Self-Reported Physical Activity and Cardiovascular Disease Risk Factors in Patients with Lacunar Stroke

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Background: Physical inactivity is a major modifiable risk factor for stroke. The aim was to explore if stroke patients admitted with lacunar stroke adhere to the international recommendations on physical activity prestroke (≥150 minutes of moderate-intensity activity, or ≥75 minutes of vigorous-intensity activity, or an equivalent combination). Further, to assess association between prestroke physical activity and cardiovascular disease (CVD) risk factors. *Methods:* A cross-sectional study, including patients with lacunar stroke according to the Trial of Org 10172 in Acute Stroke Treatment criteria. Data collected included prestroke physical activity using the self-reported Physical Activity Scale. Cardiorespiratory fitness was estimated as the power output from the Graded Cycling Test with Talk Test and sociodemographic factors including age, sex, education, and CVD risk factors including pre-existing diabetes, history of hypertension, body mass index, and lipids were assessed. *Results:* We included 19 women and 52 men (mean age 64 years). Overall, 79% of the recruited patients adhered to the physical activity recommendations prestroke, but only 35% did vigorous-intensity activity. Prestroke physical activity was associated with a history of hypertension. *Conclusions:* A high proportion of the lacunar stroke patients reported to adhere to the recommendations on physical activity prestroke; however, only one third engaged in vigorous-intensity activity. Studies are warranted to investigate if vigorous-intensity activity is effective as secondary prevention in patients with a lacunar stroke.

Key Words: Cardiorespiratory fitness—cardiovascular disease risk factors—lacunar stroke—physical activity—secondary stroke prevention

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Background

Physical inactivity is one of the most important modifiable risk factors to prevent lifestyle-associated diseases such as stroke.[1] The American Heart Association and the World Health Organization[2] recommend a weekly minimum of 150 minutes of moderate-intensity activity, 75 minutes of vigorous-intensity activity, or an equivalent combination of the two. This recommendation applies to all individuals aged 65 years or older[2] and to individuals aged 50-64 years with chronic conditions or functional limitations affecting ambulation or cardiorespiratory fitness.[3]

The literature highlights associations between a high level of physical activity in healthy individuals and reduced risk of stroke.[4] Whether this also applies to risk of recurrent stroke in patients with a well-known cardiovascular event has not yet been fully established.[5] Physical inactivity[6] and low cardiorespiratory fitness[7] are both risk factors for stroke, whereas physical activity reduces stroke severity and improves long-term outcomes, 2 years after the first-ever stroke.[8] Increasing age is reported to affect cardiorespiratory fitness negatively.[9]

We hypothesized that patients diagnosed with lacunar stroke generally did not adhere to the recommendations on physical activity prestroke, corresponding to the reports that physical inactivity is one of the major risk factors for stroke.[1] Further, if prestroke physical activity is low, it may be associated with low cardiorespiratory fitness. To evaluate this, we investigated self-reported prestroke physical activity and cardiovascular disease (CVD) risk factors, including cardiorespiratory fitness, body mass index (BMI), blood pressure, lipids, and smoking and drinking habits in patients recently diagnosed with lacunar stroke.

Methods

Design

We analyzed baseline data from a randomized controlled trial (home-based aerobic exercise in patients with lacunar stroke: design of the High-Intensity interval Training in PAtients with Lacunar Stroke (HITPALS) randomized controlled trial).[10] This study was approved by the Danish Data Protection Agency (ID: HGH-2015-021) and the Research Ethics Committee in the Capital Region of Denmark (H-15012371). Eligible patients provided written informed consent before enrollment and the study was registered at ClinicalTrials.gov (NCT02731235, registered January 2016) and reporting adhered to the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) statement.[11]

Setting

Following stroke diagnosis and acute treatment, patients were enrolled consecutively from stroke units at hospitals in the Capital Region of Copenhagen, Denmark: Herlev Gentofte Hospital, Rigshospitalet, and Nordsjaellands Hospital, recruitment period from January 2016 to January 2018. All assessments were carried out at Herlev Gentofte Hospital.

