ORIGINAL RESEARCH

Types of physical activity performed pre and post stroke

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Abstract
Background: The relationship between pre- and post-stroke physical activity levels is underexplored.
Objective: To determine whether self-reported physical activity changes from pre-stroke to two years post-stroke; and to explore the relationship between self-reported and objectively measured physical activity post-stroke.
Methods: Stroke survivors admitted to rehabilitation were included in this observational study. Participants were assessed at rehabilitation discharge (five months post-stroke) and two years later. Participants were asked about their pre-stroke and current activity levels. The Sensewear Armband was worn for one week to measure physical activity at each timepoint. The relationship between self-reported and objectively measured physical activity was explored with Spearman correlation coefficients and multiple regression models.
Results: Sixty-eight stroke survivors (65% male, mean age 64) participated at baseline. Fifty participants reported undertaking physical activity pre-stroke, and 48 of these active participants reported undertaking physical activity two years post-stroke. At two years one third of the active participants reported doing the same type of activity (primarily walking). Approximately one third reported doing the same type of activity and more and approximately one third had to modify the type of activity undertaken. Self-reporting of physical activity time was positively correlated with objective measures of physical activity at two years ($r = 0.61$, $p<0.001$). Objectively measured physical activity, age, and sex predicted 26.5% of the variance in self-reported physical activity ($p<0.001$).
Conclusion: In this single-site study of relatively able participants, stroke survivors frequently returned to their pre-stroke types of physical activity. A positive correlation between self-reported and objective measures of physical activity was demonstrated, but self-reported activity overestimates objective physical activity post-stroke.

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Introduction

Maintaining adequate cardiovascular health is important for stroke survivors who have an increased risk of further stroke and cardiovascular events. Physical activity participation is a modifiable lifestyle factor that can reduce recurrent stroke risk.[1] However, the consequences of stroke, such as weakness and cognitive and mood impairments, often impact on one's ability to participate in physical activity. Stroke survivor attitudes and beliefs around exercise may also influence physical activity participation.[2,3] These are commonly lifelong and may form part of a person's identity prior to the stroke.[2] Pre-stroke physical activity can therefore influence post-stroke physical activity.[4] In a study of 81 acute stroke survivors, 81% of participants reported participating in physical activity during the month prior to their stroke. However, much of the physical activity reported was of a low intensity (e.g., activities of daily living).[5] Higher pre-stroke physical activity levels are associated with lower stroke severity,[6] however pre- and post-stroke physical activity levels have seldom been compared.

Understanding whether the type of physical activity undertaken changes after stroke is also underexplored.[3] Some stroke survivors have no choice but to alter the type of physical activity performed due to their stroke-related disability, and this may lead to frustration and lack of motivation.[2] It is often assumed that many stroke survivors cannot return to their preferred pre-stroke physical activity, but longitudinal studies examining changes in activity from pre to post stroke are few.[7] Consideration of stroke survivor preferences for types of physical activity is important for physical therapists to consider when developing physical activity programs that stroke survivors will adhere to long term.

Objective assessment of physical activity is the gold standard.[8] However, patient-reports of physical activity are both simpler to acquire and arguably patient-centred. Patient reports (subjective) of physical activity levels in people with stroke have been reported as inflated.[9] This can be due to issues such as recall bias or a mismatch between perceived exertion and actual work effort.[8] In other chronic disease populations, subjective reports are correlated with objective physical activity levels.[10] This suggests that subjective reports might be useful to provide an indication of physical activity levels, their trajectory, and changes over time in a clinical setting where objective physical activity data are frequently not available, even if absolute agreement with objective measures is not achieved. Consequently, the relationship between subjective and objective measurement of physical activity in people with stroke needs to be further explored.

In this exploratory analysis we report data from a single-centre longitudinal prospective observational study of physical activity and cardiovascular risk of stroke survivors over two years. The primary results of this study have been reported elsewhere.[11] Here we report our findings related to three research questions: 1) Do people who report being active prior to stroke resume activity by two years post discharge? 2) What types of physical activity do stroke survivors engage in, and are they the same types of activity pre and post stroke? and, 3) Do self-reports of physical activity correlate with objective measures of activity in stroke survivors at two years post discharge?

Methods

Design

A longitudinal study in which stroke survivors who had completed rehabilitation were assessed at baseline (completion of all rehabilitation) and two years post baseline to determine physical activity and cardiovascular risk.[8] The full protocol has been published.[12]

Participants

Participants were adults admitted to a large metropolitan inpatient stroke rehabilitation service with primary stroke. Those with previous stroke, a concurrent palliative diagnosis, living more than two hours from the hospital or being admitted to rehabilitation for less than five days were excluded.

