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Journal article

Safety of performing a graded exercise test early after stroke and transient ischemic attack

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Safety of performing a graded exercise test early after stroke and transient ischaemic attack

Abstract

Introduction: Low cardiorespiratory fitness is a predictor of stroke risk and poor outcome post-stroke. Fitness levels are rarely assessed in the acute-phase and it is unclear if it is safe for stroke survivors and people with transient ischaemic attack (TIA) to perform a graded exercise test to assess fitness.

Objective: To determine if people within 14 days post-stroke can safely perform a graded exercise test.

Design: Observational study.

Setting: Research institute

Participants: People with stroke or TIA admitted to an acute stroke unit

Intervention: Not applicable

Main outcome measures: Safety of performing a graded exercise test early post-stroke. Safety outcomes were: 1) occurrence of an adverse event or 2) $<85\%$ blood oxygen saturation (SpO_2). Participants performed a graded exercise test on a recumbent stepper at a research institute <2 weeks post-event. Cardiorespiratory fitness was determined by measuring peak volume of oxygen-uptake (VO_{2peak}) using a metabolic cart.

Results: Twenty-nine participants were enrolled in the study (median age 69 years; interquartile range 58-75). Sixteen were diagnosed with TIA and 13 suffered a mild stroke.

Results: Twenty-eight participants completed the test; one participant was unable to perform the test due to back pain. The test was terminated due to standardised stopping criteria in 26

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cases (5=volitional fatigue, 6=unable to keep required cadence, 15=reaching 85%HR_{max}), one due to safety (i.e. SpO₂ <85%), and one was inadvertently terminated before stopping criteria were reached. Average cardiorespiratory fitness determined by the exercise test was low; mean VO_{2peak} of 16.2±4.5 ml.kg.min⁻¹ for men (n=20) and 12.4±3.6 ml.kg.min⁻¹ for women (n=8).

Conclusions: Determining exercise capacity early post-stroke and TIA using a graded exercise test appears to be safe in patients with mild deficits. This information should be useful to plan tailored exercise programs. Further research should focus on determining safety of exercise testing in more severely affected stroke survivors.

Keywords: Acute stroke, exercise test, cardiorespiratory fitness, exercise.

Introduction

Low cardiorespiratory fitness (CRF) level is a well-established predictor of poor functional and cardiovascular outcomes, and mortality after stroke.[1] CRF levels of people with stroke or transient ischaemic attack (TIA), are low and are estimated at approximately 50% of healthy individuals.[2,3] These low CRF levels remain in the months and years after the event.[4,5] Physical inactivity before[6] and after stroke[7] are related to low levels of CRF. Also, direct effects of the stroke itself (e.g. hemiparesis), and the hospital environment have an impact on physical activity and fitness. Several studies have shown that inpatients spend little time exercising at the required intensity to elicit cardiovascular benefits.[8,9] Low CRF levels of people with stroke or TIA limit their ability to engage in rehabilitation. Furthermore, physical inactivity and low CRF are risk factors for cardiovascular events, which puts people with stroke and TIA[10,11] at a higher risk of recurrent stroke.[12]

Multiple clinical stroke practice guidelines recommend an early initiation of individually-tailored CRF training.[13,14] CRF training can improve fitness, mobility, balance,[15] and cognitive function,[16] and moderates cardiovascular risk profile.[17] It has beneficial effects on metabolic adaptations[3] both in sub-acute (>3 months) and chronic (>6 months) stroke populations. These benefits are relevant to stroke survivors as well as people with TIA since they have similar cardiovascular risk profiles. In a large pre-post study the feasibility of a six month cardio-rehabilitation program for people with mild stroke and TIA (time post-event range 19-285 days) was investigated.[18] The intervention included twice weekly exercise sessions and education on risk factors and nutrition; the program was feasible and safe and participants showed improvements in cardiorespiratory capacity and reduction in cardiovascular risk factors (e.g.

cholesterol and body weight).[18] Whether these exercise benefits can be enhanced by an earlier start to CRF training (i.e. within the first 14 days post-stroke) remains unknown, given that the majority of studies that underpin the effect of CRF on improving fitness primarily include stroke survivors beyond three months of onset. Pre-clinical studies have shown however, that CRF training can benefit neural recovery and neuroplasticity when implemented in the first days of stroke recovery.[19] This early time point might therefore be a window of opportunity for a fitness training intervention.