Participants

Patient records were screened each morning for eligible patients, and patients were approached during hospital stay and invited into the study if they were admitted with a first-time or a recurrent event of a lacunar stroke caused by small artery occlusion according to the Trial of Org 10172 in Acute Stroke Treatment criteria.[12] Patients were enrolled after clinical and imaging-based verification of diagnosis by a neurologist. Inclusion criteria were as follows: age 18 years or older, ability to speak, read, and understand Danish. Patients were excluded if they had previous large artery stroke, atrial fibrillation, aphasia, dementia, hypertension or diabetes not successfully treated, cardiac or lung disease, carotid artery stenosis greater than 50%, symptoms, or comorbidities that did not allow aerobic exercise on a bicycle ergometer.

Procedure

After hospital admission, diagnostic brain magnetic resonance imaging was acquired as part of clinical workup on a 1.5T clinical system (Achieva, Philips Healthcare, Best, the Netherlands) using diffusion-weighted imaging, apparent diffusion coefficient value, fluid-attenuated inversion recovery, and T2*-weighted image.

From enrollment to first trial visit, eligible patients completed a self-report questionnaire (Physical Activity Scale version 2.1 [PAS2]) at home describing their average weekly physical activity behavior 2 weeks prior to hospital admission. The first trial visit took place 12 $\pm$ 7 days poststroke hospital admission with assessment of CVD risk factors (biomarkers, blood pressure, and BMI) and cardiorespiratory fitness. All assessments were performed by the study coordinator except evaluation of cardiorespiratory fitness, which was carried out by a specially trained physiotherapist.

Variables

Prestroke physical activity

We evaluated prestroke physical activity using PAS2, in which patients estimated time spent on various activities.[13] The PAS2 comprises 9 questions in total. Six questions address the time spent daily on each of the following activities: sleep, sitting down at work, standing/walking at work, heavy physical work during working hours, active commuting to/from work, and sedentary behavior. The remaining 3 questions focus on time spent weekly on light-intensity, moderate-intensity, and vigorous-intensity activity during leisure time.[13]

Each activity corresponds to a specific metabolic equivalent of task (MET) intensity according to the compendium of physical activity.[14] Physical activity was estimated as a total 24-hour MET score. The performed daily activities were divided into 1 of 4 categories: sleep, sedentary behavior, light activity, and moderate/vigorous activity. Sleep corresponded to 0.9 MET. Television viewing, reading, and sitting down during working hours were categorized as sedentary behavior (1-1.5 MET). Standing/walking at work and light leisure-time physical activity were categorized as light activity (2-3 MET). Active commuting to/from work, heavy physical work during working hours, and moderate leisure-time physical activity and vigorous leisure-time physical activity were categorized as moderate/vigorous activity (≥4 MET). The total time reported per 24 hours was calculated by adding the hours from all the questions in PAS2, we added or subtracted time that was not accounted for to the category light physical activity (2 MET), similar to previous studies.[13]

Cardiorespiratory fitness

Cardiorespiratory fitness was assessed by the Graded Cycling Test with Talk Test (GCT-TT), a submaximal aerobic exercise test performed on a bicycle ergometer (Monark 928E-G3, Vansbro, Sweden).[15,16] The outcome of the test was exercise intensity expressed as Watts (W). The GCT-TT identifies the exercise intensity at which the patient perceives that it is no longer possible to speak comfortably due to excessive breathing.[15,16] The workload was increased by 15 W each minute, and at the end of each minute, the patient recited a standardized text passage. The test was stopped when the patient was no longer able to speak comfortably. A detailed test protocol has previously been published,[15] and the test showed high reliability and only minor measurement errors in patients with ischemic heart disease,[16] and in patients with lacunar stroke.[15]

Cardiovascular risk factors and sociodemographic factors

We drew venous blood from patients at inclusion to assess level of triglycerides, total cholesterol, low-density lipoproteins (LDL) and high-density lipoproteins as part of the routine analyses.

Blood pressure (Microlife BP A100/Microlife BP A3L Comfort, Widnau, Switzerland) was recorded after an overnight fast with the patient in a supine position. BMI (body weight/height^2 [kg/m^2]) was measured by a body composition monitor (OMRON HBF-500-E, Kyoto, Japan). The following sociodemographic factors and CVD risk factors were collected and categorized systematically from the patients or patient records: age, sex, mobility, marital status, occupation, education level, previous stroke, hypertension and hypercholesterolemia upon admission, history of hypertension, pre-existing diabetes, smoking, and drinking habits.