Ethics approval was gained from the Alfred Hospital and La Trobe University Research Ethics Committees. Informed consent was provided by participants or the "person responsible" if participants were deemed unable to provide consent.

Outcomes measured and procedure

Objective measures of physical activity
Physical activity was objectively measured using the Sensewear MF Armband (Bodymedia, Pittsburgh) over one week at the baseline and two year assessments. Sensewear-derived measures in this study included daily duration of light (1.5−3 metabolic equivalents (METS)), and moderate to vigorous (>3 METS) physical activity and daily amount of time spent in bouts of moderate to vigorous physical activity of ≥10 min. The Sensewear is a valid measure of energy expenditure in the stroke population.[13,14] Participants were instructed to wear the arm band on their unaffected arm for one week and encouraged to undertake their usual physical activity.

Self-reported physical activity
Participants were asked subjective questions regarding their *pre-stroke* physical activity participation, type, frequency, and amount, at the baseline assessment with the same questions about their *current* physical activity levels asked at the baseline and two-year assessments. Participants were asked if they participated in physical activity or exercise in the month prior to their stroke and currently (yes/no) − participants were asked to consider structured physical activity,

Table 1 Participant characteristics at study entry.

Characteristics	n = 68
Sex, n male (%)	44 (65%)
Age *(years)*, mean ± SD	64 ± 14
NIHSS at stroke onset, median [IQR]	9 [4,13]
Time post stroke *(days)*, median [IQR]	155 [78, 234]
Mobility:	
Unaided, n (%)	48, (71%)
SPS or crutch x 1, n (%)	7, (10%)
4PS, n (%)	2, (3%)
Crutches x 2, n (%)	1, (1%)
Wheeled frame, n (%)	10, (15%)
Gait speed *(metres / second)*, median [IQR]*	1.2 [0.9, 1.5]
6-minute walk test *(metres)*, mean ± SD^v	413 ± 191
LPA duration *(minutes/day)*, median [IQR]^α	163 [131, 204]
MVPA duration *(minutes/day)*, median [IQR] ^α	57 [21, 137]
Systolic Blood Pressure *(mmHg)*, mean ± SD	122 ± 13
Total Cholesterol *(mmol/L)*, mean ± SD	4.2 ± 1.2
Plasma Glucose *(mmol/L)*, median [IQR]	5.2 [4.7, 5.7]
BMI *(kg/m²)*, median [IQR]	26.0 [22.6, 29.8]

*n = 61,
^vn = 60.
^α n = 57.

4PS, four point stick; BMI, body mass index; LPA, light physical activity; MVPA, moderate to vigorous physical activity; NIHSS, National Institutes of Health Stroke Scale (0−42); SPS, single point stick.

examples provided included going for a walk, going to the gym or playing lawn bowls; the type or types of physical activity they undertook in a regular week; how often they completed each type of physical activity in a regular week; and the duration of each session.

Cardiovascular risk factors (Table 1), mobility, cognition, and fatigue were also measured. These outcomes can have been reported previously[11] and are not discussed in this paper.

Statistical analyses

Sensewear data were processed using Sensewear Version 7.0 software and SPSS version 24 (SPSS Inc., Chicago, IL) was used to analyse the data. Participant characteristics are reported descriptively as means with standard deviations for normally distributed data, and medians with inter-quartile ranges for non-normally distributed data. A power calculation for this study was not performed as it is a secondary analysis of data. The power calculation for the overarching longitudinal study calculated a target sample size of 77 participants at baseline.

To address whether people who report being active prior to stroke resume activity post stoke at two years post discharge, we calculated the proportion of participants who reported being active and inactive (yes vs no) pre-stroke and again post-stroke (two-year assessment). We also calculated the proportion of participants who reported being active both pre- and post-stroke.

To determine the types of physical activity stroke survivors perform, and whether they are the same types of activity pre and post stroke we used self-report information on activity type which we categorised into common clusters (eg. walking, going to the gym, playing tennis). These categories were then explored to determine if they were the same, similar but modified, or different pre-stroke compared to the two-year assessment at both the participant and group level.

