J Rehabil Med 2015 Preview

**ORIGINAL REPORT**

# EFFECTS OF PREMORBID PHYSICAL ACTIVITY ON STROKE SEVERITY AND POST-STROKE FUNCTIONING

Marie Helene Ursin, PT, MSc[1,2], Hege Ihle-Hansen, MD, PhD[1,2], Brynjar Fure, MD, PhD[3], Arnljot Tveit, MD, PhD[2] and Astrid Bergland, PT, PhD[4]

*From the [1]Department of Medicine and [2]Department of Medical Research, Vestre Viken Hospital Trust, Bærum Hospital, Drammen, [3]Specialist Health Care Section, National Knowledge Center for the Health Services and [4]Faculty of Health Sciences, Oslo and Akershus University College of Applied Sciences, Oslo, Norway*

***Objective:*** **To explore the impact of premorbid physical activity on stroke severity and functioning, measured by activities of daily living, gait and balance during the acute period of first-ever stroke and at one-year follow-up.**
***Methods:*** **Acute phase and one-year follow-up registrations of 183 patients with first-ever stroke or transient ischaemic attack were included in the study. Gender, age, education, living arrangements, body mass index, smoking, hypertension, stroke classification and use of walking aids were recorded. Premorbid physical activity was recorded with the Walking Habits questionnaire. The outcomes post-stroke were the National Institutes of Health Stroke Scale, the Modified Ranking Scale, Barthel ADL Index, Maximal Walking Speed and Berg Balance Scale.**
***Results:*** **Significant associations ($p<0.05$) were found between the participants` pre-stroke "duration of regular walks" and functioning on all outcomes in the acute phase of stroke. Participants who walked for more than 30 min each time achieved significantly better results. The measures of gait and balance showed similar associations ($p<0.05$) at one-year follow-up.**
***Conclusion:*** **There are significant associations between premorbid walking habits and functional status after first-ever stroke. Weekly light-intensity activity, such as walking for more than 30 min, may have a sustained impact on functioning after stroke.**

*Key words:* stroke severity; physical activity; walking speed; balance; activities of daily living.

J Rehabil Med 2015; 47: XX–XX

*Correspondence address: Marie Helene Ursin, Vestre Viken Hospital Trust, NO-3004, Norway. E-mail: marie.ursin@gmail.com*

Accepted Mar 3, 2015; Epub ahead of print XXX ?, 2015

## INTRODUCTION

Stroke is the leading cause of disability and reduced quality of life in adults (1). Approximately 50% of patients will experience some degree of permanent disability after stroke, and many will require long-term rehabilitation and use of healthcare services. Reducing the severity of stroke and preventing loss of function are of great importance for individuals surviving a stroke (2); however, the effect of physical activity, such as walking habits, on stroke severity and stroke outcomes is not clear.

As with general health and longevity (3), there is strong evidence of a consistent association between physical activity (4) and reduced risk of stroke. Thus, regular physical activity is an important recommendation for stroke prevention (2). Walking is an important component of total physical activity in adult populations and one of the most common elements of physical activity across ethnicity, culture, income and age (5). A recent study, objectively assessing walking by accelerometer, found that walking duration was associated with a more favourable cardiovascular biomarker profile, even after adjustment for covariates (6). Previous studies have indicated that pre-stroke physical activity is associated with less severe stroke (7–9), but a prospective study of a male population did not find this influence (10). One study shows a dose-dependent decrease in stroke severity by physical activity (8). There is little data regarding which aspects of pre-stroke physical activity might be protective, and there is a need to determine the characteristics that influence functional outcomes, in order to provide customized recommendations. Research is needed into whether specific types of physical activity or other lifestyle factors influence functional outcome of stroke (10). Only a few studies have explored whether physical activity prior to stroke is associated with improved functional outcome after stroke (7–10), and it is not clear whether light-intensity activity provides any health benefits after stroke.

Performance in balance and gait are important for independent functioning (11), and gait measured by walking speed is recognized as a "vital sign" of health (12, 13). However, the potential impact of physical activity prior to stroke on balance and gait after stroke is not known, and the required level of physical activity is uncertain (9). In this study, we aimed to explore the impact of self-reported premorbid physical activity on stroke severity, activity of daily living (ADL), gait and balance during the acute period of first-ever stroke and at one-year follow-up. Our hypothesis was that physical activity prior to stroke is associated with favourable effects on functional status post-stroke. The aim of this study is to add knowledge about preventing disability post-stroke, and provide appropriate recommendations about physical activity.


 doi: 10.2340/16501977-1972
Journal Compilation © 2015 Foundation of Rehabilitation Information. ISSN 1650-1977

