal training intensities for different stroke populations.
4.4 Limitations

- A sample size calculation was carried out, however the study may have been underpowered to detect a relationship between Borg RPE and HRR due to the heterogeneity of the sample.

- Other confounding factors may have affected exertion levels such as post stroke fatigue, sleep quality and other therapies carried out on the day of testing. These factors were not controlled for in the study protocol.

- VO\textsubscript{2} is the gold standard as a physiological measure of exertion but was not available due to the scale of the study, therefore heart rate was used as a proxy which may not be as accurate. However, measurement of VO\textsubscript{2} is not readily available in the clinical setting therefore results from the current study may be more transferrable to clinical practice.

- The Borg RPE 11-20 scale was used in this study as this was used in previous studies. However, the Borg RPE 1-10 scale may have been more user friendly and may have provided a more accurate rating of exertion.

- Results of this study are generalizable to exercise on a lower limb ergometer only, different forms of exercise may have resulted in different findings. Further research into how various types of exercise affect exertion and cardiac strain would be beneficial.

- Sub-group analysis of different impairment levels and different pre-stroke activity levels, may have revealed if there was an effect on exertion and cardiorespiratory strain. This would provide useful information in prescription and progression of exercise intensity. However, sample size was too small for sub-group analysis.
• Subjects were excluded due lack of capacity to understand the study protocol therefore results cannot be generalised to this group of patients. Participants were also excluded due to aphasia and language barrier which may have biased the results.
• Qualitative information regarding reasons for exertion levels experienced was not collected and may have provided further information to aid analysis.
• The results of the study cannot infer information about the effect of aerobic exercise on outcomes as it was an observational design and did not measure any outcomes pre and post.
• Outcome measures collected were of an impairment level only, the results of the study do not indicate how function and participation may be affected in the sub-acute stroke population.

4.5 Recommendations for future research

• Investigation of the use of self-reported measures of exertion versus HR monitors to determine exercise intensity.
• Investigation of the effect of different modalities of exercise on HR achieved.
• Longitudinal studies to determine the adherence of individuals post stroke to exercise intensities recommended by physiotherapists in the acute setting.
• The role of education sessions on exercise intensity in the acute setting prior to discharge to encourage adherence.
• How to promote longer term adherence to cardiovascular exercise when it is introduced in the subacute setting
• Investigation of the best methods of recording and prescribing exercise intensity in the stroke population.

• The effect of different exercise intensities on cardiovascular fitness and functional outcomes should be investigated to guide prescription of intensity for individuals with differing pre-morbid fitness and impairment levels.

4.6 Clinical Implications

Overall, the lack of relationship between Borg RPE and %HRR achieved indicated that the Borg RPE is not suitable for use in a sub-acute stroke population to guide exercise intensity. Self-reported measures of exertion in the sub-acute stroke population are likely to underestimate cardiopulmonary exertion. Objective measures such as heart rate monitors should be used to determine exercise intensity. No adverse events occurred during the cardiovascular exercise test therefore it was a feasible exercise modality in sub-acute stroke. However, exercise intensity achieved was low and more adverse events may have occurred at greater intensities. The study was carried out in a clinical environment and not under laboratory conditions, therefore results are generalizable to the clinical setting. Practitioners should be mindful of prescription and monitoring of exercise intensity as it is likely that without objective measurement, target intensity is unlikely to be achieved. The study also highlights the need for education regarding exercise intensity at an early stage post stroke.
CONCLUSION

This study found that there was a weak relationship between reported values on the Borg Scale of Rate of Perceived Exertion and %HRR during aerobic exercise, in a sub-acute stroke population. The results also indicated that use of the Borg RPE scale to rate exertion up to a level of somewhat hard (level 14) during exercise, did not result in achievement of the recommended heart rate reserve levels between 40%-70% HRR.

Very few participants achieved recommended target HRR levels during the exercise test which is likely to be representative of clinical practice. Baseline characteristics of participants including age, sex, time since stroke, stroke severity, smoking history, number of medications, number of comorbidities and physical activity levels prior to stroke were not significantly associated with the level of HRR achieved during exercise. However, those who did achieve target heart rate had milder strokes, completed the testing within a shorter timeframe post stroke and were more physically active prior to stroke. This suggests that individuals with more severe strokes, who were less fit prior to stroke, are less likely to achieve target heart rate. Clinicians may be interested to implement aerobic training with close attention to intensity, in this cohort of individuals post stroke.

It was evident from the study findings that target exercise intensity is unlikely to be achieved by proxy measures of exertion such as the Borg RPE scale. Physiotherapists should make use of objective measures such as a heart rate monitor, to ensure recommended intensities are achieved. Feedback should also be provided during exercise.
In summary, the lack of relationship between Borg RPE values and HRR post stroke is unlikely to be caused by one factor alone. It is likely that a combination of the factors discussed had an impact on the results of the study. A higher RPE may be attributed to the presence of stroke specific impairments such as muscle weakness that may increase peripheral muscle discomfort and be perceived as requiring more exertion.
REFERENCES


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Lennon, O., Carey, A., Gaffney, N., Stephenson, J., 2015. A pilot randomized controlled trial to evaluate the benefit of the cardiac rehabilitation paradigm for the non-acute ischaemic stroke population, *Clinical Rehabilitation* (22) 125–133.


APPENDICIES

Appendix 1: Research Information Leaflet and Consent Form

Title of study
An Investigation of the Association between Perceived Exertion and Heart Rate during Aerobic Training in Individuals Post-Stroke.

About the Study
It is recommended that after having a stroke, you should take part in aerobic exercise. Aerobic exercise is any exercise that causes you to breathe harder and gets your heart beating faster. The purpose of this study is to investigate how you rate the exertion you feel during exercise. The study involves using a moto-med bike and having your heart rate recorded. At the same time you will tell your Physiotherapist how exerted you are feeling by using a scale provided. The aim of the study is to determine whether the level of exertion is causing your heart to beat fast enough, so that you will gain the benefits of the aerobic exercise, such as improved fitness levels.

Who can be in the study?
This study is for people who have been admitted to Tallaght Hospital because of a Stroke. You have been asked to take part because you have met the inclusion criteria. This means that you are medically fit enough to take part in the exercise.

What will the study involve?
The study involves attending the Physiotherapy gym to use the moto-med bike on four different occasions. The first three times will be to get used to using the bike. You will be supervised by a Physiotherapist while you exercise and you will cycle for 15 minutes or until you want to stop. During the testing you will be fitted with a heart rate monitor, your Physiotherapist will monitor you while you are using the bike and ask you how exerted you are feeling by using a scale called the BORG scale of Rate of Perceived Exertion.

Will the study benefit me?
The results of this study will help your Physiotherapist to determine if the exercise you are receiving is at the best intensity for you. Taking part in aerobic exercise after Stroke has many beneficial effects including improved fitness which can help to prevent another Stroke from occurring and may also help your energy levels and ability to do daily tasks.
Are there any risks?

The intensity you will exercise at in the study is a moderate level and is associated with a low risk of cardiac complications, however you will be closely monitored during the exercise and after you are finished. After exercising on the bike you may have muscle stiffness and soreness and you may also find the exercise tiring.

Important points to note

- You do not have to be a part of this study to be treated. You will have access to use of the moto-med bike as part of your Physiotherapy treatment even if you do not take part.

- Your identity will remain confidential. Your name will not be published and will not be disclosed to anyone outside the hospital. Your Physiotherapist is covered by Clinical Indemnity Insurance. Nothing in this document restricts or curtails your rights.

- You have volunteered to participate in this study. You may quit at any time. If you decide not to participate, or if you quit, you will not be penalised and will not give up any benefits which you had before entering the study.