Despite the known benefits of CRF training, the level of practice intensity during routine physiotherapy sessions in inpatient[9] and outpatient[8] stroke rehabilitation have been shown to be too low to induce a CRF training effect. Our limited knowledge about the safety of exercise training programs for, and the aerobic capacity of, stroke survivors, especially early after stroke onset, may be contributing to this insufficient intensity of therapy. Poor understanding of the exercise capacity of people with stroke or TIA early after the event (i.e. <14 days post-stroke) limits our ability to prescribe CRF training. Submaximal, graded exercise tests have been successfully used to determine exercise capacity in subacute[20,21] and chronic stroke phases.[22,23] When using a graded exercise test to estimate exercise capacity early after stroke and TIA, one is faced by challenges such as stroke-specific impairments (e.g., hemiparesis, impaired muscle coordination) and the presence of pre-existing co-morbid conditions (e.g., atrial fibrillation, chronic obstructive pulmonary disease). Currently it is unclear if people with stroke or TIA can safely perform a graded exercise test early after onset.

We believe that understanding CRF could help clinicians to prescribe a tailored exercise program starting within the first two weeks post stroke or TIA. In this study, our aim was to investigate the safety of performing a submaximal exercise test in people with stroke or TIA within 14 days after onset. We hypothesized that: 1) people with stroke or TIA would be able to safely perform a submaximal test and 2) CRF levels would be low early after stroke. Additionally, to be able to better understand factors that may influence exercise capacity we also explored the relationship between CRF and stroke severity, mood, fatigue and pre-morbid fitness (as determined by a non-exercise estimation of fitness).

Methods

Study design

This was an observational study in which the CRF of people with stroke or TIA was determined using a standardised graded exercise test. Fatigue, mood, quality of life, and premorbid fitness were also measured prior to the exercise test on the same day.

Participants

All participants provided written consent before inclusion in this study, which received ethical approval from the local Ethics Committee. Participants were recruited from the acute stroke ward. People meeting the following criteria were eligible to participate: 1) diagnosis of ischaemic stroke/TIA within the previous 14 days; 2) cognitively able to consent to participate; 3) sufficient English to understand simple verbal commands and complete the assessments; and 4) medically stable as assessed by their attending clinician. Exclusion criteria were based on the American College of Sports Medicine guidelines for exercise testing and prescription and included the

following: 1) evidence of cardiac disease that contraindicates participation in an exercise test (e.g., rapid atrial fibrillation, ventricular tachycardia); 2) other major medical or neurological comorbidities that preclude exercise testing.[24] People with haemorrhagic stroke were excluded given that there is evidence that early initiation of upright mobility training after haemorrhagic stroke may lead to worse outcome.[25]

We determined age, premorbid smoking status, cardiovascular risk factors, number and type of medications, date of stroke or TIA, severity of stroke, side of lesion and hemiparesis, stroke subtype, and disability on admission from the medical records. Stroke severity at the time of testing was assessed using the National Institutes of Health Stroke Severity Scale (NIHSS),[26] which consists of 11 items and severity was classified as: mild (NIHSS < 8), moderate (NIHSS 8 to 16) and severe (NIHSS > 16).[27]

Graded exercise test procedure

The exercise test was performed according to a modified protocol on a total body recumbent stepper (TBRS; NuStep, T5XR, NuStep, Inc., Ann Arbor, MI) as described by Billinger et al (2008).[28] The stepper requires both arm and leg activity in a seated position. Participants began the test with an initial resistance of 25 Watts (W), increasing by 15 W every 2 minutes, stepping at a cadence of 80 steps per minute until one of the termination criteria was reached. The standard termination criteria were: 1) the participant reaches volitional fatigue and requests to end the test; 2) the participant's $VO_{2\text{peak}}$ plateaus or decreases despite continued (or increased) exercise intensity (based on visual inspection of the VO_2 trace during the test); 3) the participant is unable to maintain the stepping cadence; or 4) 85% of age-predicted maximum HR (HR_{max}) is

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achieved ($0.85 [220 - \text{age}]$). For participants who were prescribed beta blocker medication, the percentage of age-predicted HR_{max} was adjusted to 75%.[29] Safety-related criteria for termination, the primary outcome of interest, is described in the Outcome section of the methods.

Prior to the start of the test, participants were familiarised with the movement pattern of the stepper and the required stepping cadence. The participants resting heart rate (HR_{rest}) and blood pressure (BP) were measured after 10 minutes of quiet sitting prior to the test.

