Original Article

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Reducing sedentary time and fat mass may improve glucose tolerance and insulin sensitivity in adults surviving six months after stroke: A phase I pilot study

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Keywords

Stroke, glycaemic control, physical activity, body composition

Abstract

Background: Deranged glycaemic control is common post-stroke, increasing risks of recurrent stroke and development of diabetes.

Aim: To examine glucose metabolism in relation to body composition, physical activity and sedentary time post-stroke.

Method: Observational study. Non-diabetic adults, unable to walk independently, were recruited within one week of first stroke. Primary outcome: 2-hour glucose level (oral glucose tolerance test), assessed at baseline and six months. Homeostasis Model Assessment of Insulin Sensitivity (HOMA%S), total body fat and lean mass (dual energy X-ray absorptiometry), and time lying, sitting, standing and walking (PAL2 acceleerometer)were assessed at baseline, one, three and six months. Sedentary time calculated as time lying or sitting. Generalised estimating equations were used to examine change over time and associations.

Results: 36 participants (69.5years (SD 11.7), 13 (36.1%) female, moderate stroke severity (NIHSS 11.5 (IQR 9.75, 16)). Adjusting for age and NIHSS, 2-hour glucose reduced monthly by 4.5% ($p<0.001$), insulin sensitivity improved 3% ($p=0.04$), and fat mass decreased 490g (95%CI 325, 655; $p=0.01$). For every extra kilogram body fat, 2-hour glucose increased by a factor of 1.02 (95%CI 1.01, 1.02; $p=0.001$); HOMA%S reduced by a factor of 0.98 (95%CI 0.97, 0.99; $p=0.001$). Sedentary time reduced

monthly by a factor of -2.84 (95%CI -3.85. -1.83, p<0.001), from 98.5% (IQR 94.3, 99.8) to 74.3% (IQR 65.5, 88.6). For every additional 5% sedentary time, 2-hour glucose increased by a factor of 1.045 (95%CI 1.035, 1.065; *p*<0.001).

Conclusion: Reducing sedentary time and fat mass within six months of stroke may improve glucose tolerance and insulin resistance.

Trial Registration: ACTRN12612000123842

Introduction

Hyperglycaemia is common within hours of stroke onset (1), and dysglycaemia is prevalent in up to 80% of stroke survivors in sub-acute (3 months), and chronic (>6 months) (2, 3) recovery phases. Impaired glucose tolerance and insulin resistance following a stroke are independent risk factors for recurrent stroke (4) and are also associated with the development of diabetes (4). Stress hyperglycaemia in the setting of stroke (1), insular cortical ischaemia and older age (5) may contribute to post-stroke hyperglycaemia, and the emergence of insulin resistance after stroke is associated with younger age (<65 years), obesity, lacunar stroke and greater disability (modified Rankin grade > 1) (6). Ischaemic neural damage and resultant neuroendocrine dysregulation and inflammatory cascades may contribute to the development of insulin resistance (7) following stroke, however, the relationship between impaired glucose tolerance and insulin resistance in stroke survivors without diabetes is not fully understood.

In a recent randomized controlled study (8) of 3876 people aged 63.5 years (SD 10.6) with insulin resistance (>3.0 on the homeostasis model assessment of insulin resistance (HOMA-IR) index), treatment with the insulin sensitising drug Pioglitazone within six months of mild stroke or transient ischaemic attack reduced the 5-year risk for recurrent stroke or myocardial infarction, however fracture risk and weight gain were increased. The study highlights insulin resistance as a target for cardiovascular disease after stroke and suggests a need to investigate non-pharmacological treatment methods.

Physical inactivity which is common after stroke (9, 10) may contribute to post-stroke insulin resistance via its associations with reduced muscle mass (11), changes in paretic leg muscle fibre type (12), reduced muscle capillarisation and peripheral blood flow (13) and increased intramuscular fat and inflammatory markers (14). The timing of the changes in lean and fat mass in relation to glycaemic control after stroke is not well characterised (15, 16). Furthermore, evidence suggests that sedentary behaviour (defined as waking behaviour that involves an energy expenditure of <1.5 metabolic equivalents (METs) such as sitting or lying) may be an independent risk factor for cardiovascular disease and mortality regardless of the amount of physical activity undertaken (17). To study the relationship between glucose control and physical activity after stroke, sedentary behaviour also needs to be considered.