Statistical analyses

Descriptive statistics were used to characterize the study population, report poststroke health profile in patients with lacunar stroke, and to evaluate whether patients adhered to the recommendations on physical activity for health. An unpaired *t*-test was used when analyzing continuous variables, and Fisher's exact test was used for categorical variables. Data are presented as mean ± standard deviation unless otherwise indicated.

To evaluate the association between prestroke physical activity level (moderate-/vigorous-intensity activity; dependent variable) and CVD risk factors and sociodemographic factors (independent variables)—sex, age, education, pre-existing diabetes, history of hypertension, total cholesterol, LDL, and BMI—a multiple linear regression analysis was performed. No further confounders were included. All tests were 2-tailed at a significance level of $P \leq 0.05$. Statistical analyses were performed using Microsoft Excel 2010 (Microsoft Corporation, Redmond, WA) and IBM SPSS Statistics version 22 (Armonk, NY).

Results

Baseline characteristics

In total, 129 eligible patients with lacunar stroke were identified, 58 patients (45%) declined participation: 25 patients with no reason, 21 due to reduced mental surplus, 8 due to pain, and 4 because of work obligations. Of the declining patients, 31 were men (mean age 70 ± 9 years) and 27 were women (mean age 69 ± 11 years). During the physical examination visit, 1 patient did not complete the cardiorespiratory fitness test due to fatigue of the paretic leg, and 2 LDL samples were not available for technical reasons related to a high level of triglyceride.

A total of 71 patients with lacunar stroke were included in the study with a mean of 6 ± 4 days (range 1-17) after hospital admission for stroke. The majority (73%) were men, and the mean age for all patients was 64 ± 9 years (Table 1).

Physical activity, prestroke

Self-reported data on prestroke physical activity (PAS2) showed that 56 patients (79%) adhered to the international minimum recommendations on physical activity to improve health, whereas 15 (21%) did not (Fig 1). Overall, patients who did not adhere to the recommendations on physical activity did not differ significantly from patients who did adhere in terms of baseline characteristics (Table 2). The 56 patients who adhered to the recommendations engaged in a mean of 1 hour and 30 minutes/day in a combination of moderate-intensity and vigorous-

Table 1. *Patient characteristics of the total study population*

Characteristics	Patients (n = 71)
Men, n (%)	52 (73)
Age, years (mean ± SD) [range]	64 ± 9 [42−80]
Mobility	
Without walking aids, n (%)	63 (89)
Prestroke use of walking aids, n (%)	1 (1)
Marital status	
Cohabitates, n (%)	47 (66)
Lives alone, n (%)	24 (34)
Occupation	
Working full-time, n (%)	33 (47)
Retired, n (%)	36 (51)
Student, n (%)	1 (1)
Unemployed, n (%)	1 (1)
Education	
Primary education, n (%)	5 (7)
Apprenticeship, n (%)	20 (28)
Upper secondary education/high school, n (%)	3 (4)
Short-cycle tertiary education, n (%)	9 (13)
Bachelors or equivalent, n (%)	17 (24)
Masters, equivalent or higher, n (%)	17 (24)
Sequelae of lacunar stroke, n (%)	7 (10)
Previous clinical symptoms, n (%)	14 (20)
Thrombolysis, n (%)	7 (10)
Clinical symptoms on admission	
Paresis/dexterity of extremities, n (%)	48 (68)
Sensory impairments of the extremities, n (%)	26 (37)
Facial palsy, n (%)	22 (31)
Dysarthria, n (%)	18 (25)
Vertigo, n (%)	15 (21)
Visual problems, n (%)	7 (10)

intensity activity, while the 15 patients who did not adhere to the recommendations engaged in a mean of 7 minutes/day of moderate-intensity activity and did not perform vigorous-intensity activity at all. In total, 25 patients (35%) performed vigorous-intensity activity for a mean of 2 hours and 53 minutes/week.