## METHODS

This one-year longitudinal follow-up study included patients with first-ever stroke or transient ischaemic attack (TIA) admitted to Bærum Hospital during the period March 2007 to July 2008. All patients were participating in a study evaluating the effect of an intervention on cognitive impairment (14). Only patients who survived the acute phase were assessed. Stroke was defined according to the World Health Organization (WHO) criteria (15). Stroke is, by definition, a clinical syndrome, and a TIA is defined as the acute loss of focal cerebral function with symptoms lasting less than 24 h (16). We included patients with TIA, since many patients with clinical TIA have signs of infarction on magnet resonance imaging (MRI), and cognitive impairments may persist after resolution of clinical symptoms, indicating potential influence on functioning (17). Follow-up registrations were performed until July 2009. Exclusion criteria were: pre-stroke cognitive impairment, dementia and previous stroke, patients with subarachnoid haemorrhage, known cognitive decline (as indicated by a score $\geq$3.7 on the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE) (18)), previous stroke or TIA; and patients who did not speak Norwegian. The Regional Committee for Medical Ethics in Norway approved the study, and written informed consent was obtained. If the patient was not able to understand the information, the next of kin gave informed consent.

Registration of physical activity, gait and balance were performed by the physiotherapists at the stroke unit, 2–6 days after the patients were admitted to the hospital, as well as at one-year follow-up. Sociodemographic characteristics, such as gender, age, education (more or less than 9 years), living arrangements, current smoking, treated hypertension before hospitalization, weight and height, were recorded. Body mass index (BMI) was calculated. The Trial of Org 10172 in Acute Stroke Treatment classification (TOAST) was used to classify patients with ischaemic stroke into 5 subgroups according to presumed aetiological mechanism: cardioembolic disease, large vessel disease, small vessel disease, unusual causes of stroke and stroke of undetermined aetiology (19). The TOAST subgroups were computed into 2 variables; "small vessel disease" and "other aetiological mechanisms."

Physical activity was recorded with the "Walking Habits" questionnaire (20, 21), which reports walking habits during the week before admission, how often and for how long. The questions used were: "Do you take a daily walk?" and "How long does your walk generally last?" (20). The questionnaire is considered as a valid measurement for walking habits and physical activity for elderly people. Regarding scores on the different questions of "walking habits", we combined the original categories into 3 and 2 categories to provide more robust analyses. The computed categories of "duration of regular walks" were <30 min, 30–60 min and >60 min and categories of "frequency of walking" $\leq$2 days and $\geq$3 days.

Gait was measured with the Maximal Walking Speed (MWS) test: subjects walked for a 10 m distance from a standing still position and the time (in s) was registered (22).

Balance was assessed using the Berg Balance Scale (BBS). The test rates performance on a 5–level scale, from 0 (cannot perform) to 4 (normal performance) on 14 different tasks involving functional balance control, including transfer, turning and stepping (23). The total score ranges from 0 to 56. MWS and BBS are commonly used to assess gait and balance in patients who have had a stroke, and have been tested according to reliability and validity (23, 24). An experienced stroke physician registered activities of daily living by the Barthel ADL-index (Barthel) (25) and stroke severity by the National Institute of Health Stroke Scale (NIHSS) (26) and the Modified Ranking Scale (mRS) (27) at discharge. All tests are widely used for stroke populations and tested for validity and reliability (28, 29).

### *Statistical analysis*

Data are described with means and standard deviations (SD) or with proportions and percentages for categorical variables. Continuous variables are analysed using independent samples *t*-tests, but with NIHSS, Barthel, MWS, BBS and when analysing the mRS, the Wilcoxon-Mann-Whitney test is used.

The associations between stroke severity and physical functioning performance (outcome variables) and premorbid walking habits (explanatory variables) were studied using linear regression. First, separate univariate regression was performed. Secondly, multivariate linear regression model in order to control for possible confounding variables; age, gender and other variables which proved to be significant, in the bivariate analyses, showed a *p*-value below 0.1 (30). Statistical analyses were performed with the Statistical Package for Social Science (SPSS), version 19 (SPSS Inc., Chicago, IL, USA). *p*-values <0.05 were considered statistically significant and all tests were 2-sided.

## RESULTS

A total of 201 patients were invited to join the study, and, of these, 198 were willing to participate. Fifteen patients were excluded: 7 did not complete the inclusion criteria (4 had an IQCODE score $\geq$3.7, 1 had an infarct in the spinal cord, 1 had had a previous TIA and 1 died before signing the consent) and 8 patients were diagnosed with other disease than stroke causing the symptoms. The mean length of stay at the stroke unit was approximately 8 days. The 183 participants at baseline were diagnosed as 135 (73.8%) with cerebral infarction, 31 (16.9%) with TIA, and 17 (9.3%) with cerebral haemorrhage. Of these, 161 participated in the follow-up registrations one year later; 13 died, 5 withdrew their consent, and 4 did not receive the physical examinations. Table I shows the baseline characteristics and follow-up registrations regarding the outcome measurements in the study.