- This trial has hospital Research Ethics Committee approval

- Further information: You can get more information or answers to your questions about the study, your participation in the study, and your rights, from

  Carla Spring
  MSc Student RCSI, and Physiotherapist employed by Tallaght Hospital. Tel: 01 414 2750.

- If your Physiotherapist learns of important new information that might affect your desire to remain in the study, she will tell you.
CONSENT FORM

Title of research study: An Investigation of the Association between Perceived Exertion and Heart Rate during Aerobic Training in Individuals Post-Stroke.

This study and this consent form have been explained to me. My Physiotherapist has answered all my questions to my satisfaction. I believe I understand what will happen if I agree to be part of this study. I have read, or had read to me, this consent form. I have had the opportunity to ask questions and all my questions have been answered to my satisfaction. I freely and voluntarily agree to be part of this research study, though without prejudice to my legal and ethical rights. I have received a copy of this agreement.

PARTICIPANT’S NAME:

PARTICIPANT’S SIGNATURE:

Date:

Statement of investigator’s responsibility: I have explained the nature, purpose, procedures, benefits, risks of, or alternatives to, this research study. I have offered to answer any questions and fully answered such questions. I believe that the participant understands my explanation and has freely given informed consent.

Physiotherapist’s signature: Date:
### Appendix 2: ACSM Guidelines Absolute and Relative Contraindications to Exercise

**ABSOLUTE**
- Unstable CHD
- Decompensated HF
- Uncontrolled arrhythmias
- Severe pulmonary hypertension (mean pulmonary arterial pressure >55 mm Hg)
- Severe and symptomatic aortic stenosis
- Acute myocarditis, endocarditis, or pericarditis
- Uncontrolled hypertension (>180/110 mm Hg)
- Aortic dissection
- Marfan syndrome
- High intensity RT (80% to 100% of 1-RM) in patients with active proliferative retinopathy or moderate or worse nonproliferative diabetic retinopathy

**RELATIVE (SHOULD CONSULT A PHYSICIAN BEFORE PARTICIPATION)**
- Major risk factors for CHD
- Diabetes at any age
- Uncontrolled hypertension (>160/100 mm Hg)
- Low functional capacity (<4 METs)
- Musculoskeletal limitations
- Individuals who have implanted pacemakers or defibrillators

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CHD, Coronary heart disease; HF, Heart failure; METs, Metabolic equivalents; RM, Repetition maximum; RT, Resistance training.
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Appendix 3 MODIFIED RANKIN SCALE (MRS)

Patient Name: ___________________________

Rater Name: ___________________________

Date: ___________________________

Score Description

0 No symptoms at all

1 No significant disability despite symptoms; able to carry out all usual duties and activities

2 Slight disability; unable to carry out all previous activities, but able to look after own affairs without assistance

3 Moderate disability; requiring some help, but able to walk without assistance

4 Moderately severe disability; unable to walk without assistance and unable to attend to own bodily needs without assistance

5 Severe disability; bedridden, incontinent and requiring constant nursing care and attention

6 Dead

TOTAL (0–6): _______

References

Rankin J. “Cerebral vascular accidents in patients over the age of 60.” Scott Med J 1957;2:200-15


STANDARD APPLICATION FORM

For the Ethical Review of Health-Related Research Studies, which are not Clinical Trials of Medicinal Products For Human Use as defined in S.I. 190/2004

DO NOT COMPLETE THIS APPLICATION FORM IF YOUR STUDY IS A CLINICAL TRIAL OF A MEDICINAL PRODUCT

Title of Study: An Investigation of the Association between Perceived Exertion and Heart Rate in Individuals Post Stroke

Application Version No: ________________________________

Application Date: ________________________________

For Official Use Only – Date Stamp of Receipt by REC:
This Application Form is divided into Sections.

*Sections A, B, C, D, E, J and K are Mandatory.

(Sections F, G, H, I and L are optional. Please delete Sections F, G, H, I and L if these sections do not apply to the application being submitted for review.)

**IMPORTANT NOTE:** Please refer to Section I within the form before any attempt to complete the Standard Application Form. Section I is designed to assist applicants in ascertaining if their research study is in fact a clinical trial of a medicinal product.

**IMPORTANT NOTE:** This application form permits the applicant to delete individual questions within each section depending on their response to the preceding questions. Please respond to each question carefully and refer to the accompanying Guidance Manual for more in-depth advice prior to deleting any question.

**PLEASE ENSURE TO REFER TO THE ACCOMPANYING GUIDANCE MANUAL WHEN COMPLETING THIS APPLICATION FORM.**

**SECTION A GENERAL INFORMATION**

**SECTION A IS MANDATORY**

**A1 Title of the Research Study:**

| An Investigation of the Association between Perceived Exertion and Heart Rate in Individuals Post Stroke |  |
A2 (a) Is this a multi-site study?  

If you chose ‘yes’ please delete questions A2 (e) and (f). If you chose ‘no’ please delete Questions A2 (b) (c) and (d)

A2 (e) If no, please name the principal investigator with overall responsibility for the conduct of this single-site study.

Title: MRS.  
Name: Carla Spring
Qualifications: Bsc Physiotherapy
Position: Basic Grade Physiotherapist
Dept: Physiotherapy Department
Organisation: Tallaght Hospital
Address: Tallaght, Dublin 24
Tel: 0871676792  
E-mail: carlajspring@rcsi.ie

A2 (f) For single-site studies, please name the only site where this study will take place.

Tallaght Hospital

A3. Details of Co-investigators:

Name of site (if applicable): Answer
Title: Prof.  
Name: Marie Guidon
Qualifications: Dip. Physio, Dip. Stat, MSc. PhD, MISCP
Position: Head, RCSI School of Physiotherapy
Dept : RCSI School of Physiotherapy
Organisation: Royal College of Surgeons in Ireland
Address: 123 St Stephen’s Green, Dublin 2, Ireland
Tel: 01 402 2396  
E-mail: mguidon@rcsi.ie
Role in Research e.g. statistical / data / laboratory analysis: Supervisor

A4. Lead contact person who is to receive correspondence in relation to this application or be contacted with queries about this application.

Name: Carla Spring
Position: Physiotherapist
Organisation: Tallaght Hospital
Address for Correspondence: Physiotherapy Department, Tallaght Hospital, Dublin 24
Tel (work): 01 414 2759  
Tel (mob.): 0871676792
E-mail: carlajspring@rcsi.ie

A5 (a) Is this study being undertaken as part of an academic qualification?  

If answer is No, please delete remaining questions in Section A

A5 (b) If yes, please complete the following:
Student Name(s): Carla Spring
Academic Course: Masters in Neurology and Gerontology
Academic Institution: RCSI

A5 (c) Academic Supervisor(s):

Title: Prof.  
Name: Marie Guidon
Qualifications: Dip. Physio, Dip. Stat, MSc. PhD, MISCP
Position: Head, RCSI School of Physiotherapy
Dept: School of Physiotherapy
Organisation: RCSI
SECTION B STUDY DESCRIPTORS

SECTION B IS MANDATORY

B1. What is the anticipated start date of this study?

October 1st, 2015

B2. What is the anticipated duration of this study?

Eight Months

B3. Please provide a brief lay (plain English) description of the study. Please ensure the language used in your answer is at a level suitable for use in a research participant information leaflet.

This study aims to investigate whether the level of exertion felt by a patient after having a stroke is associated with their heart rate. Guidelines suggest that aerobic training after having a stroke should be included in their rehabilitation. Often patients are not exerted to a level that will challenge their fitness. The main aim of the study is to investigate whether asking a participant to work to exercise to a level that feels between “somewhat hard” and “hard” to them on the Borg Scale of exertion (levels 11-14), achieves their recommended target heart rate.

B4. Provide brief information on the study background.