The total study population reported that, prestroke, they slept mean 7 hours and 21 minutes ± 1 hour and 9 minutes/day (range 4-12 hours), engaged in sedentary behavior: mean 6 hours and 11 minutes ± 2 hours and 33 minutes/day (range 2-15 hours), engaged in light activity: mean 9 hours and 16 minutes ± 2 hours and 34 minutes/day (range 1 hour and 26 minutes to 14 hours and 30 minutes) and engaged in moderate/vigorous-intensity activity for a mean: 1 hour and 11 minutes ± 1 hour and 8 minutes/day (range 0-5 hours). The wide range of hours spent on each activity demonstrates individual differences among the patients (Fig 2A,B). Hours not accounted for by patient self-report (residual activity) were categorized as light activity; these hours comprised approximately 75% of all light activity.

The total study population had a mean 24-hour MET score prestroke of 39 ± 5 METs. The 56 patients who adhered to the recommendations had a mean 24-hour MET score of 41 ± 5 METs, while the 15 patients who did not adhere to the recommendation had a mean score of 35 ± 2 METs.

Associations between prestroke physical activity and sociodemographic factors and CVD risk factors

The potential interaction of self-reported physical activity and sociodemographic factors and CVD risk factors (Table 3) was analyzed by multiple linear regression. There was a significant association between PAS2 (moderate/vigorous-intensity activity prestroke) and previous history of hypertension: patients without a previous history of hypertension reported doing 5 hours and 42 minutes/week more of moderate/vigorous-intensity activity prestroke than patients with a previous history of hypertension.

Discussion

We found that the majority (79%) of our study population adhered to the international minimum recommendations on physical activity to improve health prestroke. Though active, only 35% (25 patients) of the total patient population reported vigorous-intensity activity. The baseline characteristics of patients who did not adhere to the recommendations (15 patients) did not differ significantly from those who were active.

A health survey of the Danish general population from 2017 on physical activity[17] used a different questionnaire than PAS2. However, the questions regarding time spent doing moderate-intensity and vigorous-intensity activity during an average week and time of sedentary behavior during an average day were, almost identical to the corresponding questions used in PAS2. The survey showed that 71% of the Danish population, including those 16 years of age or older, met the international minimum recommendations on physical activity, with higher activity in younger age and men being more active than women. Surprisingly, our study supports these data in a stroke population, though we saw no age or gender difference in adherence to exercise (Table 2), except for those adhering to both moderate-intensity and vigorous-intensity activity where an over-representation of men were seen. These results call for further investigations into the activity required to reduce risk of lacunar stroke, or whether physical activity is of less importance in lacunar stroke compared with other stroke subtypes.

The international recommendations on weekly physical activity to improve health specify the minimum number of hours of exercise required to reduce risk of lifestyle-associated disease.[2] For additional health benefits, individuals are encouraged to double the time spent on moderate-intensity activity (300 minutes) or vigorous-intensity