The results of the outcome measures by the different categories of the Walking habits questionnaire "duration of regular walks" are shown in Table II.

As illustrated in Table III, multivariate regression analyses show significant associations between the walking habits categories of "<30 min","30–60 min" and ">60 min" ($p<0.005$) regarding the functional outcomes mRs, Barthel, MWS and BBS at baseline and, in addition, on MWS and BBS at the one-year follow-up. Frequency of walking ($\leq$2 days; $\geq$3 days); is significantly associated with mRs in the acute phase, but not when controlling for confounders in the multivariate analyses (Table III).

There was a significant difference between the category <30 min compared with the other 2 categories ($p<0.005$) for all outcome measures. The categories 30–60 min and >60 min did not differ significantly from each other according to NIHSS, mRs, Barthel, MWS or BBS, measured in the acute phase. The mean values seen in Table II show that the persons who walked for more than 30 min prior to stroke have better scores on the outcome measures in the acute phase.

At the one-year follow-up, the registrations of MWS in the category "<30 min" were significantly different from the categories "$\geq$30–60 min" (t=3.00, $p=0.002$) and ">60 min" (t=3.50, $p=0.001$). The same results was observed regarding BBS; the category "<30 min" was significantly different from ">60 min" (t=–2.0, $p=0.045$) and "$\geq$30–60 min" (t=– 4.7, $p=<0.001$). The mean values of MWS and BBS (Table II) illustrate that the participants who walked for less than 30 min each time prior to stroke have lower walking speed and impaired balance compared with participants in the other categories even one year after onset of stroke. The results were similar if participants with a TIA diagnosis were excluded from the analysis.

Table I. *Baseline characteristics and follow-up registrations*

| | Baseline ($n$=183) | | | | One-year follow-up ($n$=161) | | | |
|---|---|---|---|---|---|---|---|---|
| | *n* (%) | Mean (SD) | Min | Max | *n* (%) | Mean (SD) | Min | Max |
| NIHSS, points | 181 (98.9) | 2.6 (4.8) | 0 | 25 | 161 (100) | 1.9 (4.0) | 0 | 22 |
| mRS, points | 180 (98.4) | 1.5 (1.4) | 0 | 6 | 161 (100) | 1.3 (1.1) | 0 | 5 |
| Barthel, points | 180 (98.4) | 17.4 (5.2) | 0 | 20 | 161 (100) | 18.5 (3.9) | 0 | 20 |
| MWS, s | 155 (84.7) | 8.8 (2.0) | 3.1 | 48 | 147 (91.3) | 7.8 (4.3) | 3.8 | 37.9 |
| BBS, points | 178 (96.7) | 44.5 (17.6) | 0 | 56 | 157 (97.5) | 49.6 (12.7) | 0 | 56 |
| Age, years | 183 (100) | 72.1 (12.2) | 25 | 94 | | | | |
| BMI, kg/m$^2$ | 172 (94.0) | 25.6 (4.2) | 14.0 | 39.5 | | | | |
| TOAST | | | | | | | | |
| Large vessel disease | 20 (10.9) | | | | | | | |
| Cardioembolic disease | 57 (31.1) | | | | | | | |
| Small vessel disease | 48 (26.2) | | | | | | | |
| Stroke of undetermined aetiology | 58 (31.7) | | | | | | | |
| Gender (women) | 88 (48.1) | | | | | | | |
| Education (>9 years) | 140 (76.5) | | | | | | | |
| Living arrangement (cohabitant) | 122 (66.7) | | | | | | | |
| Current smoking | 39 (21.3) | | | | | | | |
| Hypertension | 110 (60.1) | | | | | | | |
| Use of walking aid indoor ($n$=173) | 13 (7.1) | | | | | | | |
| Use of walking aid outdoor ($n$=170) | 27 (15.9) | | | | | | | |
| Duration of regular walks ($n$=171) | | | | | | | | |
| 0–15 min | 25 (14.6) | | | | | | | |
| 15–30 min | 53 (31.0) | | | | | | | |
| 30–60 min | 57 (33.3) | | | | | | | |
| 1–2 h | 25 (14.6) | | | | | | | |
| >2 h | 11 (6.4) | | | | | | | |
| Frequency of walking ($n$=174) | | | | | | | | |
| Never | 4 (2.3) | | | | | | | |
| Almost never | 4 (2.3) | | | | | | | |
| 1–2 days | 20 (11.5) | | | | | | | |
| 3–4 days | 10 (5.7) | | | | | | | |
| Almost every day | 15 (8.6) | | | | | | | |
| Daily walks | 121 (69.5) | | | | | | | |

*n*: number of participants; Min: minimum value; Max: maximum value; Median: median value; Mean: mean value; 95% CI: 95% confidence interval; SD: standard deviation; min: minutes; NIHSS: National Institutes of Health Stroke Scale in points; mRS: Modified Rankin Scale in points; Barthel: Barthel ADL-index in points; MWS: Maximal Walking Speed in seconds; BBS: Berg Balance Scale in points; BMI: body mass index in numbers; TOAST: Trial of Org 10172 in Acute Stroke Treatment classification.