Stroke is the most common cause of acquired major physical disability in Ireland (Irish Heart Foundation National Audit of Stroke Care, April 2008). As a consequence, stroke survivors are often deconditioned and predisposed to a sedentary lifestyle that limits performance of activities of daily living, increases the risk for falls and may contribute to a heightened risk for recurrent stroke. Low aerobic fitness has also been related to an increased risk of various forms of cardiovascular disease in adults (Warren et al., 2010). Recurrent stroke and cardiac disease are the leading causes of mortality in stroke survivors.

Given the potentially adverse health consequences of reduced aerobic capacity in individuals with stroke, there has been an increasing recognition of the importance of aerobic exercise training in this population. Data from studies involving stroke have documented the beneficial impact of regular physical activity on multiple cardiovascular risk factors and provided evidence that such benefits are likely to translate into a reduced risk for mortality from stroke and cardiac events (Thompson et al., 2003, Lee et al., 2002).

Benefits of aerobic exercise include improved quality of life, improved functional capacity and mobility, reduced neurological impairment, improved motor function, prevention of complications of prolonged inactivity, decreased risk of recurrent stroke and increased aerobic fitness (Gordon et al., 2004). There is ongoing strong evidence that aerobic exercise (40–70% Heart Rate Reserve (HRR)) conducted 20–40 minutes and 3–5 days per week is beneficial for enhancing aerobic fitness, walking speed and walking endurance in people who have had mild to moderate stroke (Pang et al., 2013). This is in line with the American Heart Association (AHA) Guidelines which recommend aerobic training at 40-70% HRR at a similar frequency and duration (Gordon et al., 2004). The Irish Stroke Guidelines 2009 state that all patients should participate in aerobic training as soon as possible after stroke unless there are contraindications unrelated to stroke, and this should be included as part of their inpatient rehabilitation programme (Royal College of Physicians: National Clinical Guidelines for Stroke, 3rd edition, 2008).

Historically, the intensity of stroke rehabilitation interventions have been insufficient to induce aerobic challenge. During rehabilitation, patients routinely undertake aerobic training on a cycle ergometer. Patients are asked to exercise to an intensity that they feel out of breath but still able to talk. It is not
known whether current practice induces sufficient aerobic challenge for a patient to achieve Heart Rate Reserve Levels of 40-70%. The proposed study would identify if using perceived level of exertion to prescribe exercise intensity, measured on the BORG Scale of Perceived Exertion (as recommended to level 14), results in participants reaching the recommended Heart Rate Reserve Levels of 40-70%.

B5. List the study aims and objectives.

The aim of the study is to investigate whether there is an association between ratings of perceived exertion (RPE), measured by the BORG, and Heart Rate Reserve (HRR) levels in a sub-acute stroke population.

The objectives are

- To determine if patients in the sub-acute stage post stroke achieve target heart rate levels exercising up to level 14 on the BORG (6-20) scale.
- To optimise the aerobic exercise training programmes for stroke survivors

B6. List the study endpoints / measurable outcomes (if applicable).

The primary measurable outcomes are Heart Rate measured using a Polar Heart Rate Monitor and Perceived Exertion measured using The BORG Scale of Perceived Exertion.

B7. Provide information on the study design.

A cross-sectional, observational study

B8. Provide information on the study methodology.

Study Design

An observational, cross-sectional study will be conducted to investigate the relationship between perceived exertion and heart rate in individuals with Stroke during Aerobic Exercise.

Subjects

Subjects will be recruited from The Stroke Unit in Tallaght Hospital, Dublin 24. All patients admitted with a Stroke will be screened using the inclusion criteria by a Gate Keeper (Gillian Harte, Senior Physiotherapist Stroke Service). Once medically stable it is normal practice that patients undertake aerobic training on a cycle ergometer. If they are deemed suitable for inclusion to the study, during their aerobic training, they will undergo the testing procedure as attached (Appendix 7). All participants will receive medical screening by a physician in the stroke team prior to commencing aerobic training as per usual care. If deemed suitable, a patient information leaflet (Appendix 2) will be given to participants detailing the study. Written informed consent will be obtained (Appendix 2). For the duration of the study, prior to each aerobic training session each subject will be assessed for contraindications to exercise as per American College of Sports and Medicine (ACSM) guidelines (ACSM Guidelines for Exercise Testing and Prescription, 2013)(Appendix 9). If absolute or relative contraindications are identified as per ACSM guidelines, the patient will be excluded from the study.

Subject Recruitment

The patients will be consecutively recruited from the Stroke Unit in Tallaght Hospital, when a patient is admitted they will be screened for suitability for inclusion by a gate keeper (the Senior Stroke Physiotherapist). Patients will be approached by the gatekeeper to determine if they wish to participate, each patient will be provided with an information pack containing a participant information leaflet and consent form (Appendix 2). Participants will be given 24 hours to think about whether they want to participate. All patients who meet the inclusion criteria for the study outlined below will have the opportunity to take part in the study. Participants will have the right to withdraw from the study at any point.

Inclusion Criteria
Hospital dwelling patients admitted with stroke medically stable and <3 months post stroke (confirmed by CT or MRI scan)
Cognitive and communication functions adequate to understand study participation (ability to repeat back what he/she understands about the study after education provided)
All levels of mobility will be eligible to participate

Exclusion Criteria
Medical instability including, oxygen dependent, angina, unstable cardiac conditions, un-controlled diabetes mellitus, major medical conditions, claudication, febrile illness. All of the above are to ensure safe exercise testing.
Prescribed Beta-Blocker medication
Modified Rankin Score >5 (Appendix 3): severe disability would inhibit participation in this study as patients in this category are bed ridden and would be unable to complete the cycle ergometry program

Measurements/Outcome Measures
-Baseline descriptives including stroke subgroup classification, age, sex, co-morbidities, smoking history, Modified Rankin Scale (Appendix 3), NIHSS Score(Appendix 1), medical history, medications and previous cardiac events will be noted from each participant’s medical chart
-Baseline resting heart rate (HR) and heart rate will be recorded during the aerobic training protocol.
-BORG level of Perceived Exertion will be recorded every minute during the aerobic training protocol.
-Physical activity levels pre-stroke assessed by questionnaire (Appendix 10)

Aerobic training programme
The testing procedure will be conducted as described in Appendix 7. All subjects in the study will be in receipt of an individualised physiotherapy treatment as per usual care which will focus on functional activities, balance and gait and an aerobic component.

Subjects will undergo familiarisation with the cycle ergometer (Motomed Viva 2) three times, if this has not already been done so as part of their normal care. Participants will also practice using the BORG scale of Perceived Exertion during the practice trials. Resistance and speed will be adjusted as indicated until the participant rates themselves to be working at level 14 on the BORG Scale (between hard and somewhat hard). When a participant indicates that they are at level 14 resistance will no longer be increased and the participant will be advised to maintain this level of exertion by slowing their pedalling if required. After every minute of training subjects will be asked to rate their exertion level by looking at the BORG Scale and their heart rate will be noted. As subjects will be asked to exercise to a maximum level of 14 on the BORG (as recommended by The American Stroke Association) the study procedure does not involve pushing the participant beyond the limits of normal care.

All interventions will be supervised by a physiotherapist. Staff will have cardiac resuscitation and defibrillation certification. Indications to cease exercising will include chest pain, dizziness, malaise, heart rate in excess of 60% maximal heart rate, or the participant requests to stop in accordance with AHA guidelines (ACC/AHA Guidelines for Exercise Testing: Executive Summary, 2014).

B9. Provide information on the statistical approach to be used in the analysis of your results (if appropriate) / source of any statistical advice.
Baseline characteristics will be described using descriptive statistics. Mean (standard deviation) will be used to describe continuous data and frequency (percentage) to describe categorical data. Association between BORG levels reported and Heart Rate Reserve levels achieved will be analysed using The Pearson Product Moment Correlation.
Association between baseline characteristics and heart rate reserve level achieved will be analysed using the Pearson Product Moment Correlation calculation for parametric testing.