We used a portable metabolic cart (Oxycon™ Mobile Device, CareFusion, Sydney, Australia, Pty Ltd) to collect expired respiratory gases through a breath-by-breath pneumotach system connected to gas analysers. Participants wore a face mask (Hans Rudolph Inc., Shawnee, KS) and chest harness (Vyair medical Inc., Jaeger™, Würzburg, Germany), containing the portable gas analysers. The metabolic cart was calibrated as per the manufacturer's instructions before each test. Respiratory gases, volume of oxygen uptake [VO_2] and carbon dioxide production [VCO_2], were sampled breath-by-breath. HR and blood oxygen saturation ($\text{SpO}_2\%$) levels were monitored continuously throughout the test, and subjective measures of intensity were recorded using the rating of perceived exertion (RPE). Participants were asked to rate 'how hard they were working' at the end of every two-minute workload during the test on a Borg scale ranging from 6 (no exertion at all) to 20 (maximal exertion) scale (Borg₆₋₂₀).[30]

Outcomes

Primary outcome

The primary outcome measure was safety of performing an exercise test. The following criteria were defined and the exercise test was terminated if any of the following safety criteria were met:

- occurrence of an adverse cardiovascular event (e.g., cardiac arrest, cyanosis, dizziness, pallor etc.)
- increase of neurological symptoms (e.g., numbness, dizziness, slurred speech etc.) during the test
- blood oxygen saturation of <85%

Any reasons for test termination other than the standard termination criteria or safety reasons were also recorded.

Secondary outcome

The main secondary outcome measure was CRF expressed as peak volume of oxygen consumption (VO_{2peak} ; $ml.kg.min^{-1}$) obtained during the exercise test. We also recorded absolute VO_{2peak} ($L.min^{-1}$), HR_{peak} (bpm), peak respiratory exchange ratio (RER_{peak}) and peak metabolic equivalents of task (MET_{peak}).

We also explored the relationship between CRF (VO_{2peak}) determined by the exercise test and a non-exercise estimate of pre-stroke CRF, age, fatigue, mood and quality of life. These variables were determined before the exercise test using the following measures.

Pre-stroke fitness of the participants was calculated using a formula providing a non-exercise estimation of VO_{2peak} . [31] The estimate uses age, body mass index (BMI) and a physical activity

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levels to predict VO_{2max} . Physical activity levels were estimated using the physical activity rating (PA-R) scale. Participants were asked to rate their general levels of physical activity on an 8-point scale ranging from 0 (do not participate regularly in programmed recreation sport or heavy physical activity) to 7 (run over 10 miles or 16 km a week or spend over 3 hours per week in comparable physical activity). The following formulae were then used to calculate the non-exercise VO_{2peak} ($ml.kg.min^{-1}$):

$$\text{Female: } VO_{2peak} = 56.633 + 1.921(\text{PA-R}) - 0.381(\text{age}) - 0.754(\text{BMI})$$

$$\text{Male: } VO_{2peak} = 67.350 + 1.921(\text{PA-R}) - 0.381(\text{age}) - 0.754(\text{BMI})$$

Fatigue was measured using the 10-item Fatigue Assessment Scale, with scores ranging from 0-50.[32] A higher score on the scale indicates higher levels of fatigue. The FAS has been used to assess post-stroke fatigue in several studies.[33,34,35]

Mood was measured using the Generalised Anxiety Disorder-7 (GAD-7)[36] for anxiety and the Patient Health Questionnaire (PHQ-9)[37] for depression. The GAD-7 has been shown to be a valid measure of anxiety.[36] Scores on the GAD -7 range from 0-21, with higher scores indicating greater anxiety disorder symptoms. The PHQ-9 has been shown to be a reliable measure of depression severity after stroke.[38] PHQ -9 scores range from 0-27, a higher score indicate higher levels of mood disorder symptoms.

Quality of life was measured using the Stroke Specific Quality of Life Scale.[39] The scale includes 12 domains with 49-items in total scored on a 5-point scale, with a higher score representing better quality of life.

Sample size and data analysis

In this safety study we took a purposive approach with no sample estimation. We aimed to recruit a representative sample of 25 people with stroke or TIA, which would allow exploration of associations between CRF and potentially important factors.