Table II. *Walking habits questionnaire question "duration of walking" and respective scores of the outcome measures NIHSS, mRS, Barthel, MWS and BBS*

| | Baseline ($n$=183) | | | One year follow-up ($n$=161) | | |
|---|---|---|---|---|---|---|
| Walking habits question; "duration of regular walks" | *n* (%) | Mean (SD) | 95% CI | *n* (%) | Mean (SD) | 95% CI |
| Duration of walking and respective NIHSS values | 170 (92.9) | | | 153 (95.0) | | |
| <30 min | 76 | 3.7 (6.0) | 2.3–5.1 | 67 | 3.1 (5.2) | 1.8–4.3 |
| 30–60 min | 58 | 2.0 (4.0) | 0.9–3.0 | 52 | 1.0 (2.1) | 0.4–1.6 |
| >60 min | 36 | 1.5 (3.2) | 0.4–2.6 | 34 | 1.5 (3.7) | 0.3 –2.8 |
| Duration of walking and respective mRS values | 171 (93.4) | | | 153 (95.0) | | |
| <30 min | 78 | 2.0 (1.5) | 1.6–2.3 | 68 | 1.7 (1.3) | 1.4–2.0 |
| 30–60 min | 57 | 1.1 (1.6) | 0.7–1.4 | 51 | 0.8 (0.8) | 0.6–1.1 |
| >60 min | 36 | 1.1 (1.0) | 0.7–1.4 | 34 | 1.3 (1.0) | 0.9–1.6 |
| Duration of walking and respective Barthel values | 170 (92.9) | | | 153 (95.0) | | |
| <30 min | 78 | 15.6 (6.4) | 14.1–17.1 | 68 | 17.2 (5.3) | 16.0–18.5 |
| 30–60 min | 56 | 18.8 (3.4) | 19.8–19.7 | 51 | 19.6 (1.4) | 19.2–20.0 |
| >60 min | 36 | 19.3 (3.3) | 18.1–20.4 | 34 | 19.2 (3.0) | 18.2–20.2 |
| Duration of walking and respective MWS values | 150 (82.0) | | | 140 (87.0) | | |
| <30 min | 61 | 10.5 (6.7) | 8.8–12.2 | 59 | 9.4 (5.6) | 7.9–10.9 |
| 30–60 min | 54 | 7.7 (3.2) | 6.9–8.5 | 49 | 6.7 (3.1) | 5.8–7.6 |
| >60 min | 35 | 7.4 (2.4) | 6.5–8.2 | 32 | 6.6 (1.7) | 6.0–7.2 |
| Duration of walking and respective BBS values | 169 (92.3) | | | 148 (91.9) | | |
| <30 min | 76 | 37.8 (20.3) | 33.1– 42.4 | 64 | 45.2 (15.6) | 41.3–49.1 |
| 30–60 min | 57 | 49.6 (13.5) | 46.0–53.2 | 50 | 54.5 (2.8) | 53.7–55.3 |
| >60 min | 36 | 51.7 (9.5) | 48.4–54.9 | 34 | 51.1 (12.6) | 46.7–55.5 |

NIHSS: National Institutes of Health Stroke Scale in points; mRS: Modified Rankin Scale in points; Barthel: Barthel ADL index in points; MWS: Maximal Walking Speed in seconds; BBS: Berg Balance Scale in points; min: minutes, *n*: number of participants; Mean: mean value; SD: standard deviation; 95% CI: 95% confidence interval.