The aim of this study was to examine glucose metabolism in relation to body composition, physical activity and sedentary time following a stroke. We hypothesised that glucose tolerance and insulin sensitivity would decrease within six months of stroke. Further, we hypothesised that higher levels of physical activity and lower levels of sedentary time would be associated with improved glucose tolerance and insulin sensitivity.

Methods

This was a phase 1 pilot investigation that was a sub-study nested within a larger longitudinal observational study of post-stroke bone loss (18). Adults admitted to the acute stroke unit of two large metropolitan teaching hospitals in Melbourne (Australia) between March 2010 and August 2014 were screened for inclusion into the study. The inclusion criteria were diagnosis of a hemispheric stroke in the past week, and the ability to follow simple verbal commands. Exclusion criteria were: ability to walk independently, known diabetes, medical instability, previous stroke, other neurological or bone disease, other conditions significantly limiting function (e.g. limb amputation) and use of steroid or bone specific (e.g. bisphosphonate) medication. Informed written consent was obtained for all participants as approved by Austin Health (H2008/03428), Northern Health (P4/13) and La Trobe University (09-065) Human Research Ethics Committees, in accordance with the Helsinki Declaration of 1975, as revised in 1983.

Assessments occurred at baseline (within two weeks of stroke), one month later, and at three and six months post-stroke. Assessments were undertaken on the hospital ward, then at the research centre or at participants' homes once they were discharged from hospital.

Outcomes

Participant demographics (age, sex, living arrangements, education level, smoking status, medical history), stroke severity (National Institute of Health Stroke Scale,

NIHSS) and stroke classification (Oxfordshire Classification) were recorded. The modified Rankin score (mRS) was used to assess disability at each assessment time point. Adverse medical events were prospectively recorded from patient report and medical records: deaths, falls, neurological and cardiovascular events requiring hospitalisation, and any study related medical event.

Glucose metabolism

The primary outcome for this study was change in 2-hour plasma glucose on oral glucose tolerance test (OGTT) assessed at baseline and six months. Glucose response was classified as normal, impaired or diagnostic of diabetes on the basis of plasma glucose value two hours after ingestion of 75g of glucose in a fasted state, according to World Health Organization (2006) classifications (19). Glucose and insulin concentrations were measured at each time point before 9am following an overnight fast, and were used to calculate insulin sensitivity (HOMA %S) by the Homeostasis Model Assessment of Insulin Sensitivity (20). Glycated haemoglobin A1c (HbA1c, coefficient of variation, CV, 2.2 – 3.4%) was measured to estimate glycaemic status during the preceding three months. C-peptide was measured as a marker of insulin production. Plasma glucose was measured using a hexokinase assay on the Roche Cobas 702, CV 2.0 - 3.2%. Insulin was measured by electrochemiluniscence immunoassay (ECLIA, CV 3.3 – 5.6%) on the Roche Cobas 602. HbA1c was measured by immunoassay on the Roche Integra 800, CV 2.2 – 3.4%.

Body composition.

Total body fat and lean masses were estimated using dual-energy x-ray absorptiometry ((DXA), Lunar Prodigy DXA System, analysis software: 13.60), using the manufacturer's procedures, CV 1-1.2% (21). No systematic long-term bias was evident in calibration data. All scans were undertaken on the same machine.

Physical activity

Physical activity was measured using a dual-axis accelerometer with switch tilt, sample rate 10Hz (PAL2, positional activity logger 2, Gorman ProMed Pty Ltd, Melbourne, Australia). It is comprised of two parts: a control unit and an auxiliary switch which are attached to the right leg above and below the knee by elasticised straps. PAL2 registered the number of changes in position and the amount of time that participants spent lying down, sitting, standing and walking (22). There is high agreement between PAL2 recordings and behavioural mapping of people with acute stroke: lying ICC 0.74 (95% CI 0.46 – 0.89), sitting 0.68 (0.36 – 0.86), upright 0.72 (0.43 – 0.88) (23). PAL2 is a modified version of the 'Uptime' device, which has high test-retest reliability (Pearson's $r= 0.84$, $p < 0.001$) (24).