Descriptive statistics (medians and inter-quartile ranges [IQR]) were used to report the stroke and demographic characteristics of the participants and other variables (i.e. fatigue, anxiety, depression and quality of life). Safety of performing the exercise test was determined by the number of participants that terminated the test due to one of the safety criteria. Exercise test outcomes were calculated by averaging the values over the last 30 seconds of the exercise test for the following variables: relative VO_{2peak} ($ml.kg.min^{-1}$), absolute VO_{2peak} ($L.min^{-1}$), HR_{peak} (bpm) and $RER_{peak} \cdot MET_{peak}$ was calculated by dividing relative VO_{2peak} by 3.5. RPE_{peak} was recorded at the end of the test for each individual. We confirmed that the exercise variables were normally distributed using the skewness and kurtosis test; test variables were reported as means and standard deviations.

We calculated Spearman correlation coefficients (r) to explore associations between fitness (relative VO_{2peak}) and age, fatigue, mood, and quality of life. Correlations were considered strong if the coefficient ranges from 0.8 to 1, moderate from 0.5 to 0.8, weak from 0.2 to 0.5, and very weak when less than 0.2.^[40]

All data were analysed using StataCorp 2013 (Stata Statistical Software: Release 13. College Station, TX: StataCorp LP).

Results

We screened 783 individuals admitted to an acute stroke ward from July 2015 to December 2017. Of the 228 stroke survivors who were eligible, 33 provided written consent. Three participants were excluded after consent, as it was confirmed that no stroke or TIA had occurred, and one participant withdrew due to personal reasons. One participant could not complete the test due to joint pain which left a total of 28 participants who completed the test (see Figure 1. Flowchart of screened individuals and included participants).

[Insert Figure 1. Flowchart of screened individuals and included participants]

Of the 28 who completed the test, ten participants had 0-1 cardiovascular risk factor and 18 had two or more cardiovascular risk factors. Twenty-three out of 28 participants were using at least one anti-hypertensive drug. The demographic characteristics of the participants are detailed in Table I.

[Insert Table I.]

Safety

Only one test was terminated based on safety monitoring measures; the participant's SpO₂% levels dropped below 85%. Twenty-six participants stopped due to standard test termination criteria and a VO_{2peak} could be estimated; five participants requested to stop the test due to volitional fatigue, six participants were unable to maintain the required stepping cadence, and 15 stopped due to exceeding 85% of their age-predicted HR_{max}. One test was inadvertently terminated before any of the pre-determined stopping criteria were reached.

Cardiorespiratory fitness

The fitness levels of the participants were low (mean VO_{2peak} 15.1 ± 4.6 ml.kg.min⁻¹) and were lower than the reference data for sedentary men and women of similar age groups.[41] The work rate achieved ranged from 40 to 160 Watts, equating to an exercise time ranging from 2-4 minutes and 18-20 minutes respectively. The results of the submaximal exercise tests and the ratings of fatigue, mood and quality of life for the participants are presented in Table II.

[Insert Table II.]

Correlation

Higher fitness levels were associated with younger age ($r = -0.65$, $p < 0.001$). Fitness levels of male participants with TIA were in most cases higher than the fitness levels of male participants with stroke (see Figure 2; Scatterplot VO_{2peak} and age by gender and stroke type (ischaemic or TIA)). All other correlations coefficients (ρ) ranged from very weak to weak ($r = 0.01-0.25$) and were not significant.

[Insert Figure 2. Scatterplot VO_{2peak} and age by gender and stroke type (ischaemic or TIA)]

Correlation coefficient between VO_{2peak} and stroke severity were not calculated and no scatterplot was generated due to the lack of variance in NIHSS scores; of the 28 participants, 24 had a score of 0.

Higher exercise test derived estimated VO_{2peak} after stroke was correlated with higher non-exercise estimates of VO_{2peak} . The scatterplot (Figure 3. Scatterplot exercise derived VO_{2peak} and non-exercise VO_{2peak} by gender and stroke type (ischaemic or TIA)) shows that the non-exercise estimate of VO_{2peak} is lower than the exercise derived VO_{2peak} in 7/8 women and is higher than the exercise derived VO_{2peak} in 19/20 men.