To address the final question of whether self-reports of physical activity at two years post discharge correlate with objective measures of activity in stroke survivors at two years post discharge we firstly used Spearman correlation coefficients to determine the relationship between the weekly self-reported total minutes of structured physical activity and the total duration of objectively measured physical activity (light *plus* moderate to vigorous physical activity (>1.5 METS).[15] We also explored the relationship of self-reported structured physical activity to moderate to vigorous physical activity alone (>3 METS)[15] and time spent in 10 min *bouts* of moderate to vigorous physical activity at the two-year assessment. To further investigate the relationship between self-reported structured physical activity and objectively measured physical activity at the two-year assessment, three multiple regression models were developed. The dependant variables for each of the models were 1) objectively measured total physical activity duration (light *plus* moderate to vigorous physical activity), 2) objectively measured moderate to vigorous physical activity duration (minutes), 3) objectively measured time spent in 10-minute bouts of moderate to vigorous physical activity. The independent variables (decided a-priori) of self-reported physical activity, age, and sex were entered into the model.

To explore alignment between subjective and objective measurement in more depth we examined whether these data aligned at an individual level. For example, we sought to determine whether a participant who subjectively reported walking for 20 min three times per week, had a bout of ≥18 min of moderate to vigorous physical activity on at least three days. This was achieved through visual inspection of self-report and objectively measured moderate to vigorous physical activity, together with the use of a purpose-built custom macro, which identified bouts of at least 10 min of moderate to vigorous activity between 7am and 9pm. The percentage of participants whose self-reported and objectively measured physical activity matched (within 10% of self-report) is then reported.

Results

Sixty-eight participants had subjective data at both the baseline and two-year follow-up assessments. They were on average 64 ± 14 years old, 44 were male and 71% of the sample was able to walk unaided. Table 1 displays participant

characteristics. Fifty-seven of the 68 participants had objective physical activity data of at least three days duration at the two-year assessment. No significant differences were found between participants with complete and missing data for age, sex, time post stroke, stroke severity, or gait speed.[11] Reasons for missing data included loss to follow-up and failure to wear the Sensewear Armband for the minimum duration required for inclusion.

Pre vs post stroke self-reported physical activity

Of the 68 participants, 50 (74%) were active before stroke and 18 (26%) were not. Forty-eight of the 50 (96%) previously active participants were still active at two years and 16 of the 18 (89%) previously inactive participants were now active. Only four out of 68 participants (6%) were not active at the two-year assessment.

Types of physical activity pre and post stroke

Walking was the most commonly reported type of physical activity both pre and post stroke. Of the 48 stroke survivors who reported being active pre and post stroke, 16 (33%) reported choosing to do the same type of activity at both time points. Fourteen participants (29%) reported doing the same type of physical activity as pre-stroke and more (for example their physical therapy exercises) at the two-year follow-up. Eight participants (17%) reported choosing to do some of the same type of activity but were unable to do all of the types of physical activity that they performed pre-stroke. Ten participants (21%) reported choosing to do completely different types of physical activity pre- and post-stroke. A group summary of the types of physical activity reported by participants is outlined in Fig. 1. Fig. 2 represents an individual participant matrix for change in type of physical activity pre- and post-stroke for all 68 participants.

Correlation between self-reported and objectively measured physical activity

Self-reported physical activity duration displayed moderate correlations with each of the objectively measured physical activity measures total physical activity (r = 0.61, 95%CI: 0.42, 0.75, n = 57), moderate to vigorous physical activity (r = 0.57, 95%CI: 0.37, 0.72, n = 57), and time spent in bouts of moderate to vigorous physical activity (r = 0.57, 95%CI: 0.36, 0.72, n = 57).

Table 2 displays the results of the multiple regression analyses. Self-reported physical activity, age, and sex predicted 26.5% of the objectively measured total physical activity duration. Self-reported physical activity was an independent predictor of objectively measured total physical activity duration (p = 0.001). There was a similar pattern for the other models where self-reported physical activity, age, and sex predicted 24.3% and 22.5% of objectively measured moderate to vigorous physical activity duration and time spent in bouts of moderate to vigorous physical activity, respectively. Again, self-reported physical activity was an individually significant predictor of objectively measured physical activity in each of the models. Self-reported physical activity made a unique contribution of 19% (total physical activity), 10% (moderate to vigorous physical activity duration), and 9% (time spent in bouts of moderate to vigorous physical activity) to each model.