Table III. *Results of unadjusted and adjusted linear regression models for premorbid walking habits and other proposed explanatory variables and the 5 outcomes at acute phase and 1-year follow-up*

| | NIHSS | | | | mRS | | | | Barthel | | | | MWS | | | | BBS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Acute phase | | Follow- up | | Acute phase | | Follow-up | | Acute phase | | Follow- up | | Acute phase | | Follow- up | | Acute phase | | Follow- up | |
| Variable | Unadj. b (p)* | Adjust. b (p)** | Unadj. b (p)* | Adjust. b (p)** | Unadj. b (p)* | Adjust. b (p)** | Unadj. b (p)* | Adjust. b (p)** | Unadj. b (p)* | Adjust. b (p)** | Unadj. b (p)* | Adjust. b (p)** | Unadj. b (p)* | Adjust. b (p) ** | Unadj. b (p)* | Adjust. b (p) ** | Unadj. b (p)* | Adjust. b (p) ** | Unadj. b (p)* | Adjust. b (p)** |
| Duration of walking (<30, 30–60, >60 min) | –1.178 (0.015) | | –0.922 (0.029) | | –0.500 (<0.001) | –0.361 (0.009) | –0.304 (0.009) | | 2.0033 (<0.001) | 1.466 (0.002) | 1.190 (0.004) | | –1.695 (0.001) | –1.400 (0.006) | –1.538 (0.001) | –1.267 (0.006) | 7.612 (<0.001) | 5.998 (<0.001) | 3.650 (0.005) | 2.270 (0.045) |
| Frequency of walking (≤2 days; ≥3 days) | –0.878 (0.401) | | –0.387 (0.672) | | –0.836 (0.005) | | –0.417 (0.095) | | 1.267 (0.248) | | 1.944 (0.029) | | –1.407 (0.229) | | –1.490 (0.155) | | 5.789 (0.128) | | 3.132 (0.283) | |
| Use of walking aid indoor (no=0) | –5.475 (<0.001) | | –5.135 (<0.001) | –3.938 (0.014) | –1.638 (<0.001) | | –1.269 (<0.001) | | 7.757 (<0.001) | | 8.279 (<0.001) | 5.204 (0.002) | –6.504 (0.001) | | –4.861 (0.026) | | 24.374 (<0.001) | | 24.932 (<0.001) | 17.122 (0.001) |
| Use of walking aid outdoor (no=0) | –2.812 (0.002) | | –1.316 (0.111) | | –1.132 (<0.001) | | –0.515 (0.025) | | 4.386 (<0.001) | | 1.894 (0.018) | | –4.299 (<0.001) | –2.963 (0.014) | –1.998 (0.055) | | 13.113 (<0.001) | | 9.733 (<0.001) | |
| Age in years | 0.056 (0.058) | | 0.049 (0.061) | | 0.024 (0.005) | | 0.018 (0.015) | | –0.107 (0.001) | | –0.084 (0.001) | –0.053 (0.030) | 0.081 (0.012) | | 0.084 (0.003) | | –0.453 (<0.001) | | –0.356 (<0.001) | –0.340 (0.009) |
| Gender (women=0) | 1.267 (0.077) | | 1.640 (0.010) | | 0.323 (0.124) | | 0.352 (0.048) | | –2.259 (0.003) | | –1.750 (0.005) | | 0.996 (0.212) | | 1.290 (0.068) | | –8.601 (0.001) | | –6.930 <0.001) | –4.758 (0.047) |
| Education (>9 years=0) | 1.500 (0.068) | | 2.336 (0.002) | 2.207 (0.006) | 0.517 (0.035) | | 0.537 (0.011) | 0.481 (0.034) | –1.164 (0.191) | | –1.810 (0.013) | | 0.099 (0.919) | | 0.840 (0.355) | | –5.144 (0.096) | – | –6.944 (0.003) | –6.375 (0.005) |
| BMI in kg/$m^2$ (<25=0) | –1.033 (0.152) | | –0.565 (0.379) | | –0.393 (0.062) | | –0.296 (0.098) | | 0.700 (0.370) | | 0.870 (0.166) | | –1.948 (0.015) | –1.608 (0.047) | –0.587 (0.412) | | 3.638 (0.172) | | 4.093 (0.041) | |
| Living arrangements (living alone=0) | –2.023 (0.008) | | –1.650 (0.018) | | –0.500 (0.024) | | –0.430 (0.022) | | 2.583 (0.001) | | 1.424 (0.036) | | –2.678 (0.002) | | –2.158 (0.006) | | 10.568 (<0.001) | | 6.085 (0.005) | |
| Smoking (yes=0) | –0.096 (0.913) | | –0.140 (0.857) | | 0.143 (0.577) | | 0.062 (0.775) | | 0.599 (0.533) | | 0.003 (0.997) | | 0.945 (0.330) | | 0.307 (0.723) | | 1.097 (0.735) | | 1.118 (0.646) | |
| Hypertension (yes=0) | –0.552 (0.451) | | –0.362 (0.578) | | –0.007 (0.975) | | –0.112 (0.538) | | 0.556 (0.483) | | –0.192 (0.763) | | –0.181 (0.825) | | –0.392 (0.586) | | 1.310 (0.629) | | –0.791 (0.698) | |
| TOAST (0=other, 1=small vessel disease) | –2.107 (0.009) | –1.783 (0.024) | –1.851 (0.009) | –1.746 (0.015) | –0.653 (0.006) | –0.558 (0.018) | –0.507 (0.012) | –0.443 (0.028) | 2.456 (0.005) | 1.902 (0.021) | 1.389 (0.047) | | –1.903 (0.030) | –1.680 (0.046) | 0.000 (1.000) | | 7.263 (0.016) | 6.336 (0.022) | 4.226 (0.056) | |