[Insert Figure 3. Scatterplot exercise derived VO_{2peak} and non-exercise VO_{2peak} by gender and stroke type (ischaemic or TIA)]

Discussion

We demonstrated that the vast majority of people with mild stroke or TIA are able to safely perform a submaximal exercise test early after onset. This is consistent with the results of studies in which subacute stroke survivors performed a graded exercise test.[42,43] No serious cardiovascular or neurological adverse events occurred. One participant could not attempt the test due to pre-existing lumbar pain. Only one participant had to cease the test due to safety criteria, namely a drop in $SpO_2\%$ below 85%. It is likely that this drop was due to an ear sensor

recording issue, rather than a true O₂ desaturation. Symptomatic presentation throughout the test did not indicate that the participant was hypoxic, and at the cessation of the test the rating of perceived exertion (RPE) was only 13 (i.e. “somewhat hard”).

The most frequent reason for stopping the exercise test was reaching 85% of age-predicted HR_{max} (15 out of 28 participants). As a comparison a study in subacute stroke survivors used a different formula ($208 - 0.7 \times \text{age}$), [42] to determine HR_{max} test termination criterion and only three out of 34 participants reached this criterion. We chose to set a conservative upper limit of 85%HR_{max} as a termination criterion, given that there is limited knowledge about the safety of exercise testing early after stroke. However, the formula used in this study to determine HR_{max} ($220 - \text{age}$) is a crude measure and can over or underestimate true HR_{max}.^[44,45] Given the absence of any serious adverse events in this study, it is unlikely that a gross overestimation of HR_{max} occurred. Further studies are warranted investigating other more accurate measures to estimate maximal tolerated heart rate. Proceeding beyond an arbitrary cut-off will lead to a more accurate estimate of an individual exercise capacity and support a more precise approach to tailored exercise prescription to improve CRF after stroke.

We found that higher exercise derived VO_{2peak} levels are correlated with age. These results are consistent with existing evidence in which age is recognised as a well-established factor predictive of fitness levels in healthy people[46] and after stroke.[47] We also found a strong correlation with a non-exercise estimate of fitness. Interestingly, the fitness levels determined using the graded exercise test were lower than the non-exercise estimate in 95% of the male participants and was higher in 85% of the female participants. Additionally, for one of the

participants, the non-exercise estimate resulted in a negative VO_{2peak} . Using a non-exercise estimate of fitness might not be an appropriate measure in people with minor stroke and TIA.

Although reaching 85% HR_{max} in this study might be based on a crude measure, it does provide valuable information about exercise capacity of the individuals. In some clinical guidelines it is recommended that aerobic fitness training for stroke survivors should be performed at a moderate to vigorous intensity.[14,48] The results of this study suggest that early post-stroke training should commence at a moderate intensity, that is, at approximately 40% HR_{max} . The results of this study showed that the majority of participants at their peak effort can reach a level far beyond the minimum level required. The results of a graded exercise test can inform clinicians about the intensity level of initial training likely to be tolerated safely by the post-acute stroke survivor. Additionally, the experience of performing a graded exercise test will give people with stroke and TIA confidence in their ability to engage in exercise programs, especially those who are not used to high levels of physical activity or usual exercise.

The results of this study are limited to people with minor stroke and TIA early after the onset. We used purposive sampling and although our aim was to include participants with moderate and severe strokes, recruitment proved difficult. Very few stroke survivors who were moderately or severely affected agreed to participate or were eligible. Recruitment from an acute hospital setting is challenging given that individuals receive care that includes multiple tests, assessments and therapies. For many individuals who just had a serious medical event, participating in a research study that requires a physical effort might be too much to cope with. Additionally, the majority of participants were men. The percentage of male and female stroke survivors who were

eligible were also unbalanced (64% males, 37% females) and could partially explain the difference between number of male and female participants. Given the small sample size, our results should not be generalised to a broader population of people with stroke and TIA.

Conclusion

A graded exercise test provides valuable information about post-stroke and TIA exercise capacity and helps to determine a safe intensity of CRF training tailored to the individual. Knowing the exercise capacity determined by an exercise test will help clinicians to provide training at an appropriate level to improve aerobic capacity and give people with stroke and TIA the confidence that they can safely exercise. Further research should focus on determining the safety of a graded exercise test in moderate to-severely affected early post-stroke populations. Larger studies should be conducted to confirm the safety of exercise testing in people with TIA and stroke.

Conflict of interest

None of the authors have any conflicts of interests to disclose.