Consistent with previous studies of physical activity after stroke (9) that have shown that activity levels do not differ between days in acute stroke units, the device was worn for one day at each time point from 8am to 5pm, representing the most active part of the

day (25). Follow-up assessments were undertaken on a self-selected weekday that represented participants' typical daily activity. Sedentary time was calculated as the sum of time lying and sitting as a proportion of total wear time.

Anthropometry

Body mass was measured on an electronic scale (WB-100A, Tanita Corporation, Tokyo, Japan) with participants wearing light clothing. Height was measured using a wall mounted standiometer (Holtain, Crosswell, UK). Participants unable to stand were weighed in their wheelchair on floor scales (Model 8000 Ranger, Wedderburn) or weight was taken from medical records; height was measured in supine from the top of head to heel using a standard measuring tape. Body mass index (BMI) was calculated (kg/m^2). Waist and hip circumferences were measured in standing at the narrowest point between ribs and iliac crest, and at the widest part of buttocks.

Walking ability

Walking ability was evaluated using the Functional Ambulation Category (FAC) (26). This seven point scale measures the ability to negotiate various terrains,with or without gait aid. The scale ranged from "1: non-functional ambulation" to "6: independent ambulation on uneven surfaces".

Statistical analysis

Given that this was a phase 1 pilot study it is exploratory by design and was not powered to detect a change in glucose tolerance. Data for people who did not complete the study (deaths and drop outs) cannot be assumed to be missing-at-random (27): these participants were not included in analyses and no results can be generalised for those participants. Missing data from all other participants were assumed to be missing-at-random.

Generalized estimating equations (GEE) were used to investigate change over time (months since stroke) of log transformed 2-hour glucose and HOMA2 %S and secondary outcomes body composition, physical activity and sedentary time. This approach was also used to test the strength of associations between 2-hour glucose and HOMA2 %S and secondary outcomes. Interpretation of the effect sizes produced by GEEs, is the population-averaged change in the dependent variable (eg 2-hour glucose or HOMA2 %S) per one unit change in an independent variable (eg every extra month after stroke) assuming other independent variables held constant. Models were then run adjusting for expected confounders stroke severity and age, which were a priori known to be associated with poorer recovery after stroke. Analyses were performed using STATA v 13 IC statistical software (StataCorp LP, College Station, Texas, USA). A significance level of $p = 0.05$ was set for all statistical tests and no correction for multiplicity was undertaken due to the exploratory nature of this analysis. De-identified individual data is available from the corresponding author.

Results

Recruitment, retention and demographic details.

We screened 2749 patients on hospital admission. Almost one in five (17%) people had known diabetes so were excluded from the study, Figure 1. Consent was obtained for 36 patients (age 69.5 (SD 11.7), 13 (36.1%) female, NIHSS 12.8 (SD 4.7). Four participants did not complete the study - three died and one withdrew due to deteriorating health, Figure 1.

There were no significant differences between participants who did and did not complete the study, except for the Oxfordshire stroke classification ($\chi^2 = 9.9$, $p = 0.02$),Table 1.

<Figure 1 here>

<Table 1 here>

Glycaemic control and insulin sensitivity.

Due to swallowing impairment (dysphagia), 13 participants could not undertake OGTT at baseline. Six people subsequently completed OGTT at one-month assessment; their OGTT results are included as “baseline” in Table 2 (median 9 days post stroke, IQR (7, 18)).

Within the first six months of stroke, glucose tolerance improved ie for every month, 2-hour glucose level was lower by 4.5% (95% CI 2.9, 6.1, p= 0.033). Insulin sensitivity also improved monthly by 2.9% (95% CI 0.2, 5.6, p = 0.03). Both associations remained significant when adjusting for age and stroke severity, Table 2.

Body composition: muscle and fat mass, and body mass index

Baseline DXA scans were undertaken at 10.7 (IQR 7.5, 13.9) days post stroke. World Health Organisation BMI classifications indicated that at baseline four people (12.5%) were underweight (BMI <18.5), seven (21.9%) were normal weight (BMI 18.5 – 25), 13 (40.6%) were overweight (BMI 25 – 30) and eight people (25%) were obese (BMI >30), Table 2. Between baseline and six months, total body fat mass decreased by 10.4% (95% CI 0.8, 21.1) which equated to 489g per month (95 % CI 325, 655, p =0.01), but no statistically significant change in lean mass was observed.