B10 (a) Please justify the proposed sample size and provide details of its calculation (including minimum clinically important difference).
The proposed sample size is calculated based on a significance p value of 0.05, a power of 0.8 and a minimum correlation coefficient rho of 0.5 which gives a value of 24. To allow for a dropout rate of 20% the total sample size for recruitment is n=29 (Machin et al, 1997). Hicks (2009) states that a coefficient rho of at least 0.5 represents a moderate correlation and therefore this value was chosen.
B10 (b) Where sample size calculation is impossible (e.g. it is a pilot study and previous studies cannot be used to provide the required estimates) then please explain why the sample size to be used has been chosen.

Answer

B11. How many research participants are to be recruited in total?

29

B12 (a) How many research participants are to be recruited in each study group (where applicable)? Please complete the following table (where applicable).

Not applicable

<table>
<thead>
<tr>
<th>Name of Study Group:</th>
<th>Name of Study Group:</th>
<th>Name of Study Group:</th>
<th>Name of Study Group:</th>
<th>Name of Study Group:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Answer</td>
<td>Answer</td>
<td>Answer</td>
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<td>Answer</td>
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<tr>
<td>Number of Participants in this Study Group:</td>
<td>Number of Participants in this Study Group:</td>
<td>Number of Participants in this Study Group:</td>
<td>Number of Participants in this Study Group:</td>
<td>Number of Participants in this Study Group:</td>
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<td>Answer</td>
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<td>Answer</td>
</tr>
</tbody>
</table>

B12 (b) Please provide details on the method of randomisation (where applicable).

Not Applicable

B13. How many research participants are to be recruited at each study site (where applicable)? Please complete the following table.

<table>
<thead>
<tr>
<th>Site:</th>
<th>Number of Research Participants at this site:</th>
</tr>
</thead>
<tbody>
<tr>
<td>TALLAGHT HOSPITAL</td>
<td>29</td>
</tr>
</tbody>
</table>

SECTION C STUDY PARTICIPANTS

SECTION C IS MANDATORY

C1 PARTICIPANTS – SELECTION AND RECRUITMENT

C1.1 How will the participants in the study be selected?

All patients admitted to the Stroke Unit in Tallaght Hospital will be screened for suitability using the inclusion criteria by a gate keeper (the Senior Stroke Physiotherapist).

C1.2 How will the participants in the study be recruited?

The patients will be consecutively recruited from the Stroke Unit in Tallaght Hospital, when a patient is admitted they will be screened for suitability for inclusion by a gate keeper (the Senior Stroke Physiotherapist). Patients will be approached by the gatekeeper to determine if they wish to participate, each patient will be provided with an information pack containing a participant information leaflet and consent form (Appendix 2). Participants will be given time to think about whether they want to participate.
All patients who meet the inclusion criteria for the study outlined below will have the opportunity to take part in the study. Participants will have the right to withdraw from the study at any point.

C1.3 What are the inclusion criteria for research participants? (Please justify, where necessary)

- Hospital dwelling patients admitted with stroke medically stable and <3 months post stroke (confirmed by CT or MRI scan)
- Cognitive and communication functions adequate to understand study participation (ability to repeat back what he/she understands about the study after education provided)
- All levels of mobility will be eligible to participate

C1.4 What are the exclusion criteria for research participants? (Please justify, where necessary)

<table>
<thead>
<tr>
<th>Exclusion Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical instability including, oxygen dependent, angina, unstable cardiac conditions, un-controlled diabetes mellitus, major medical conditions, claudication, febrile illness. All of the above are to ensure safe exercise testing.</td>
</tr>
<tr>
<td>Prescribed Beta-Blocker medication</td>
</tr>
<tr>
<td>Modified Rankin Score &gt;5 (Appendix 4): severe disability would inhibit participation in this study as patients in this category are bed ridden and would be unable to complete the cycle ergometry program</td>
</tr>
</tbody>
</table>

C1.5 Will any participants recruited to this research study be simultaneously involved in any other research project? Not to my knowledge

C2 PARTICIPANTS – INFORMED CONSENT

C2.1 (a) Will informed consent be obtained? Yes

C2.1 (b) If no, please justify. You must provide a full and detailed explanation as to why informed consent will not be obtained.

Answer

C2.1 (c) If yes, please outline the consent process in full. (How will consent be obtained, when, by whom and from whom etc.)

Each potential participant will be provided with an information pack containing a participant information leaflet and consent form (Appendix 2) by the gate keeper who will be the senior physiotherapist in the stroke unit. The gate keeper will provide verbal and written information regarding the study. Participants will be given at least 24 hours to think about whether they want to participate. The gate keeper will then return to the participant and ask the patient to repeat back what they understand of the study procedure and testing. The gate keeper will then gain consent from the patient to be included. Participants will have the right to withdraw from the study at any point.

C2.2 (a) Will participants be informed of their right to refuse to participate and their right to withdraw from this research study? Yes

C2.2 (b) If no, please justify.

Answer

C2.3 (a) Will there be a time interval between giving information and seeking consent? Yes

C2.3 (b) If yes, please elaborate.
Participants will be given at least 24 hours between receiving the information pack and being asked if they wish to participate in the study.

C2.3 (c) If no, please justify and explain why an instantaneous decision is reasonable having regard to the rights of the prospective research participants and the risks of the study.

Answer

C3 ADULT PARTICIPANTS (AGED 18 OR OVER) - CAPACITY

C3.1 (a) Will all adult research participants have the capacity to give informed consent? **Yes**

If answer is **Yes**, please delete remaining questions in Section C3

C4 PARTICIPANTS UNDER THE AGE OF 18

C4.1 (a) Will any research participants be under the age of 18 i.e. Children? **No**

If answer is **No**, please delete remaining questions in Section C4

C5 PARTICIPANTS - CHECKLIST

C5.1 Please confirm if persons from any of the following groups will participate in this study. This is a quick checklist to assist research ethics committee members and to identify whether study participants include persons from vulnerable groups and to establish what special arrangements, if any, have been made to deal with issues of consent. It is recognised that not all groups in this listing will automatically be vulnerable or lacking in capacity. Please refer to the HSE’s National Consent Policy, particularly Part 3, Section 5.

Committees are particularly interested to know if persons in any of these groups are being targeted for inclusion, as per the inclusion criteria.

(a) Healthy Volunteers **No**

(b) Patients **Yes**

- Unconscious patients **No**
- Current psychiatric in-patients **No**
- Patients in an emergency medical setting **No**

(c) Relatives / Carers of patients **No**

(d) Persons in dependent or unequal relationships **No**

- Students **No**
- Employees / staff members **No**
- Persons in residential care **No**
- Persons highly dependent on medical care **No**
(e) Intellectually impaired persons [No]

(f) Persons with a life-limiting condition [No]
(Please refer to guidance manual for definition)

(g) Persons with an acquired brain injury [No]

C5.2 If yes to any of the above, please comment on the vulnerability of the research participants, and outline the special arrangements in recognition of this vulnerability (if any).

The inclusion criteria state that participants must have the ability to give informed consent. It will be explained verbally and in writing on the participant information leaflet that participants have the right to refuse to participate and that this will not affect their standard care. A time period of at least 24 hours between providing information about the study and gaining consent will allow the participant to think their decision through and address any concerns in order to make an informed decision to participate. Medical consent will also be obtained for all the participants prior to participation in the study.

C5.3 Please comment on whether women of child-bearing potential, breastfeeding mothers, or pregnant women will be included or excluded in this research study.

Not applicable

SECTION D RESEARCH PROCEDURES

SECTION D IS MANDATORY

D1 (a) What activities, procedures or interventions (if any) are research participants asked to undergo or engage in for the purposes of this research study?