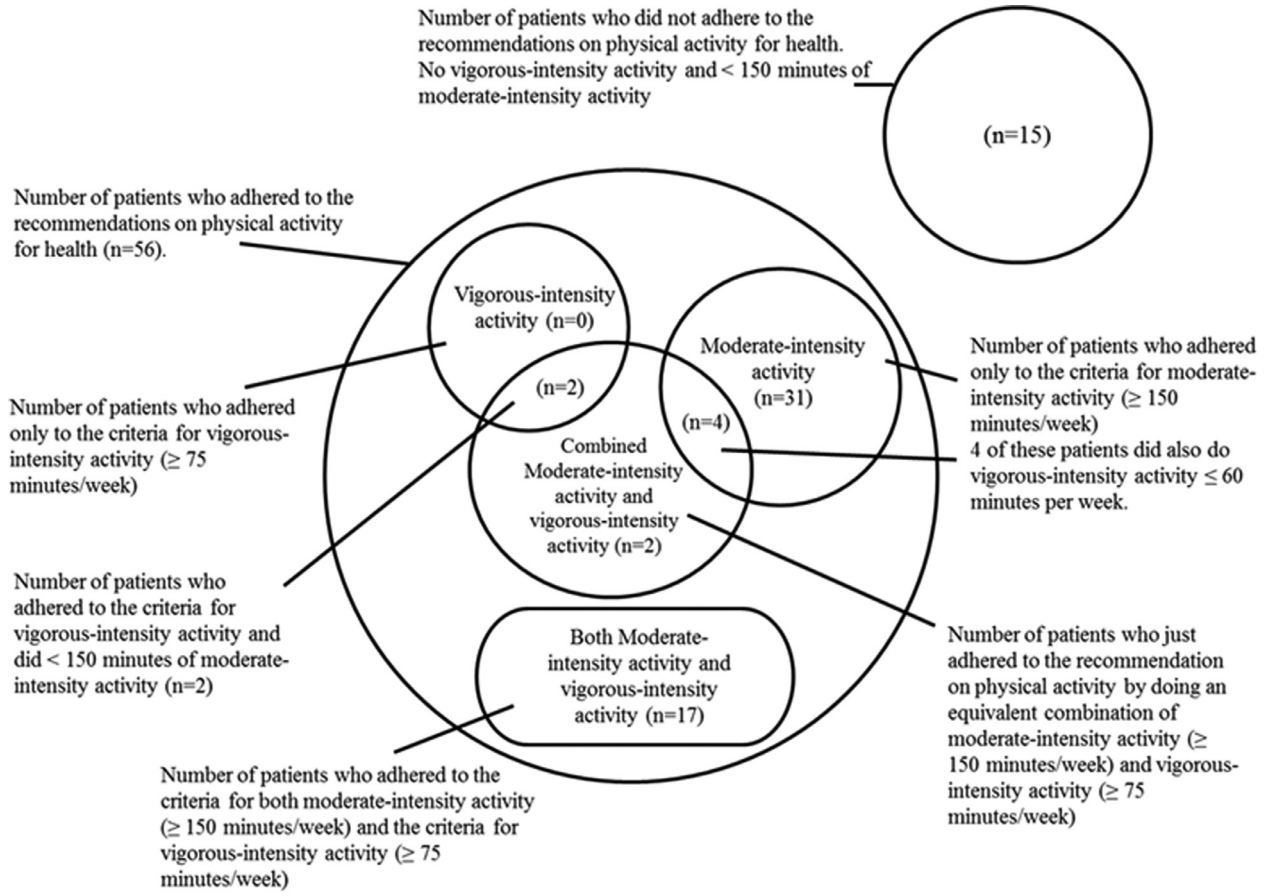

Figure 1. *Number of patients and their self-reported engagement in physical activity, prestroke. A total of 56 patients adhered to the recommendations on physical activity for health by performing either moderate-intensity activity (≥150 minutes/week), vigorous-intensity activity (≥75 minutes/week), or an equivalent combination.*

activity (150 minutes) or an equivalent combination of both, weekly.[2] In this study, we also saw a considerable variation of individual adherence among the patients who fulfill the recommendations on physical activity, and a difference in moderate/vigorous-intensity activity between the groups who adhered and those who did not adhere to the recommendations (Fig 2A,B). Literature shows that physical activity, including cardiorespiratory fitness, helps reduce the risk of hypertension, CVD, and stroke.[18,19] A greater health benefit appears to occur with longer duration, higher frequency and/or higher intensity of activity,[19] and a direct dose-response relation is shown between higher duration, frequency, volume, and intensity of activity, and reduced risk of coronary heart disease and cardiovascular disease.[18,19]

Patients with symptoms of minor stroke (not classified according to Trial of Org 10172 in Acute Stroke Treatment criteria) or transient ischemic attack show a 5.8%-11.7%

Table 2. *Characteristics of the patients who did or did not adhere to the recommendations on physical activity for health, prestroke**

Characteristics	Did adhere (n = 56)	Did not adhere (n = 15)	*P* value
Men, n (%)	41 (73)	11 (73)	1.0
Retired, n (%)	27 (48)	9 (60)	.56
Age, years (mean ± SD)	64.0 ± 8.9	63.0 ± 10.5	.73
GCT-TT, W (mean ± SD)	118.4 ± 50.3†	99.0 ± 46.0	.18
BMI, kg/m^2 (mean ± SD)	26.4 ± 4.1	27.5 ± 3.9	.36
Total cholesterol, mmol/L (mean ± SD)	5.5 ± 1.4	5.2 ± 1.1	.46
LDL, mmol/L (mean ± SD)	3.2 ± 1.1‡	2.9 ± 1.1	.38

*Recommendations on physical activity for health: moderate-intensity activity greater than or equal to 150 minutes/week, vigorous-intensity activity greater than or equal to 75 minutes/week or an equivalent combination.
†n = 55.
‡n = 54.