<Table 2 here>

Physical activity

At baseline, almost all (median 98.5%, (IQR 94.3, 99.8) of the day was spent sedentary, and only 1.5% (IQR 0.2, 5.8) of the time was spent upright, either standing or walking. Participants stood up on average six times (IQR 0, 13) throughout the day, Figure 2. By six months, most participants (21/32, 66%) were able to walk independently (FAC > 4), but were dependent on others for daily assistance (mRS, median = 3, (IQR 2, 4)). All

activity measures changed significantly between baseline and six months ($p < 0.001$). At six months, participants were sedentary for most of the day (74.3%, (IQR 65.5, 88.6), n = 27), mostly sitting (66.8%, (IQR 39.9, 86.0), n = 27), and a quarter of the time was spent upright (25.7%, (IQR 11.4, 34.5)). The number of times that participants stood up during activity monitoring increased to 24 (IQR 17, 35.5). Controlling for age and NIHSS, for every month, the percentage of time spent upright increased by a factor of 2.84 (95% 1.83, 3.85, p<0.001).

<Figure 2 here>

Associations between Glycaemic Control Physical Activity, and Fat Mass.

Better glycaemic control was significantly associated with lower total fat mass: for every kilogramincrease in total fat mass , when adjusting for age and stroke severity, 2hr glucose increased by a factor of 1.02 (95% CI 1.01, 1.02), Figure 3

Figure 3. Likewise, for every 5% increase in sedentary time, 2 hr glucose increased by a factor of 1.045 (95% CI 1.035, 1.065, $p < 0.001$) , after adjusting for number of times that participants stood up and total time that the accelerometer was worn. Higher (better) insulin sensitivity was associated with lower total fat mass; for every kilogram

increase in total fat mass, HOMA2 S% reduced by a factor of 0.98 (95% CI 0.97, 0.99, $p = 0.001$).

<Figure 3 here>

<Table 3 here>

DiscussionThis study was the first examination of glycaemic control and its associations with body composition, physical activity and sedentary time after stroke. The most important finding in the current study was that participants' glucose tolerance and insulin sensitivity improved within six months of stroke, and fat mass reduced by 490 grams per month. At six months after stroke, no participants had a diabetic response to oral glucose tolerance test (defined as **2-hour glucose ≥ 11.1mmol/l (19).**

Our findings are in contrast to previous studies in which glucose intolerance and insulin resistance were prevalent in chronic stroke populations(2, 3). Contrasting findings may be related to differences in the study populations and methodologies: in our study, participants who were unable to walk were recruited within two weeks of stroke and observed longitudinally. The studies by Kernan et al (2005) and Ivey et.al were cross-sectional studies of people who were on average more than three months post-stroke or transient ischemic attack, who were able to walk. Loss of fat mass in our participants and related improvements in glycemic control may be explained by increased energy costs of walking. Also, given that 13 participants in our study had swallowing

difficulties (dysphagia) at baseline, they were at risk of malnutrition (inadequate protein and calories), which is common after stroke (28). Assessment of nutritional status is warranted in future studies.

In our study, better glucose tolerance and insulin sensitivity were independently associated with lower fat mass. These results reflect recommendations for weight loss in people with prediabetes to reduce their risk of progressing to diabetes, and for people with diabetes to improve their glycaemic control (29). Furthermore, we observed that improved glucose tolerance was associated with lower sedentary time when adjusting for the number of times that people stood up during activity monitoring. These results suggest that targeting reductions in sedentary time and fat mass after stroke may improve glucose tolerance and insulin sensitivity, and in turn cardiovascular health by reducing the risk of recurrent stroke and development of diabetes.

Our findings support recent Australian recommendations that regardless of the amount of physical activity undertaken, adults of all abilities should limit sedentary time due to its detrimental effects on cardiovascular health (30). Sedentary behaviour after stroke contributes to changes to more insulin resistant fast-twitch type II muscle fibre types (12), reduced muscle capillarisation and peripheral blood flow (4, 13) and increased intramuscular fat and inflammatory markers in paretic leg muscles (14), that have been related to glucose intolerance and insulin resistance (3).