Participants will undergo the aerobic training protocol as described previously (Appendix 7) Participants will undergo aerobic training on a cycle ergometer as part of their standard care. During the study intervention, Heart Rate and exertion levels measured by the BORG will be recorded during the training time.

D1 (b) What other activities (if any) are taking place for the purposes of this research study e.g. chart review, sample analysis etc?

Baseline data will be recorded from the patient’s medical chart, this would be done during standard care whether a patient was included in the study or not.

D2. Please provide details below of any potential harm that may result from any of the activities, procedures, interventions or other activities listed above.

While it is reported that cardiac disease occurs in up to 75% of stroke survivors, exertion at the levels used in rehabilitation programmes after stroke is associated with low risk of serious cardiovascular complications (Gordan et al, 2004). The proposed study, which also aims to exercise this population at a moderate i.e. ≤70% of their heart rate reserve, poses a low risk to the participants of adverse events and is within the recommended guidelines of the American Heart Association at 40-70%HRR. This is further supported by a study reporting a low frequency of medical complications during inpatient rehabilitation post stroke (Roth et al, 2001). In a scientific statement on physical activity after stroke the American Heart Association (AHA) recommend the use of aerobic training post stroke to improve cardiovascular risk factors and recommend its use for stroke survivors as part of a comprehensive stroke and cardiovascular risk reduction programme. Participants will be monitored throughout for indications to cease exercising including chest pain, dizziness, malaise or if the participant requests to stop in accordance with American Heart Association (AHA) guidelines. All intervention will be supervised by a physiotherapist. Staff will have cardiac resuscitation and defibrillation certification.

D3. What is the potential benefit that may occur as a result of this study?
Stroke patients may improve their aerobic fitness which may translate into a reduced risk for mortality from stroke and cardiac events. Improved cardiovascular fitness may also improve quality of life. Participation in the intervention also ensures standard of care in line with Irish Stroke Guidelines (2009). Knowledge of the heart rate level achieved using subjective reports of exertion, will allow the treating Physiotherapist to prescribe aerobic exercise to stroke patients at an intensity that is most beneficial to them.

D4 (a) Will the study involve the withholding of treatment?  
No

D4 (b) Will there be any harms that could result from withholding treatment?  
Yes / No

D4 (c) If yes, please elaborate.

D5 (a) How will the health of participants be monitored during the study, and who will be responsible for this?

Measurements of heart rate, blood pressure and oxygen saturation levels will be taken before and after each treatment session. As participants are inpatients they will be reviewed daily by a member of their medical team.

D5 (b) How will the health of participants be monitored after the study, and who will be responsible for this?

Participants will be receiving observation by the nursing and medical team on the hospital ward as they will be inpatients in the stroke unit.

D6 (a) Will the interventions provided during the study be available if needed after the termination of the study?  
Yes

D6 (b) If yes, please state the intervention you are referring to and state who will bear the cost of provision of this intervention?

Cycle ergometry will be available after the termination of the study. This bears no additional cost as the physiotherapy gym is equipped with two cycle ergometers.

D7. Please comment on how individual results will be managed.

A brief synopsis of the participant’s outcome measures and aerobic training programme will be documented in the medical chart.

D8. Please comment on how aggregated study results will be made available.

Results will be presented at departmental and hospital study days and at national conferences and submitted for publication.

D9. Will the research participant’s general practitioner be informed that the research participant is taking part in the study (if appropriate)?  
Non-applicable

D10. Will the research participant’s hospital consultant be informed that the research participant is taking part in the study (if appropriate)?  
Yes

SECTION E DATA PROTECTION

SECTION E IS MANDATORY
E1  DATA PROCESSING - CONSENT

E1.1 (a) Will consent be sought for the processing of data? Yes

E1.1 (b) If no, please elaborate.

Answer

E2  DATA PROCESSING - GENERAL

E2.1 Who will have access to the data which is collected?

The hard copies of the data will be stored in a locked filing cabinet in the physiotherapy department where the principal investigator and the physiotherapy manager will have access to. All electronic data will be coded and stored on the principal investigators password protected computer in the Physiotherapy Department. The principal investigator and the research supervisor (Prof. Marie Guidon) will have access to the coded data.

E2.2 What media of data will be collected?

Computerised spreadsheets and hard copy paper forms

E2.3 (a) Would you class the data collected in this study as anonymous, irrevocably anonymised, pseudonymised, coded or identifiable data?

Coded

E2.3 (b) If ‘coded’, please confirm who will retain the ‘key’ to re-identify the data?

The principle investigator and the ‘key’ will remain in Tallaght hospital and be held on a password protected computer, separately from the original data

E2.4 Where will data which is collected be stored?

Electronic data will be stored on a password protected computer in the physiotherapy department. Hard copies will be held in a locked cabinet in the physiotherapy department, where the principal investigator and the physiotherapy manager will have access only.

E2.5 Please comment on security measures which have been put in place to ensure the security of collected data.

All data will be coded and stored in a locked filing cabinet or password protected laptop as described above.

E2.6 (a) Will data collected be at any stage leaving the site(s) of origin?

No

E2.6 (b) If yes, please elaborate.

Answer

E2.7 Where will data analysis take place and who will perform data analysis (if known)?

In Tallaght Hospital by the Principal Investigator

E2.8 (a) After data analysis has taken place, will data be destroyed or retained?
Retained and destroyed

E2.8 (b) Please elaborate.

Clinical data will be retained as part participant healthcare records as be routine clinical practice. Research data will be destroyed.

E2.8 (c) If destroyed, how, when and by whom will it be destroyed?

The Principal Investigator. Hard copies will be shredded and computer data will be deleted.

E2.8 (d) If retained, for how long, for what purpose, and where will it be retained?

Hard data in a locked filing cabinet in the physiotherapy department, electronic data on a password protected computer in the physiotherapy department for five years after the period of data collection. This timeframe is stipulated by the Royal College of Surgeons in Ireland with respect to good research practice when conducting a research study.

E2.9 Please comment on the confidentiality of collected data.

Participants will be allocated a reference code
Names and details that may identify participants will be removed
Use of codes will only be meaningful to the principal investigator
All data collected will be saved in limited access computer files
All written documentation will be held in secured filing cabinets
Access to study data will be restricted to the principal investigator and the supervisor involved in the study only.

E2.10 (a) Will any of the interview data collected consist of audio recordings / video recordings? **No**

E2.10 (b) If yes, will participants be given the opportunity to review and amend transcripts of the tapes?

Answer

E2.11 (a) Will any of the study data collected consist of photographs/ video recordings? **No**

E2.11 (b) If yes, please elaborate.

Answer

**E3 ACCESS TO HEALTHCARE RECORDS**

E3.1 (a) Does the study involve access to healthcare records (hard copy / electronic)? **Yes**

If answer is **No**, please delete remaining questions in Section E3

E3.1 (b) If yes, please elaborate.

Access to medical charts to obtain information on participant’s medical history is part of routine medical care

E3.1 (c) Who will access these healthcare records?

Answer
E3.1 (d) Will consent be sought from patients for research team members to access their healthcare records? **No**

If answer is **Yes**, please delete remaining questions in Section E3

E3.2 (a) Who or what legal entity is the data controller in respect of the healthcare records?

**Tallaght Hospital**

E3.2 (b) What measures have been put in place by the data controller which may make access to healthcare records permissible without consent?

**Access to healthcare records is part of routine care**

---

SECTION F HUMAN BIOLOGICAL MATERIAL

F1 BODILY TISSUE / BODILY FLUID SAMPLES - GENERAL

F1 1 (a) Does this study involve human biological material? **No**

If the answer is **No**, please delete Section F

F2 BODILY TISSUE / BODILY FLUID SAMPLES PROSPECTIVELY COLLECTED

F2.1 Does this study involve the prospective collection of human biological material? **Yes**

F2.2 Please state the type of human biological material which is being prospectively collected.