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Tables

Table I. Participant characteristics and stroke diagnostics (n = 28)

Demographic characteristics	
Age, median years (IQR)	69 (58-75)
Female gender, n (%)	8 (29)
Days post-stroke, median (IQR)	9 (5-11)
Ischaemic stroke	16 (57)
Transient Ischaemic Attack	12 (43)
Hemisphere affected, n (%)	
Right	18 (64)
Left	8 (29)
Unclear	2 (7)
Stroke Severity on admission, n (%)	
Mild (NIHSS 0-7)	27 (96)
Moderate (NIHSS 8-16)	1 (4)
mRS on admission, n (%)	
Independent (0-2)	26 (93)
Dependent (>2)	2 (7)
Cardiovascular risk factors n (%)	
Hypertension	18 (64)
Atrial fibrillation	1 (4)

Hyperlipidaemia	15 (54)
Type II Diabetes Mellitus	5 (18)
Ischaemic heart disease	8 (29)
Previous smoker [†] /Smoker	3 (11)/1 (4)
Hypertensive medication, n (%)	
β -blockers	3 (14)
Ca ² channel antagonist	5 (14)
Other hypertensive medication	23 (82)

[†]Stopped smoking since stroke

Table II. Graded exercise test, fatigue, mood and quality of life results (n = 28).

Exercise test variable <i>(mean ± SD)</i>	All per protocol (n = 26)	Male per protocol (n = 19)	Female per protocol (n = 7)	Stopped safety ♀ (n = 1)	Stopped other ♂ (n = 1)
Age	69.5				
(median IQR)	(59-75)	70.0 (57-75)	69 (65.5-74)	65	55
VO _{2peak} (ml.kg.min ⁻¹)	15.3 ± 4.5	16.1 ± 4.7	12.9 ± 3.4	8.6	16.6
VO _{2peak} (L.min ⁻¹)	1.3 ± 0.5	1.4 ± 0.5	1.0 ± 0.3	0.9	1.17
MET _{peak}	4.4 ± 1.3	4.6 ± 1.3	3.7 ± 1.0	2.5	4.8
HR _{rest} (bpm)	71 ± 15	69 ± 15	75 ± 14	88	68
HR _{peak} (bpm)	114 ± 25	115 ± 26	112 ± 24	93	114
RER _{peak}	1.1 ± 0.1	1.1 ± 0.1	1.0 ± 0.1	1.05	1.2
RPE _{(6-20)peak}	15 ± 2	15 ± 2	15 ± 2	16	12
Work-rate _{peak} (W)	78 ± 35	87 ± 37	55 ± 17	70	85
Non-exercise VO _{2peak} (ml.kg.min ⁻¹)	19.6 ± 10.9	24.8 ± 6.7	6.9 ± 9.7	8.6	16.6
Other variables <i>(median and IQR)</i>	All (n = 28)	Male (n = 19)	Female (n = 7)	Stopped safety ♀ (n = 1)	Stopped other ♂ (n = 1)
Fatigue (FAS)	17 (13-20)	17 (14-20)	21(15.5-21)	13	15
Anxiety (GAD-7)	2 (0-5) [†]	2 (0.25-5) [‡]	2 (0-3)	7	1
Depression (PHQ-9)	2.5 (1-5)	3 (0-4)	2 (1.5-6.5)	2	8

Quality of Life (QoL)	222	221	222	229	232
	(206-229.5)	(205-236.5)	(207-225.5)		

‡n = 25 participants, †n = 18 male participants, VO₂ – volume of oxygen consumption; MET – metabolic equivalents. VO₂; HR – heart rate; RER – respiratory exchange ratio; RPE – rating of perceived exertion. FAS = fatigue assessment scale, GAD-7 = generalised anxiety disorder 7-item scale, PHQ-9 = patient health questionnaire, SS-QoL = stroke specific quality of life scale, ♀ = female, ♂ = male

Figure legends

Figure 1. Flowchart of screened individuals and included participants

Figure 2. Scatterplot VO_{2peak} and age by gender and stroke type (ischaemic or TIA)

Legend

- Stroke male (n = 10)
- ◆ TIA male (n = 10)
- Stroke female (n = 6)
- ◇ TIA female (n = 2)

Figure 3. Scatterplot exercise derived VO_{2peak} and non-exercise VO_{2peak} by gender and stroke type (ischaemic or TIA)]

Legend

- Stroke male (n = 10)
- ◆ TIA male (n = 10)
- Stroke female (n = 6)
- ◇ TIA female (n = 2)