On inspection of individual participant data, objectively measured moderate to vigorous physical activity duration was within 10% of subjective reports of structured physical activity for only six participants (12%). Most participants (89%) overestimated their physical activity levels, particularly in terms of the number of days physical activity was undertaken, for example if they reported walking for 20 min three times per week, they may have a bout of ≥18 min of moderate to vigorous physical activity on two, but not three days. Three participants reported not participating in
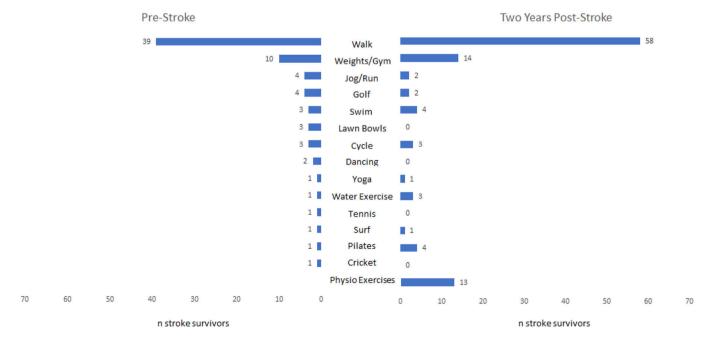

Fig. 1 Types of physical activity performed by stroke survivors pre and post stroke.
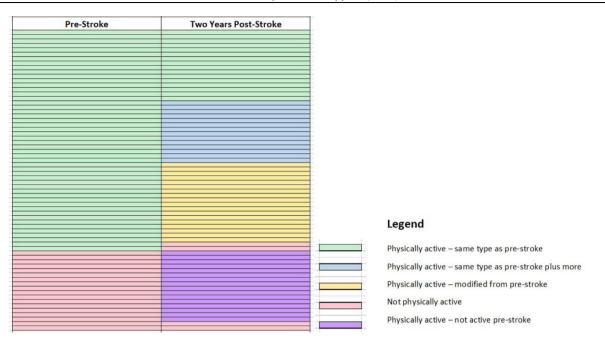
Fig. 2 Individual participant matrix for change in type of physical activity pre and post-stroke.

physical activity and two participants reported swimming, which could not be captured by the monitor, as such their data were not included in these calculations.

Discussion

This study demonstrates that most stroke survivors report undertaking physical activity; including the majority of those who reported being physically inactive pre-stroke. We were pleased to find that most (almost two thirds of) stroke survivors were able to participate in the same type of physical activity pre and post stroke. Walking was by far the most prevalent type of physical activity reported pre- and post-stroke, followed by doing weights/attending a gym both pre- and post-stroke. Self-reports of physical activity were independent predictors of objectively measured physical activity, however, the regression models demonstrated that self-reports of physical activity explain only a small proportion of the variance in objectively measured physical activity outcomes (9−19%). There was also evidence of subjective over-reporting when considering bouts of moderate to vigorous physical activity and the number of days per week that physical activity was undertaken.

An assessment of pre-stroke physical activity is an important part of any stroke assessment undertaken by a physical therapist, occupational therapist, or exercise professional. Participants overestimated the number of days on which physical activity was completed, so it is important that clinicians are very clear with their questioning and specifically ask about the physical activity performed in the *previous* week, rather than a "regular" week, as participants are likely to comment on an "ideal" weeks' worth of physical activity. This study demonstrates that many stroke survivors are able to return to the same or preferred type of physical activity that was undertaken pre-stroke. However, it should be noted that this sample of participants was relatively physically able with most participants walking faster than

one metre/second and may not be representative of all community-dwelling stroke survivors. Interestingly this study also demonstrates that stroke survivors who were not active pre-stroke were able to change their behaviour post-stroke. For both those who can and cannot return to pre-stroke exercise preferences, health professionals should be creative in exploring options and means to allow meaningful physical activity participation.[2] The Stroke Exercise Preference Inventory (SEPI)[16] is a rigorous assessment of exercise preferences which provides useful information about preferences for supervision and support, confidence, health beliefs, exercise context, exercising alone or with others, peer support, and music. This information could prove to be useful when designing sustainable physical activity programs post stroke.

Walking was the most common type of physical activity reported both pre and post stroke. There are many plausible reasons for this — there is no cost, equipment is not required, and for many (but not all) it is possible to do it independently, even when walking aids are required. There were some types of physical activity that were listed pre-stroke but not post-stroke and these were dancing, cricket, lawn bowls, and tennis — all more organised types of activity. It is known that stroke survivors can experience psychological, social, cognitive, and emotional challenges,[17] which could impact on group activities. Additionally, these activities all involve a high level of skill — namely ball skills and hand-eye coordination (tennis, lawn bowls, and cricket), complex balance and coordination (dancing and tennis), which are all likely to be affected following stroke.[18] Finally, each of these activities is also likely to have a cost involved, which is a common barrier to physical activity participation.[2,19] However, it is important that these types of leisure and social activities are explored post-stroke because motivation and enjoyment post-stroke can be improved by participating in social activities.[4] It was also interesting to note that two years following discharge from therapy 13 stroke survivors were still performing their

Table 2 The relationship between self-reported and objectively measured physical activity.