High levels of sedentary time observed in this study was not a surprising finding despite most participants regaining the ability to walk independently within six months. Less than 20% of monitored time consisted of standing or walking at 3 and 6 months.Similar results were demonstrated by Askim et al. (9) who, using the same accelerometer as that in the current study, observed that low levels of activity were maintained throughout six months of stroke. In the current study, participants lost body fat despite maintaining high levels of sedentary time within six months of stroke. This is in contrast to a study by Carin-Levy et al (31) (2006) who observed increases in DXA derived fat mass within six months of stroke: from 25.2 kg (IQR 20.2, 30.6) at baseline to 26.5 (20.7, 28.2), $p = 0.01$. Participants in the study by Carin-Levy had similar BMI and mobility status at baseline compared to the current study, and similarly, their total lean mass did not change.

Moore et al (2013) undertook the only previous prospective investigation to our knowledge, of post-stroke physical activity and glycaemic control (32). The study included 31 people aged 73 ± 9 years (45% female) within 7 days of mild stroke (NIHSS = 2 ± 2) who were able to walk 10m independently (32). Participants underwent physical activity and fasting insulin and glucose tests at baseline and at three and six months. Physical activity similarly increased by three months but plateaued by six months, at which time stroke survivors were sedentary for 22.5 hours (94%) of the day. Fasting glucose and insulin sensitivity were within normal limits at baseline and

did not change over time, and no association was observed between longitudinal changes in sedentary time and glycaemic control. The contrasting glycaemic control results between studies may be explained by higher energy demands of walking (33) in participants in the current study due to their moderately severe stroke symptoms compared to mild impairments in the group studied by Moore et al (32).

A limitation of the current study is that only one day of activity monitoring occurred at each time point, whereas it is recommended that physical activity monitoring be undertaken for three days in community dwelling non-stroke adult populations to accurately predict activity levels (34). However, physical activity does not differ between days on hospital wards (10), and daily variation in activity levels of community dwelling stroke survivors is currently being examined in more detail (35). Results of this examination will guide recommendations for future post-stroke activity monitoring periods. As this was a phase 1 study with a small sample, results must be interpreted cautiously and validated in a larger trial.

In summary, this was the first prospective study to examine glycaemic control, body composition, sedentary time and physical activity from within a week of moderately severe stroke. In contrast to our expectations, glycaemic control and fat mass improved within six months of stroke, possibly due to higher energy demands of walking after stroke. Results suggest that interventions aimed at reducing sedentary time and fat mass

may improve glucose tolerance and insulin resistance, thereby reducing the risks of recurrent stroke and developing cardiovascular disease including diabetes.

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Conflict of Interest Disclosure: Nothing to disclose

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Table 1: Demographic and Stroke Characteristics

Characteristic	All recruits N = 36	Completed study n = 32	p^1
Gender, female	13 (36.1)	12 (37.5)	0.62
Age, mean (SD)	69.5 (11.7)	68.9 (11.8)	0.37
Lived with others	28 (77.8)	25 (78.1)	0.89
Education			
No formal education	2 (5.6)	2 (6.3)	0.25
Incomplete secondary	7 (19.4)	6 (18.8)	
Complete secondary	4 (11.1)	3 (9.4)	
Trade/apprentice	7 (19.4)	5 (15.6)	
Certificate/diploma	9 (25.0)	9 (28.1)	
University degree or higher	7 (19.4)	7 (21.9)	
Pre-stroke employment			
Full or part time work	14 (38.9)	13 (40.6)	0.83
Home duties	3 (8.3)	3 (9.4)	
Student	1 (2.8)	1 (3.1)	
Retired	18 (50.0)	15 (46.9)	
Non-english speaking background	7 (19.4)	7 (21.9)	0.30
Previously walked no gait aid	32 (88.9)	29 (90.6)	0.35
Body mass index	27.2 (5.4)	27.6 (5.6)	0.21
Family history of diabetes			
Yes	3 (8.3)	3 (9.4)	0.33
No	18 (50.0)	17 (53.1)	
Unknown	9 (25.0)	7 (21.9)	
Past medical history			
Hypertension	18 (50.0)	15 (46.9)	0.29
High cholesterol	12 (33.3)	10 (31.3)	0.45
Ischaemic heart disease	6 (16.7)	4 (12.5)	0.06
Atrial fibrillation	7 (19.4)	6 (18.8)	0.77
Musculoskeletal	15 (41.7)	14 (43.8)	0.47
Number co-morbidities, mean (SD)	4.1 (2.9)	4.0 (2.7)	0.24
Smoking history			
Current smoker	12 (33.3)	10 (31.3)	0.57
Never smoked	13 (36.1)	12 (37.5)	
Stopped in past 2 years	2 (5.6)	2 (6.3)	
Stopped > 2 years ago	9 (25.0)	9 (28.1)	
Stroke severity, NIHSS	11.5 (IQR 9.75, 16)8	12.5 (9.75, 16.5)	0.26
Group median (IQR)	(22.2)	7 (21.9)	
Mild	20 (55.6)	17 (53.1)	

