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ORIGINAL ARTICLE

Sedentary Behavior in the First Year After Stroke: A Longitudinal Cohort Study With Objective Measures

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Abstract

Objective: To quantify longitudinal changes in sedentary behavior (ie, nonexercise seated or lying behavior) after stroke to ascertain whether reducing sedentary behavior might be a new therapeutic target.

Design: Longitudinal cohort study of patients with acute stroke who were followed over 1 year.

Setting: Acute teaching hospital or outpatient clinic, and the community after discharge.

Participants: A convenience sample of patients with acute stroke (N=96; median age, 72y, interquartile range [IQR]=64−80y; 67% men; median National Institute of Health Stroke Scale score=2, IQR=1−3) who were assessed at 1, 6, and 12 months after stroke.

Interventions: Not applicable.

Main Outcome Measures: Objective measures of amount and pattern of time spent in sedentary behavior: total sedentary time, weighted median sedentary bout length, and fragmentation index.

Results: Stroke survivors were highly sedentary, spending on average 81% of the time per day in sedentary behavior: median=19.9 hours (IQR=18.4−22.1h), 19.1 hours (17.8−20.8h), and 19.3 hours (17.3−20.9h) at 1, 6, and 12 months, respectively. Longitudinal changes in sedentary behavior were estimated using linear mixed effects models. Covariates were age, sex, stroke severity (National Institute of Health Stroke Scale score), physical capacity (6-minute walk distance), and functional independence (Nottingham Extended Activities of Daily Living Questionnaire score). Higher stroke severity and less functional independence were associated cross-sectionally with more sedentary behavior ($\beta=.11$, SE=.05, $P=.020$ and $\beta=-.11$, SE=.01, $P<.001$, respectively). Importantly, the pattern of sedentary behavior did not change over the first year after stroke and was independent of functional ability.

Conclusions: Stroke survivors were highly sedentary and remained so a year after stroke independently of their functional ability. Developing interventions to reduce sedentary behavior might be a potential new therapeutic target in stroke rehabilitation.

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Physical activity is recommended in stroke rehabilitation and provides protective benefits in the primary and secondary prevention of stroke.[1-3] However, new evidence shows that sedentary behavior in the general population has a deleterious effect on health, independently of the amount of physical activity.[4,5] This raises the question that reducing sedentary behavior, or changing patterns of sedentary behavior, may present another therapeutic target for secondary prevention and rehabilitation of stroke survivors.

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Sedentary behavior is defined as a cluster of behaviors adopted in sitting or reclining postures with low energy expenditure (eg, watching television or traveling by car).[6,7] Sedentary behavior has significant negative effects on metabolism and cardiovascular health, especially when accumulated in long uninterrupted periods, which are not compensated by engagement in health-enhancing physical activity.[4,8-11]

Behaviorally, sedentary time and low level of activity are distinct. For example, an individual can be classified as inactive (ie, not meet the recommended guidelines for physical activity) but spend little time in seated postures, whereas another individual can be physically active (eg, running for 30min/d) and yet spend prolonged periods sitting at work.

Little is known about sedentary behavior in the stroke population, specifically the amount of time spent in sedentary behavior and the manner in which sedentary time is accumulated.[12] A recent cross-sectional study reported no differences in sedentary time between stroke survivors (N=42) and healthy controls; however, time since stroke was on average 2.8 years.[13] To date, the only longitudinal study (N=25) reported a decrease in sedentary behavior at 3 months after stroke, with no further reduction at 6 months.[14] These studies were in small, nonrepresentative samples and did not account for functional ability. Furthermore, the follow-up time in the longitudinal study was relatively short.

Larger-scale, longer term studies using in-depth measures of sedentary behavior, which account for functional ability, are therefore required to record the amount and patterns of sedentary behavior over the longer term poststroke and to explore whether this is correlated with functional ability or requires specific behavioral intervention.