b (p): unstandardized beta and p: level of significance based on univariate regression analyses; b (p)**: unstandardized beta and p: level of significance based on multivariate regression analyses; unadj.: unadjusted analyses; adjust.: adjusted analyses; (BMI: body mass index; TOAST: Trial of Org 10172 in Acute Stroke Treatment classification; NIHSS: National Institute of Health Stroke Scale; mRS: Modified Rankin Scale; Barthel: Barthel ADL-index; MWS: Maximal Walking Speed; BBS: Berg Balance Scale).

## DISCUSSION

The present study shows significant associations between premorbid walking habits and functional outcomes after first-ever stroke or TIA. Participants registered as walking for less than 30 min each time had significantly worse results on measures of gait (maximum walking speed) and balance (Berg Balance Scale) than those who walked for more than 30 min, both in the acute phase and one year after stroke. The same associations were found between walking habits and measures of stroke severity and functioning; the groups that had walked the longest time achieved significantly better results on mRS and Barthel in the acute phase of stroke. The trend was similar, but not significant, at the one-year follow-up. According to the measurement by NIHSS there were no significant differences between the groups. In this study, frequency of walking did not have the same impact on functioning as duration of walking. There is growing evidence demonstrating that regular physical activity provides numerous health benefits (31), and the findings support the hypothesis that physical activity prior to stroke is associated with favourable effects on functional status post-stroke.

Our results indicate that walking habits have a positive impact on physical functioning post-stroke, even one year after their first stroke. Four of 5 included outcome measures were associated with premorbid physical activity measured by "duration of regular walks." To our knowledge, this is the first report showing an association between premorbid physical activity and post-stroke gait and balance in patients with first-ever stroke or TIA. Walking speed is considered a vital sign and of importance to the individual. Previously, post-stroke walking speed was found to be significantly associated with participation and quality of life (32). Danielsson et al. (33) recently demonstrated a relationship between walking capacity and participation in people with chronic stroke. Schmid et al. (34) stated that, among people with stroke, balance and self-efficacy were independently associated with activity and participation. Those walking for more than 30 min prior to stroke might have better self-efficacy in their own physical capacity and thus obtain the best stroke recovery.

Walking is a common, accessible and inexpensive form of physical activity. Furthermore, walking is aerobic and necessitates use of large skeletal muscles, and confers the multifactorial health benefits of physical activity with few adverse effects. A possible explanation as to why premorbid physical activity, such as walking habits, are associated with better functional status post-stroke may involve the same mechanisms that underlie the association between physical activity and risk for cerebrovascular disease. Physical activity has several effects that are potentially beneficial for patients with stroke and TIA, such as to lower blood pressure and improve endothelial function and lipid profiles (35, 36). In addition, physical activity can have an anti-thrombotic effect by reducing blood viscosity (37), fibrinogen levels and platelet aggregation and by enhancing fibrinolysis. Individuals with higher level of physical activity may also possess greater functional neuromuscular reserves and, as a result, minimize the effects of major strokes. Studies provide evidence about the ability of physical activity to improve depressive and anxiety symptoms (38) and, since these are significantly associated with physical functioning and health (39), might contribute to better prognosis.

The results may also relate to other factors. While physical activity clearly has positive physiological effects, such as increased fitness and strength, it also affects psychological function, such as self-efficacy (40). Due to multiple losses, such as loss of activities, stroke can be related to loss of control, and many stroke patients may experience a decrease in activities and social networks.

This study has some limitations. The retrospective registration of physical activity by use of a questionnaire depends on memory, and additional use of an accelerometer or other objective measures would have strengthened our findings, i.e. as performed in the acute phase of stroke in the study of Askim et al. (41). However, the most common way to receive information about physical activity is through observation of activity or self-report. Excluding patients with pre-stroke cognitive impairment and including only first-ever stroke patients may have influenced and limited the generalizability of the results. By excluding those with cognitive impairment and assumed cerebral degenerative disease, we might more clearly define the vascular impact. In addition, one could assume that individuals who had an active lifestyle prior to stroke were probably in better overall health than those who were inactive, thus more specific information might be of interest. Furthermore, we have no information about the intervening rehabilitation, which might have an impact on the results.

The strengths of the study include the use of performance-based tests to assess balance and gait objectively, as well as the follow-up registrations that describe the duration of the health benefits.