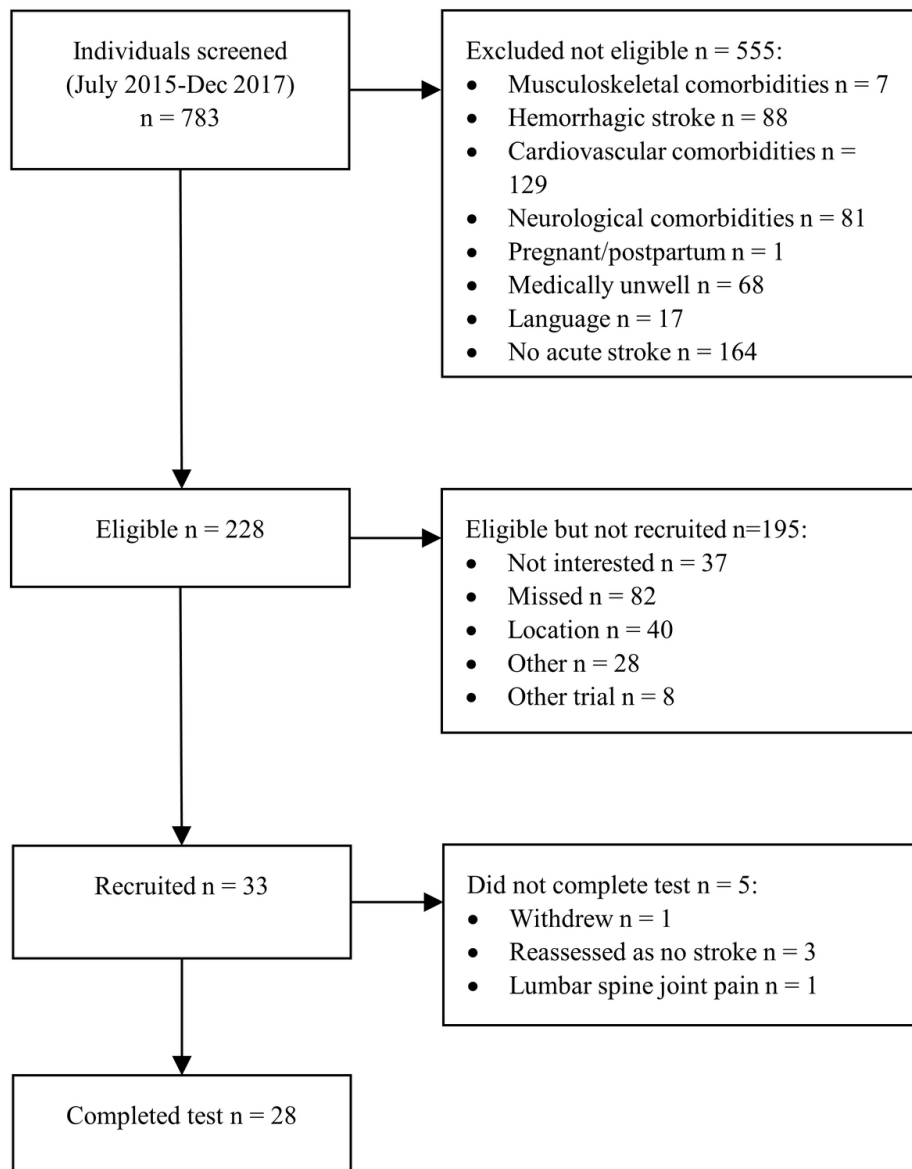


Figure 1. Flowchart of screened individuals and included participants

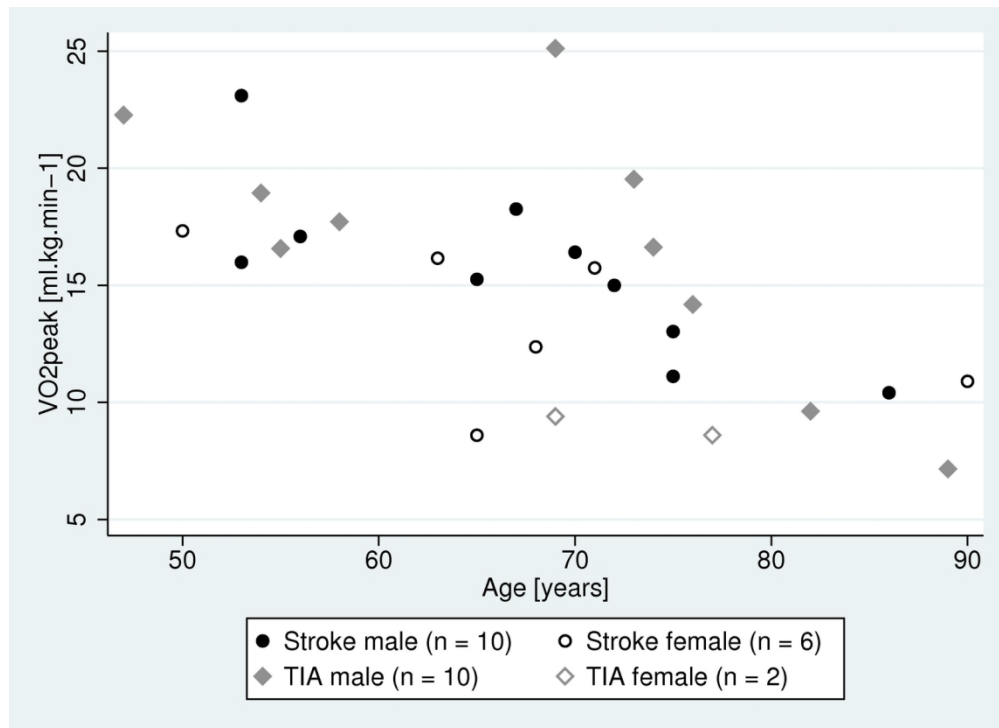


Figure 2. Scatterplot VO2peak and age by gender and stroke type (ischaemic or TIA) Legend ● Stroke male (n = 10)◆ TIA male (n = 10)○ Stroke female (n = 6)◇ TIA female (n = 2)