Moderate	8 (22.2)	8 (25.0)	
Severe			
Stroke classification			
TACI	18 (50.0)	18 (56.3)	0.02[1]
PACI	11 (30.6)	10 (31.3)	
LACI	3 (8.3)	2 (6.3)	
Haemorrhage	4 (11.1)	2 (6.3)	

Note. Data presented n (%) unless otherwise specified. NIHSS = National Institutes of Health Stroke Scale (mild < 8, moderate 8 to 16, severe > 16); TACI / PACI = total / partial anterior circulation infarct, LACI = lacunar circulation infarct. [1]Independent sample T-test or Wilcoxon rank-sums dependent on distribution of continuous or ordinal data, Chi2 for nominal data.

Table 2: Measures of Glycaemic Control and Body Composition at Baseline and Six Months after Stroke

	Baseline	Six months	Effect Size (95% CI) ^~ Change per month	*p*^
Oral Glucose tolerance test (OGTT)				
2-hour glucose, mmol/L	7.9 (6.7, 10.3), n = 24	5.9 (4.6, 7.7), n = 26	0.96 (0.94, 0.97)	<0.001
Glucose response^^, N (%)	n = 23	n = 26	n/a	0.033
Normal	12 (52.2)	20 (76.9)		
Impaired	6 (26.1)	6 (23.1)		
Diabetic	5 (21.7)	0		
HOMA2 %S	75.9 (50.5, 102.1), n = 30	92.2 (72.8,160.9), n = 29	1.03 (1.002, 1.06)	0.04
HbA1c	n = 31	n = 29		0.18
mmol/mol	40 (38, 41)	41 (39, 42)	1.001 (0.99, 1.02)	
%	5.8 (5.6, 5.9)	5.9 (5.7, 6.0)		
HOMA2 %B	115.7 (80.2, 136.4), n=30	107.6 (86.5, 148.8), n = 29	2.51 (0.15, 41.89)	0.52
C-Peptide	1.04 (0.9, 1.32), n = 29	0.82 (0.67 1.06), n = 28	0.99 (0.95, 1.04)	0.92
Fat mass, kg	23.5 (16.5, 33.1), n = 28	20.9 (14.7, 27.9), n = 27	0.98 (0.97, 0.99)	0.01
Lean mass, kg	47.2 (40.8, 53.1), n = 28	49.1 (41.2, 54.8), n = 27	1.001 (0.999, 1.003)	0.35
Waist/hip ratio	0.96 (0.86, 1.03), n = 24	0.93 (0.84, 1.01), n = 28	0.99 (0.98, 1.003)	0.15
Body mass index, kg/m^2	26.5 (23.1, 30.3), n = 32	25.1 (22.9, 27.1), n = 26	0.82 (0.58, 1.16)	0.26

Note. Data are presented median (IQR) unless otherwise specified. ^GEE = generalised estimating equation; HbA1c = glycated haemoglobin A1c; HOMA2 = updated Homeostasis Model Assessment; HOMA2 %S = insulin sensitivity; HOMA2 %B= beta cell function.; ~Adjusted for age and stroke severity (National Institute of Health Stroke Scale, NIHSS); ^^Normal fasting = <5.6 mmol/L; Impaired glucose tolerance (IGT) = 2-hour glucose 7.8 - 11.1 mmol/l; diabetes = 2-hour glucose ≥ 11.1mmol/l (World Health Organization and International Diabetes Federation, 2006).