In conclusion, leisure-time physical activity, such as walking habits pre-stroke, is associated with favourable effects on functional outcome after stroke. Walking for more than 30 min at each walk prior to stroke may significantly improve mRs, Barthel, MWS and BBS. The findings support studies that have suggested physical activity has beneficial effects on stroke severity and physical functioning post-stroke. The recommendations of weekly physical activity lasting more than 30 min each time (42) are supported by better functioning post-stroke for the participants who reported walking more than 30 min. The results imply that light-intensity activity, such as walking, seems to have sustained impact on functioning after stroke. Thus, healthcare personnel should continue to use their influence to enhance people's level of physical activity and emphasize that even light-intensity activity, such as walking, can provide significant health benefits. Knowing that secondary prophylaxis and encouragement for changes in lifestyle are challenging, and require close supervision by health professionals post-stroke, these findings highlight the need to develop good habits early in life.

## ACKNOWLEDGEMENTS

The authors would like to thank all colleagues and participants who contributed to this study.

REFERENCES


1. Leach MJ, Gall SL, Dewey HM, Macdonell RA, Thrift AG. Factors associated with quality of life in 7-year survivors of stroke. J Neurol Neurosurg Psychiatry 2011; 82: 1365–1371.
2. McDonnell MN, Hillier SL, Hooker SP, Le A, Judd SE, Howard VJ. Physical activity frequency and risk of incident stroke in a national US study of blacks and whites. Stroke 2013; 44: 2519–2524.
3. Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT, et al. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. Lancet 2012; 380: 219–229.
4. Tully MA, Cupples ME, Chan WS, McGlade K, Young IS. Brisk walking, fitness, and cardiovascular risk: a randomized controlled trial in primary care. Prev Med 2005; 41: 622–628.
5. Siegel PZ, Brackbill RM, Heath GW. The epidemiology of walking for exercise: implications for promoting activity among sedentary groups. Am J Public Health 1995; 85: 706–710.
6. Klenk J, Denkinger M, Nikolaus T, Peter R, Rothenbacher D, Koenig W. Association of objectively measured physical activity with established and novel cardiovascular biomarkers in elderly subjects: every step counts. J Epidemiol Community Health 2013; 67: 194–197.
7. Krarup LH, Truelsen T, Gluud C, Andersen G, Zeng X, Korv J, et al. Prestroke physical activity is associated with severity and long-term outcome from first-ever stroke. Neurology 2008; 71: 1313–1318.
8. Deplanque D, Masse I, Libersa C, Leys D, Bordet R. Previous leisure-time physical activity dose dependently decreases ischemic stroke severity. Stroke Res Treat 2012; 2012: 1–6.
9. Stroud N, Mazwi TM, Case LD, Brown RD, Jr., Brott TG, Worrall BB, et al. Prestroke physical activity and early functional status after stroke. J Neurol Neurosurg Psychiatry 2009; 80: 1019–1022.
10. Rist PM, Lee IM, Kase CS, Gaziano JM, Kurth T. Physical activity and functional outcomes from cerebral va-cular events in men. Stroke 2011; 42: 3352–3356.
11. Massion J, Woollacott MH. Posture and equilibrium. In: Bronstein AM, Brandt T, Woollacott MH, editors. Clinical disorders of balance, posture and gait. London: Arnold; 1996.
12. Fritz S, Lusardi M. White paper: "walking speed: the sixth vital sign". J Geriatric Phys Ther (2001) 2009; 32: 46–49.
13. Peel NM, Kuys SS, Klein K. Gait speed as a measure in geriatric assessment in clinical settings: a systematic review. J Gerontol A Biol Sci Med Sci 2013; 68: 39–46.
14. Ihle-Hansen H, Thommessen B, Fagerland MW, Oksengard AR, Wyller TB, Engedal K, et al. Multifactorial vascular risk factor intervention to prevent cognitive impairment after stroke and TIA: a 12-month randomized controlled trial. Int J Stroke 2014; 9: 932–938.
15. WHO. The World Health Organization MONICA Project (monitoring trends and determinants in cardiovascular disease): a major international collaboration. WHO MONICA Project Principal Investigators. J Clin Epidemiol 1988; 41: 105–114.
16. National Institutes of Health. A classification and outline of cerebrovascular diseases. II. Stroke 1975; 6: 564–616.
17. Pendlebury ST, Wadling S, Silver LE, Mehta Z, Rothwell PM. Transient cognitive impairment in TIA and minor stroke. Stroke 2011; 42: 3116–3121.