The objective of the present study was to characterize the longitudinal changes in the amount and pattern of sedentary behavior after stroke, using state-of-the-art objective measurement in free-living conditions on a larger, more representative sample and taking into account potential confounders: age, sex, stroke severity, and functional ability. Although this was an exploratory study, it was hypothesized that sedentary time would decrease gradually over time in line with improvements in functional ability.

Methods

Participants and study design

Participants with a recent acute hemorrhagic or ischemic stroke were recruited between July 1, 2009, and June 30, 2011, as part of a longitudinal cohort study of fatigue after stroke (the Edinburgh Fatigue after Stroke study).[15,16] Patients were admitted to the Western General Hospital or the Royal Infirmary of Edinburgh, or were seen in an outpatient clinic. Exclusion criteria were subarachnoid hemorrhage (unless secondary to an intraparenchymal hemorrhage), dysphasia or cognitive impairments severe enough to preclude them giving informed consent, medical instability, and/or being considered too unwell by the clinical team to participate. Written informed consent was obtained from all participants. The study was approved by the Lothian Research Ethics Committee. Participants underwent assessments at 1, 6, and 12 months after stroke, which included a structured interview to identify participants with clinically significant fatigue and measurement of physical activity. Figure 1 shows the study protocol.

List of Abbreviations:

IQR	interquartile range
6MWT	6-minute walk test
NEADL	Nottingham Extended Activities of Daily Living Questionnaire
NIHSS	National Institute of Health Stroke Scale

Measurements and procedures

Demographic and clinical characteristics were obtained from medical records, including stroke subtype according to the Oxfordshire Community Stroke Project classification [17] and stroke severity according to the National Institute of Health Stroke Scale (NIHSS).[18,19] The NIHSS is a 15-item systematic assessment tool that provides a quantitative measure of stroke-related neurologic deficit in the early stages after stroke. The maximum possible total score is 42 (representing the most severe neurological deficit). General cognitive functioning was measured using the Mini-Mental State Examination[20] at the 1-month assessment.

Sedentary behavior

Sedentary behavior was objectively measured using the activPAL[a] activity monitor. This monitor reliably detects sedentary postures via inclinometry of the thigh[21,22] and has been validated in patients with stroke.[23] Participants wore the activPAL sensor on the leg unaffected by stroke for up to 7 consecutive days. The activPal is capable of recording for a maximum of 7 consecutive days, and we used all available data.

Individual days of activPAL data were screened using PAL Analysis[a] (version 5.9.1.1) software, and valid days, defined as a 24-hour day of recording without any spurious data (eg, because of an interruption in wearing time), were identified. A recent study showed that for postural sensors such as the activPal, a single 24-hour recording period is sufficient for the analysis of sedentary behavior.[24]

Data were further processed using MATLAB[b] (version R2012b). Diurnal sedentary time curves were calculated by summing the sedentary time (min) for each hour of the day, separately for each follow-up assessment, and averaging data across all valid days.

Bouts of time spent sitting or lying were extracted from the activPAL data. No attempt was made to remove sleep time (both during day and night). Three metrics were extracted from the data to quantify the volume and pattern of sedentary behavior[6]: (1) Total sedentary time: The total sedentary time (h/d) was computed by summation of all sedentary bouts (an uninterrupted period of sitting or lying down) divided by the number of days of recording for each individual. (2) Weighted median sedentary bout length: The length of the sedentary bout that corresponded to 50% of accumulated sedentary time (ie, the 50% weighted percentile median bout length) was selected for each individual. A lower weighted median sedentary bout length suggests that sedentary time was accumulated predominantly in smaller bouts. (3) Fragmentation index: The fragmentation index was calculated as the ratio of the number of sedentary bouts divided by total sedentary time for each individual. This measure of behavior dynamics summarizes the pattern of accumulation of sedentary time in 1 single metric.[25] A higher fragmentation index indicates that sedentary time is more fragmented because it is predominantly accumulated in frequent shorter bouts rather than a few prolonged periods.[6,25]