Answer

F2.3 Who or what institution will be the custodian of the prospectively collected human biological material?

Answer

F2.4 (a) Will the human biological material be collected as part of routine clinical care? **Yes / No**

F2.4 (b) Will the human biological material be collected specifically for the purposes of this research study? **Yes / No**

F2.4 (c) With reference to your responses to question F2.4 (a), F2.4 (b), please provide more detail, in particular, in relation to whether participants will be consented to the taking of a sample or to the use of a sample (or part of a sample) which will be taken anyway for clinical reasons.

Answer

F2.5 (a) With respect to human biological material which it is proposed to prospectively collect for the purposes of this research study, after the laboratory analysis which this research study involves, will any human biological material remain? **Yes / No**

F2.5 (b) If yes, will this remaining biological material be retained? **Yes / No**
F2.5 (c) If yes, for how long and where will samples be retained?
Answer

F2.5 (d) If yes, for what purpose will samples be retained?
Answer

F2.5 (e) If yes, please comment on consent for retention of biological material.
Answer

F2.5 (f) If yes, will this human biological material and/or any data derived from it be used for any other purpose (including future research projects)?  Yes / No

F2.5 (g) If yes, please comment on consent for future use of human biological material.
Answer

F2.6 (a) Will the human biological material be collected specifically for the purposes of depositing this human biological material in a biobank?  Yes / No

F2.6 (b) If yes, please provide specific information in relation to this proposed biobank.
Answer

F2.6 (c) If yes, will research participants be informed in all information leaflets and consent forms that this is a biobank?
Answer

F3  BODILY TISSUE / BODILY FLUID SAMPLES RETROSPECTIVELY COLLECTED

SECTION G RADIATION

G1  RADIATION – GENERAL

G1.1  (a) Does this study/trial involve exposure to radiation?  No

If answer is No, please delete remaining questions in Section G

SECTION H MEDICAL DEVICES

H1 (a) Is the focus of this study/trial to investigate/evaluate a medical device?  No

If answer is No, please delete remaining questions in Section H.
SECTION I MEDICINAL PRODUCTS / COSMETICS / FOOD AND FOODSTUFFS

I.1 NON-INTERVENTIONAL TRIALS OF MEDICINAL PRODUCTS

I1.1 (a) Does this study involve a medicinal product? **No**

If the answer is **No**, please delete remaining questions in subsection I1

I.2 COSMETICS

I2.1 (a) Does this study involve a cosmetic? **No**

If the answer is **No**, please delete remaining questions in subsection I2

I.3 FOOD AND FOOD SUPPLEMENTS

I3.1 (a) Does this study involve food or food supplements? **No**

If the answer is **No**, please delete remaining questions in subsection I3

SECTION J INDEMNITY AND INSURANCE

SECTION J IS MANDATORY

J1 Please confirm and provide evidence that appropriate insurance/indemnity is in place for this research study at each site.

Yes- Tallaght Hospital is covered by the Clinical Indemnity Scheme. The study supervisor is covered by the RCSI indemnity policy

J2 Please confirm and provide evidence that appropriate insurance/indemnity is in place for this research study for each investigator.

The principal investigator carrying out this research is an employee of AMNCH and a qualified physiotherapist. She is covered by the indemnity of Tallaght Hospital.

J3.1 Please give the name and address of the organisation / or individual legally responsible for this research study?

The Royal College of Surgeons in Ireland
123 St. Stephens Green
Dublin 2

J3.2 Where an organisation is legally responsible, please specify if this organisation is:

A university **Yes**
Other **Yes / No** If yes, please specify: Answer
J3.3 Please confirm and provide evidence of any specific additional insurance / indemnity arrangements which have been put in place, if any, by this organisation / or individual for this research study?

This research study is conducted in part fulfilment of the requirements of a Masters in Neurology and Gerontology from the Royal College of Surgeons in Ireland. The researcher, a registered student at RCSI is also covered by the indemnity provided by RCSI.

SECTION K COST AND RESOURCE IMPLICATIONS, FUNDING AND PAYMENTS

SECTION K IS MANDATORY

K1 COST AND RESOURCE IMPLICATIONS

K1.1 Please provide details of all cost / resource implications related to this study (e.g. staff time, office use, telephone / printing costs etc.)

Participants undergo aerobic training as part of routine care so no extra staff resources will be required. Participant Information Leaflets will be printed at the Principal Investigators own expense.

K2 FUNDING

K2.1 (a) Is funding in place to conduct this study?  

No

K2.1 (b) If no, has funding been sought to conduct this study?  From where? Please elaborate.  

No

K2.1 (c) If yes, please state the source of funding (industry, grant or other), the name of the funder, the amount of funding and duration of funding.

<table>
<thead>
<tr>
<th>Source of funding (industry, grant or other):</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of Funder:</td>
<td>Answer</td>
</tr>
<tr>
<td>Amount of Funding:</td>
<td>Answer</td>
</tr>
<tr>
<td>Duration of Funding</td>
<td>Answer</td>
</tr>
</tbody>
</table>

K2.1(d) Please provide additional details in relation to management of funds.  

Answer

K2.1(e) Is the study funded by a ‘for profit’ organisation?  

No

K2.2 (a) Do any conflicts of interest exist in relation to funding or potential funding?  

No

K2.2 (b) If yes, please elaborate.  

Answer
K3  PAYMENTS TO INVESTIGATORS

K3.1 (a) Will any payments (monetary or otherwise) be made to investigators? No

K3.1 (b) If yes, please provide details of payments (including amount).

Answer

K4  PAYMENTS TO PARTICIPANTS

K4.1 (a) Will any payments / reimbursements (monetary or otherwise) be made to participants? No

K4.1 (b) If yes, please provide details of payments / reimbursements (including amount).

Answer

SECTION L ADDITIONAL ETHICAL ISSUES

L1 (a) Does this project raise any additional ethical issues? No

If answer is No, please delete remaining questions in Section L.

L1 (b) If yes, please identify any particular additional ethical issues that this project raises and discuss how you have addressed them.

Answer

PLEASE ENSURE THIS APPLICATION FORM IS FULLY COMPLETED AS INCOMPLETE SUBMISSIONS WILL NOT BE REVIEWED.
Ms. Carla Spring  
Physiotherapist  
Physiotherapy Department  
Tallaght Hospital  
Dublin 24

31st August 2015

Re: An Investigation of the Association between Perceived Exertion and Heart Rate in Individuals Post Stroke

REC Reference: 2015-08 Chairman’s Action (15)  
(Please quote reference on all correspondence)

Dear Ms. Spring,

Thank you for your recent application to SJH/AMNCH Research Ethics Committee in which you requested approval for the above referenced study.

The Chairman, on behalf of the Research Ethics Committee has reviewed this application and has granted ethical approval.

The following documents were reviewed and approved:

- Completed ethics application form for the above named Study  
- Patient Information Leaflet  
- Patient Consent Form

Yours sincerely,

Claire

Hartin
Secretary  
SJH/AMNCH Research Ethics Committee
Appendix 5 RCSI Ethics Approval

Royal College of Surgeons in Ireland
The Research Ethics Committee
121 St. Stephens Green, Dublin 2, Ireland.
Tel: +353 1 4022205  Email: recadmin@rcsi.ie

Dr David Smith, Acting Chair
Dr Niamh Clarke, Convenor

29th October 2015

Ms Carla Spring
Physiotherapy Department
Tallaght Hospital,
Tallaght,
Dublin 24

Ethics Reference No: 1171 (accepted from Tallaght Hospital)

Project Title: An Investigation of the Association between Perceived Exertion and Heart Rate in Individuals Post Stroke

Researchers Name (lead applicant & PI) Ms Carla Spring

Other Individuals Involved: Academic supervisor Prof Marie Guidon (RCSI School of Physiotherapy)

Dear Ms Spring,
Thank you for your Research Ethics Committee (REC) application. The RCSI HREC accepts the ethical approval granted by SJH/AMNCH Tallaght Hospital REC for the research study (details above) submitted by Ms Carla Spring.