Table 3: Associations between Glucose Tolerance, Insulin Sensitivity, Body Composition and Physical Activity within Six Months of Stroke

Independent variable	Glucose tolerance: 2hr glucose on OGTT, mmol/L	Insulin sensitivity: HOMA2 S%
Total fat mass, kg	1.02 (1.01, 1.02) *p* = 0.001^	0.98 (0.97, 0.99) *p* = 0.001^
Total lean mass, kg	0.003 (0.99, 1.01) *p* = 0.66	0.99 (0.97, 1.01) *p* = 0.11
Body mass index, kg/m^2	1.002 (0.99, 1.01) *p* = 0.57	0.99 (0.98, 1.01) *p* = 0.30
% Sedentary time	1.009 (1.007, 1.013) *p* < 0.001~	0.997 (0.993, 1.003) *p* = 0.38
Transitions	0.999 (0.997, 1.001) *p* = 0.22	1.001 (0.99, 1.003) *p* = 0.22

Note. Cells contain generalised estimating equation effect size (95% CI)**,** adjusting for age and stroke severity (NIHSS). HOMA2 S% = homeostasis model assessment index measure of insulin sensitivity; OGTT = oral glucose tolerance test; Sedentary = lying or

sitting; Transitions = number of times that participants stood up. ^Adjusted for number of transitions and total wear time.

<u>Figure legends:</u>

Figure 1: Participant Recruitment and Retention to Six Months of Stroke

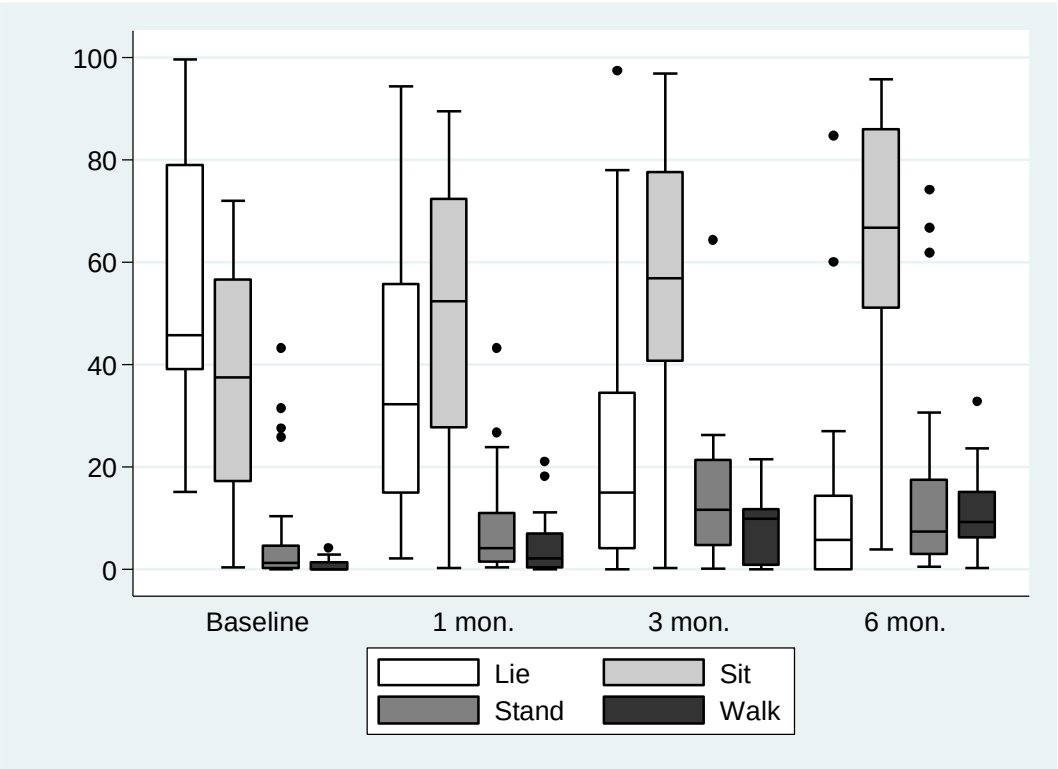

Figure 2: Physical Activity between Baseline and Six Months after Stroke

Figure 3: Association between six-month change in total body fat (kg) and 2-hour glucose level (mmol/L) on oral glucose tolerance test