Dependant variable	Independent variable	Constant	Unstandardised β (se)	Standardised β	p value	Variance explained by model
Objectively measured total physical activity duration (minutes)	Self-reported physical activity duration (minutes)	330	2.231 (0.609)	0.435	0.001	26.5%
	Age		−2.270 (1.104)	−0.243	0.045	
	Sex		0.829 (33.835)	0.003	0.981	
	Equation: Predicted total physical activity duration = 330 + 2.231 x self-reported physical activity - 2.27 x age + 0.829 (x 1 female, x 2 male)					
Objectively measured moderate to vigorous physical activity duration (minutes)	Self-reported physical activity duration (minutes)	124	1.017 (0.387)	0.317	0.011	24.3%
	Age		−1.794 (0.701)	−0.307	0.013	
	Sex		27.271 (21.507)	0.152	0.210	
	Equation: Predicted moderate to vigorous physical activity duration = 124 + 1.017 x self-reported physical activity − 1.794 x age + 27.271 (x 1 female, x 2 male)					
Objectively measured time spent in bouts of moderate to vigorous physical activity (minutes)	Self-reported physical activity duration (minutes)	45	0.453 (0.179)	0.309	0.014	22.5%
	Age		−0.786 (0.324)	−0.294	0.019	
	Sex		11.553 (9.933)	0.141	0.250	
	Equation: Predicted time spent in bouts of moderate to vigorous physical activity = 45 + 453 x self-reported physical activity − 0.786 x age + 11.553 (x 1 female, x 2 male)					

physical therapy exercises. While this shows great dedication, it is not clear whether these exercises were still applicable and of benefit.

It is evident that stroke survivors overestimate their physical activity levels in terms of bouts of moderate to vigorous physical activity and the number of days that these bouts are performed. Subjective overestimation of physical activity has been demonstrated in previous studies post stroke.[9] Nonetheless, self-reported physical activity was largely correlated with objectively measured physical activity, and we can infer from this study that stroke survivors who report doing more physical activity do participate in more physical activity. However, there may be less confidence placed in the actual numbers reported and therefore self-report/subjective and objective measurement of physical activity provide different information. This is reinforced by the fact that the amount of variance in objective physical activity that is explained by self-reports is quite low (<20%). Objective measurement overcomes the limitations of inaccurate recall and over-reporting associated with self-report methods, however, objective measurements have their own limitations and often do not capture important rich data such as the type of physical activity and setting and context in which it takes place. Therefore, it is clear that both self-reported and objectively measured physical activity are valuable and provide distinct information, but each have their shortcomings. Where possible, it would be advantageous if physical activity were measured both objectively and by self-reports.

Strengths and limitations

This study is novel in that it investigates the types of physical activity undertaken by stroke survivors both pre and post-stroke. It follows the same participants over two years and compares subjective to objective reports in over 50 participants. Limitations include the lack of a standardised tool to measure self-reported physical activity.[20] However, the fact that participants were asked open ended questions regarding the type of physical activity performed allowed for detailed data to be collected. The retrospective nature of the questioning regarding pre-stroke physical activity is a further limitation. In terms of the objective measurement of physical activity, the Sensewear Armband has been shown to be a valid[13,14] and reliable[21] tool for measuring energy expenditure, but its validity is questioned by some studies, particularly in the acute stroke population.[21,22] Additionally, it should be noted that this study represents participants from a single site, who had received inpatient rehabilitation, were on average able to walk at a gait speed of 1.2 m/s, and many (71%) were able to walk unaided. Therefore results may not be generalisable to a broader stroke population. Finally, 16% of data for physical activity measured objectively at the two-year assessment were missing and this may also limit the robustness of the data and study generalisability.

Conclusion

Including questions about pre-stroke physical activity should be part of every physical assessment post-stroke. Clinicians should be aware that stroke survivors are inclined to overestimate their physical activity so specific and targeted questioning is warranted. Most importantly this study demonstrates that stroke survivors may be capable of returning to pre-stroke types of physical activity. Clinicians and stroke survivors should work together to facilitate participation in the stroke survivor's preferred type of physical activity. Stroke survivors may be capable of behaviour change and may be able to become physically active following stroke even when they have a history of inactivity.

Conflicts of Interest

The authors report no conflicts of interest.

Acknowledgements

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