This letter provides approval for data collection for the time requested in your application and for an additional 6 months. This is to allow for any unexpected delays in proceeding with data collection. Therefore this research ethics approval will expire on 29th December 2016.

Where data collection is necessary beyond this point, approval for an extension must be sought from the Research Ethics Committee.

This ethical approval is given on the understanding that:

- All personnel listed in the approved application have read, understand and are thoroughly familiar with all aspects of the study.
- Any significant change which occurs in connection with this study and/or which may alter its ethical consideration must be reported immediately to the REC, and an ethical amendment submitted where appropriate.
- Please submit a final report to the REC upon completion of your project.

We wish you all the best with your research.

Yours sincerely,

PP Dr Niamh Clarke (Convenor)
Dr David Smith (Acting Chair)
Appendix 6: Data Collection Form

Name: ___________________________ MRN: ________________

Baseline Data

Age:

Sex:

Date of Stroke:

Lesion Location: Left/Right

Classification of Stroke:

Co-Morbidities:

Record all co-morbidities initially and then categorise

Smoking History:

Medications:

Mobility Status Prior to Stroke:

NIHSS Score:

Modified Rankin Score
Data Collection Form

Resting HR:
HRR 40% :
HRR 50% :
HRR 60% :

Outer limit of test RPE of 14

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>HR</th>
<th>% HRR</th>
<th>RPE (6-20)</th>
<th>Comments/Appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm up (3 minutes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
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<td>2</td>
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<td>10</td>
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</tr>
<tr>
<td>Cool down (2 minutes)</td>
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<td></td>
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</tr>
</tbody>
</table>

Total Time of Test: ___________ min

Reason for Ending Test:

Date:
Signature:
Appendix 7: NIH – Stroke scale (NIHSS)

Date and time  DD-MM-YYYY  HH:MM (24h)

1.a. Level of Consciousness  0: Alert  1: Not alert, but arousable with minimal stimulation

2: Not alert, requires repeated stimulation to attend  3: Coma

1.b. LOC questions (Ask patient the month and her/his age)

0: Answers both correctly   1: Answers one correctly   2: Both incorrect

1.c. LOC commands (Ask patient to open/close eyes & form/release fist)

0: Obeys both correctly   1: Obeys one correctly   2: Both incorrect

2. Best gaze (only horizontal eye movement)  0: Normal   1: Partial gaze palsy   2: Total gaze paresis or Forced deviation

3. Visual Field testing  0: No visual field loss   1: Partial hemianopia   2: Complete hemianopia   3: Bilateral hemianopia (blind including cortical blindness)

4. Facial Paresis (Ask patient to show teeth/ raise eyebrows & close eyes tightly)  0: Normal symmetrical movement   1: Minor paralysis (flattened nasolabial fold, asymmetry on smiling)   2: Partial paralysis (total or near total paralysis of lower face)   3: Complete paralysis of one or both sides (absence of facial movement in the upper and lower face)

5. Motor Function – Arm
0: Normal (extends arms 900 (or 450) for 10 seconds without drift)  1: Drift  2: Some effort against gravity  3: No effort against gravity  4: No movement  9: Untestable (Joint fused or limb amputated) (do not add score)  Right  Left

6. Motor Function - Leg  0: Normal (hold leg in 300 position for 5 sec without drift)  1: Drift  2: Some effort against gravity  3: No effort against gravity  4: No movement  9: Untestable (Joint fused or limb amputated) (do not add score)  Right  Left

7. Limb Ataxia  0: No ataxia  1: Present in one limb  2: Present in two limbs

8. Sensory (Use pinprick to test arms, legs, trunk and face - compare side to side)  0: Normal  1: Mild to moderate decrease in sensation  2: Severe to total sensory loss

9. Best Language (Ask patient to describe picture, name items, read sentences)  0: No aphasia  1: Mild to moderate aphasia  2: Severe aphasia  3: Mute

10. Dysarthria (Ask patient to read several words)  0: Normal articulation  1: Mild to moderate slurring of words  2: Near unintelligible or unable to speak  9: Intubated or other physical barrier (do not add score)

11. Extinction and inattention (Formerly Neglect) (Use visual or sensory double stimulation)  0: Normal  1: Inattention or extinction to bilateral simultaneous stimulation in one of the sensory modalities  2: Severe hemi-inattention or hemi-inattention to more than one modality

Total Score:
Appendix 8 Physical Activity Questionnaire for the Elderly

INSTRUCTIONS:
Please complete this questionnaire by either circling the correct response or filling in the blank. Here is an example:
During the past 7 days, how often have you seen the sun?
[0.] NEVER [1.] SELDOM [2.] SOMETIMES [3.] OFTEN (1-2 DAYS) (3-4 DAYS) (5-7 DAYS)
Answer all items as accurately as possible. All information is strictly confidential.

LEISURE TIME ACTIVITY

1. Over the past 7 days, how often did you participate in sitting activities such as reading, watching TV or doing handcrafts?
[0.] NEVER [1.] SELDOM [2.] SOMETIMES [3.] OFTEN (1-2 DAYS) (3-4 DAYS) (5-7 DAYS) GO TO Q.#2  □ □ □
1a. What were these activities?
_________________________________________________
1b. On average, how many hours per day did you engage in these sitting activities?
[1.] LESS THAN 1 HOUR [2.] 1 BUT LESS THAN 2 HOURS
[3.] 2-4 HOURS [4.] MORE THAN 4 HOURS

2. Over the past 7 days, how often did you take a walk outside your home or yard for any reason? For example, for fun or exercise, walking to work, walking the dog, etc.?
[0.] NEVER [1.] SELDOM [2.] SOMETIMES [3.] OFTEN (1-2 DAYS) (3-4 DAYS) (5-7 DAYS) GO TO Q.#3 □ □ □
2a. On average, how many hours per day did you spend walking?
[1.] LESS THAN 1 HOUR [2.] 1 BUT LESS THAN 2 HOURS
[3.] 2-4 HOURS [4.] MORE THAN 4 HOURS

3. Over the past 7 days, how often did you engage in light sport or recreational activities such as bowling, golf with a cart, shuffleboard, fishing from a boat or pier or other similar activities?
[0.] NEVER [1.] SELDOM [2.] SOMETIMES [3.] OFTEN (1-2 DAYS) (3-4 DAYS) (5-7 DAYS) GO TO Q.#4 □ □ □
3a. What were these activities?
_________________________________________________
3b. On average, how many hours per day did you engage in these light sport or recreational activities?
[1.] LESS THAN 1 HOUR [2.] 1 BUT LESS THAN 2 HOURS
[3.] 2-4 HOURS [4.] MORE THAN 4 HOURS
4. Over the past 7 days, how often did you engage in moderate sport and recreational activities such as doubles tennis, ballroom dancing, hunting, ice skating, golf without a cart, softball or other similar activities?

[0.] NEVER [1.] SELLDOM [2.] SOMETIMES [3.] OFTEN □ (1-2 DAYS) (3-4 DAYS)
(5-7 DAYS) GO TO Q.#5 □ □ □

4a. What were these activities?

4b. On average, how many hours per day did you engage in these moderate sport and recreational activities?

[1.] LESS THAN 1 HOUR [2.] 1 BUT LESS THAN 2 HOURS
[3.] 2-4 HOURS [4.] MORE THAN 4 HOURS

5. Over the past 7 days, how often did you engage in strenuous sport and recreational activities such as jogging, swimming, cycling, singles tennis, aerobic dance, skiing (downhill or cross-country) or other similar activities?