18. Jorm AF, Jacomb PA. The Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE): socio-demographic correlates, reliability, validity and some norms. Psychol Med 1989; 19: 1015–1022.
19. Adams HP, Jr, Bendixen BH, Kappelle LJ, Biller J, Love BB, Gordon DL, et al. Classification of subtype of acute ischemic stroke. Definitions for use in a multicenter clinical trial. TOAST. Trial of Org 10172 in Acute Stroke Treatment. Stroke 1993; 24: 35–41.
20. Frandin K, Grimby G, Mellstrom D, Svanborg A. Walking habits and health-related factors in a 70-year-old population. Gerontology 1991; 37: 281–288.
21. Horder H, Skoog I, Frandin K. Health-related quality of life in relation to walking habits and fitness: a population-based study of 75-year-olds. Qual Life Res 2013; 22: 1213–1223.
22. Bohannon RW. Comfortable and maximum walking speed of adults aged 20–79 years: reference values and determinants. Age Ageing 1997; 26: 15–19.
23. Berg KO, Wood-Dauphinee SL, Williams JI, Maki B. Measuring balance in the elderly: validation of an instrument. Can J Public Health 1992; 83 Suppl 2: S7–S11.
24. Halsaa KE, Brovold T, Graver V, Sandvik L, Bergland A. Assessments of interrater reliability and internal consistency of the Norwegian version of the Berg Balance Scale. Arch Phys Med Rehabil 2007; 88: 94–98.
25. Sulter G, Steen C, De Keyser J. Use of the Barthel index and modified Rankin scale in acute stroke trials. Stroke 1999; 30: 1538–1541.
26. Young FB, Weir CJ, Lees KR, Committee GITS, Investigators. Comparison of the National Institutes of Health Stroke Scale with disability outcome measures in acute stroke trials. Stroke 2005; 36: 2187–2192.
27. Banks JL, Marotta CA. Outcomes validity and reliability of the modified Rankin scale: implications for stroke clinical trials: a literature review and synthesis. Stroke 2007; 38: 1091–1096.
28. O'Sullivan SB, Schmitz TJ. Physical rehabilitation. 5th edn. Philadelphia: FA Davis; 2007.
29. Goldstein LB, Bertels C, Davis JN. Interrater reliability of the NIH stroke scale. Arch Neurol 1989; 46: 660–662.
30. Altman DG. Practical statistics for medical research. 2nd edn. London: Chapman and Hall; 2006.
31. Powell KE, Paluch AE, Blair SN. Physical activity for health: what kind? How much? How intense? On top of what? Ann Rev Public Health 2011; 32: 349–365.
32. Schmid A, Duncan PW, Studenski S, Lai SM, Richards L, Perera S, et al. Improvements in speed-based gait classifications are meaningful. Stroke 2007; 38: 2096–2100.
33. Danielsson A, Willen C, Sunnerhagen KS. Is walking endurance associated with activity and participation late after stroke? Disabil Rehabil 2011; 33: 2053–2057.
34. Schmid AA, Van Puymbroeck M, Altenburger PA, Dierks TA, Miller KK, Damush TM, et al. Balance and balance self-efficacy are associated with activity and participation after stroke: a cross-sectional study in people with chronic stroke. Arch Phys Med Rehabil 2012; 93: 1101–1107.
35. Hamer M, Steptoe A. Walking, vigorous physical activity, and markers of hemostasis and inflammation in healthy men and women. Scand J of Med Sci Sports 2008; 18: 736–741.
36. Laufs U, Wassmann S, Czech T, Munzel T, Eisenhauer M, Bohm M, et al. Physical inactivity increases oxidative stress, endothelial dysfunction, and atherosclerosis. Arterioscler Thromb Vasc Biol 2005; 25: 809–814.
37. Koenig W, Sund M, Doring A, Ernst E. Leisure-time physical activity but not work-related physical activity is associated with decreased plasma viscosity. Results from a large population sample. Circulation 1997; 95: 335–341.
38. Strohle A. Physical activity, exercise, depression and anxiety disorders. J Neural Transm 2009; 116: 777–784.
39. Nelson ME, Rejeski WJ, Blair SN, Duncan PW, Judge JO, King AC, et al. Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. Circulation 2007; 116: 1094–1105.
40. Kraemer HC, Wilson GT, Fairburn CG, Agras WS. Mediators and moderators of treatment effects in randomized clinical trials. Arch Gen Psychiatr 2002; 59: 877–883.
41. Askim T, Bernhardt J, Churilov L, Fredriksen KR, Indredavik B. Changes in physical activity and related functional and disability levels in the first six months after stroke: a longitudinal follow-up study. J Rehabil Med 2013; 45: 423–428.
42. WHO. Global recommendations on physical activity for health: World Health Organization; 2010 [cited 2014 July 18]. Available from: http://www.who.int/dietphysicalactivity/factsheet_recommendations/en/.