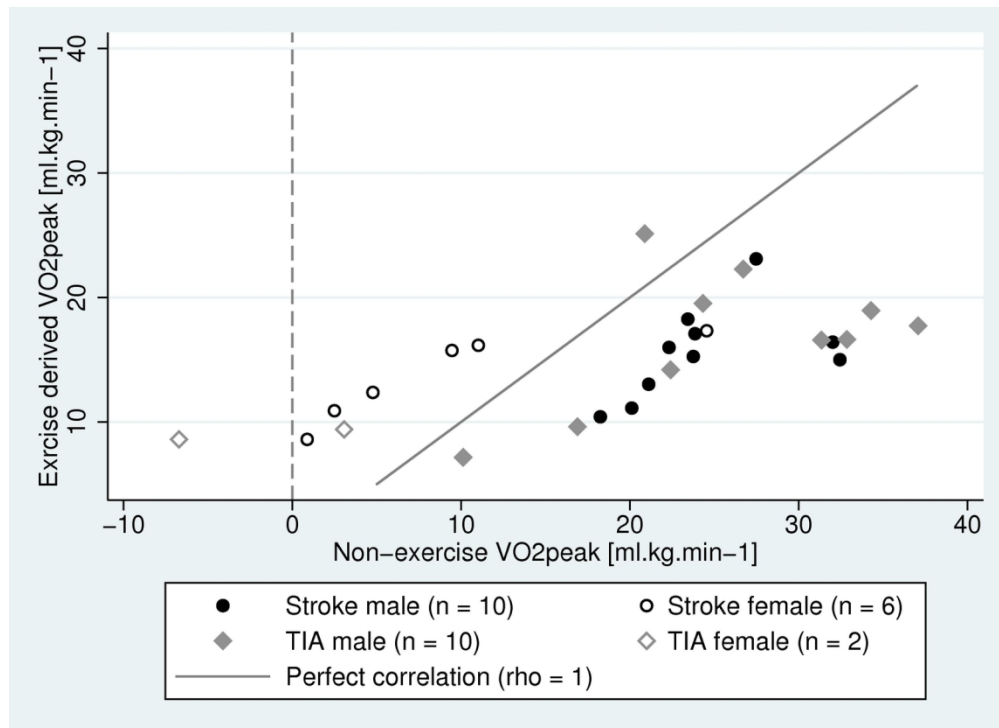


Figure 3. Scatterplot exercise derived VO₂peak and non-exercise VO₂peak by gender and stroke type (ischaemic or TIA)]Legend ● Stroke male (n = 10)◆ TIA male (n = 10)○ Stroke female (n = 6)◇ TIA female (n = 2)