[0.] NEVER [1.] SELLDOM [2.] SOMETIMES [3.] OFTEN □ (1-2 DAYS) (3-4 DAYS)
(5-7 DAYS) GO TO Q.#6 □ □ □

5a. What were these activities?

5b. On average, how many hours per day did you engage in these strenuous sport and recreational activities?

[1.] LESS THAN 1 HOUR [2.] 1 BUT LESS THAN 2 HOURS
[3.] 2-4 HOURS [4.] MORE THAN 4 HOURS

6. Over the past 7 days, how often did you do any exercises specifically to increase muscle strength and endurance, such as lifting weights or pushups, etc.?

[0.] NEVER [1.] SELLDOM [2.] SOMETIMES [3.] OFTEN □ (1-2 DAYS) (3-4 DAYS)
(5-7 DAYS) GO TO Q.#7 □ □ □

6a. What were these activities? ______________________________________

6b. On average, how many hours per day did you engage in exercises to increase muscle strength and endurance?

[1.] LESS THAN 1 HOUR [2.] 1 BUT LESS THAN 2 HOURS
[3.] 2-4 HOURS [4.] MORE THAN 4 HOURS

HOUSEHOLD ACTIVITY

7. During the past 7 days, have you done any light housework, such as dusting or washing dishes?

[1.] NO [2.] YES

8. During the past 7 days, have you done any heavy housework or chores, such as vacuuming, scrubbing floors, washing windows, or carrying wood?

[1.] NO [2.] YES

9. During the past 7 days, did you engage in any of the following activities?
Please answer YES or NO for each item.

NO YES

a. Home repairs like painting, wallpapering, electrical work, etc. 1 2
b. Lawn work or yard care, including snow or leaf removal, wood chopping, etc.
c. Outdoor gardening 1 2
d. Caring for an other person, such as children, dependent spouse, or an other adult

WORK-RELATED ACTIVITY

10. During the past 7 days, did you work for pay or as a volunteer?

[1.] NO [2.] YES

10a. How many hours per week did you work for pay and/or as a volunteer?

_______________ HOURS

10b. Which of the following categories best describes the amount of physical activity required on your job and/or volunteer work?

[1] Mainly sitting with slight arm movements. [Examples: office worker, watchmaker, seated assembly line worker, bus driver, etc.]
[2] Sitting or standing with some walking. [Examples: cashier, general office worker, light tool and machinery worker.]
[3] Walking, with some handling of materials generally weighing less than 50 pounds. [Examples: mailman, waiter/waitress, construction worker, heavy tool and machinery worker.]
[4] Walking and heavy manual work often requiring handling of materials weighing over 50 pounds. [Examples: lumberjack, stone mason, farm or general labourer.]
Appendix 9 Testing Instructions

Instructions

Do NOT proceed with test if the participant has any of the absolute contraindications to exercise as per the ACSM guidelines. Referral to the medical team may be warranted if the above conditions are found.

1. Describe use of Borg RPE (6-20) scale to the participant. Explain that “During the test, we want you to pay close attention to how you feel about your total inner feeling of exertion, combining all sensations of physical stress, effort, and fatigue. Try not to over- or underestimate your feelings of exertion; be as accurate as you can.”

2. Explain that the participant should work at a comfortable level throughout the test with regard to both intensity and duration and that the test can be stopped at any time.

3. Have the client sit for five minutes prior to testing and complete chart for the resting HR values and HRR values.

4. Warm up for 3 minutes at very low resistance (level 0) in order to acquaint the client with the cycle ergometer and explain that the aim is to have the client keep at a steady rate for the duration of the entire test. The client should select a comfortable rate that could be maintained even as resistance is increased (guideline: >50 rpm). Record the warm-up readings.

5. At the end of 3 minutes increase gear by 1 every 30 seconds as tolerated until a Borg level of 14 is achieved, maintain this level with a constant speed/resistance. It is possible that for some participants, the RPE may continue to rise without increasing the workload. The workload should be decreased or the participant prompted to reduce speed to remain at Borg level 14.

6. Record the RPE and HR at the end of every minute. Client appearance and symptoms are monitored regularly and should be noted in the comments boxes of the data collection form.

7. After ten minutes of the exercise period the gear should be reduced gradually for a two minute cool down period.
General Procedures for Submaximal Testing of Cardiorespiratory Fitness

1. Obtain resting HR and BP immediately prior to exercise in the exercise posture.
2. The client should be familiarized with the ergometer. If using a cycle ergometer, properly position the client on the ergometer (i.e., upright posture, ~25-degree bend in the knee at maximal leg extension, and hands in proper position on handlebars) (81–83).
3. The exercise test should begin with a 2–3 min warm-up to acquaint the client with the cycle ergometer and prepare him or her for the exercise intensity in the first stage of the test.
4. A specific protocol should consist of 2- or 3-min stages with appropriate increments in work rate.
5. HR should be monitored at least two times during each stage, near the end of the second and third minutes of each stage. If HR is >110 beats \( \cdot \) min\(^{-1}\), steady state HR (i.e., two HRs within 5 beats \( \cdot \) min\(^{-1}\)) should be reached before the workload is increased.
6. BP should be monitored in the last minute of each stage and repeated (verified) in the event of a hypotensive or hypertensive response.
7. RPE (using either the Borg category or category-ratio scale [see Table 4.7]) and additional rating scales should be monitored near the end of the last minute of each stage.
8. Client’s appearance and symptoms should be monitored and recorded regularly.
9. The test should be terminated when the subject reaches 70% heart rate reserve (85% of age-predicted \( HR_{\text{max}} \)), fails to conform to the exercise test protocol, experiences adverse signs or symptoms, requests to stop, or experiences an emergency situation.
10. An appropriate cool-down/recovery period should be initiated consisting of either
   a. continued exercise at a work rate equivalent to that of the first stage of the exercise test protocol or lower or
   b. a passive cool-down if the subject experiences signs of discomfort or an emergency situation occurs
11. All physiologic observations (e.g., HR, BP, signs and symptoms) should be continued for at least 5 min of recovery unless abnormal responses occur, which would warrant a longer posttest surveillance period. Continue low-level exercise until HR and BP stabilize, but not necessarily until they reach preexercise levels.

BP, blood pressure; HR, heart rate; \( HR_{\text{max}} \), maximal heart rate; RPE, rating of perceived exertion.
Appendix 11

The Karvonen formula uses the heart rate reserve to calculate training zones based on both maximum AND resting heart rate. Here’s the actual formula:

<table>
<thead>
<tr>
<th>Calculating Target Heart Rate with the Karvonen Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 220 – age = maximum heart rate</td>
</tr>
<tr>
<td>• Maximum heart rate – resting heart rate = heart rate</td>
</tr>
<tr>
<td>reserve</td>
</tr>
<tr>
<td>• (Heart rate reserve x training%) + resting heart rate</td>
</tr>
</tbody>
</table>

An example for a 50-year-old with a resting heart rate of 65 bpm who wants to train at 70% maximum:

- 220 - 50 = 170 bpm (maximum heart rate)
- 170 - 65 = 105 bpm (heart rate reserve)
- (105 x 0.7) + 65 = 139 bpm

Using the Karvonen formula this person’s target heart rate works out as 139 bpm.
### Appendix 12 Borg Scale of Rate of Perceived Exertion

<table>
<thead>
<tr>
<th>Rating</th>
<th>Perception of effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Very, very light</td>
</tr>
<tr>
<td>7</td>
<td>Very light</td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Very light</td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Fairly light</td>
</tr>
<tr>
<td>12</td>
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</tr>
<tr>
<td>13</td>
<td>Somewhat hard</td>
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<td>14</td>
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<tr>
<td>15</td>
<td>Hard</td>
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</tr>
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<td>18</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Very, very hard</td>
</tr>
<tr>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

From Borg (1973, p. 92). © by Lippincott, Williams & Wilkins. Adapted by permission.