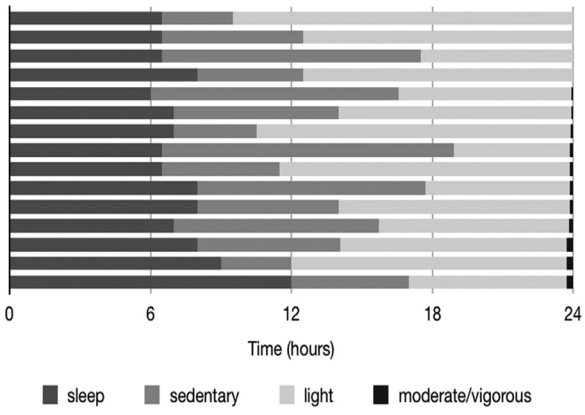

Figure 2. *Overview of 24-hour physical activity profile, prestroke: (A) patients who did not adhere to the recommendations on physical activity, prestroke (n = 15); and (B) patients who adhered to the recommendations on physical activity, prestroke (n = 56). For both figures, each horizontal line represents 1 individual patient (n = 71) and the patients are arranged by ascending time of moderate/vigorous intensity activity. (B) A considerable variation of individual adherence among the patients who adhered.*

risk of recurrent transient ischemic attack or stroke within the first 90 days after stroke onset.[20,21] Thus, early intervention related to modifiable risk factors such as physical activity may be important to initiate early poststroke.[22] The INTERSTROKE study, an international case-control study investigating 10 potentially modifiable risk factors associated with stroke, found that physical inactivity was one of the major modifiable risk factors for stroke.[1]

In contrast to our hypothesis, many patients in this study adhered to the international recommendations on physical activity, although they mainly reported moderate-intensity activity rather than vigorous-intensity activity. Previous research on cardiac rehabilitation suggests that regular exercise with an intensity level of 13-15 on Borgś scale of exertion[23] (corresponding to >6 METs) is advised to obtain positive effects on secondary prevention.[24] It is unknown if this also applies to patients with a history of stroke.[5] Further research is warranted to determine the "dose" (e.g., type, duration, frequency, intensity,

Table 3. *Poststroke profile in terms of cardiovascular disease risk factors*

Risk factors	Numbers/average scores
Hypertension at hospitalization, n (%)	58 (82)
Hypertension known from previously, n (%)	35 (49)
Hypercholesterolemia at hospitalization, n (%)	65 (92)
Pre-existing diabetes, n (%)	8 (11)
BMI, kg/m^2 (mean ± SD)	27 ± 4
Smoking	
Current smokers, n (%)	15 (21)
Previous smokers, n (%)	34 (48)
Non-smokers, n (%)	22 (31)
*Alcohol consumption**	
<Health authorities recommendations, n (%)	44 (62)
>Health authorities recommendations, n (%)	27 (38)
Biomarkers	
Total cholesterol, mmol/L (mean ± SD)	5.5 ± 1.3
Low-density lipoproteins†, mmol/L (mean ± SD)	3.1 ± 1.1
High-density lipoproteins, mmol/L (mean ± SD)	1.4 ± .4
Triglyceride, mmol/L, (mean, range)	1.6 (.7-15.5)
Blood pressure	
Systolic pressure, mm Hg (mean ± SD)	148 ± 21
Diastoloc pressure, mm Hg (mean ± SD)	88 ± 11
Infarct, time	
Acute/subacute lacunar infarct, n (%)	64 (90)
First-time lacunar stroke, n (%)	38 (54)
Recurrent lacunar stroke, n (%)	6 (8)
Only older lacunar infarct verified on MRI, with clinical symptoms, n (%)	7 (10)
First-time lacunar stroke but also sequela lacunar stroke verified on MRI, n (%)	20 (28)
Infarct localization	
Right hemisphere, n (%)	41 (58)
Left hemisphere, n (%)	27 (38)
Bilateral, n (%)	3 (4)

*The Danish health authority recommends less than 7 units/week for women (1 unit equals 1 glass of wine) and for men less than 14 units per week.
†n = 69.

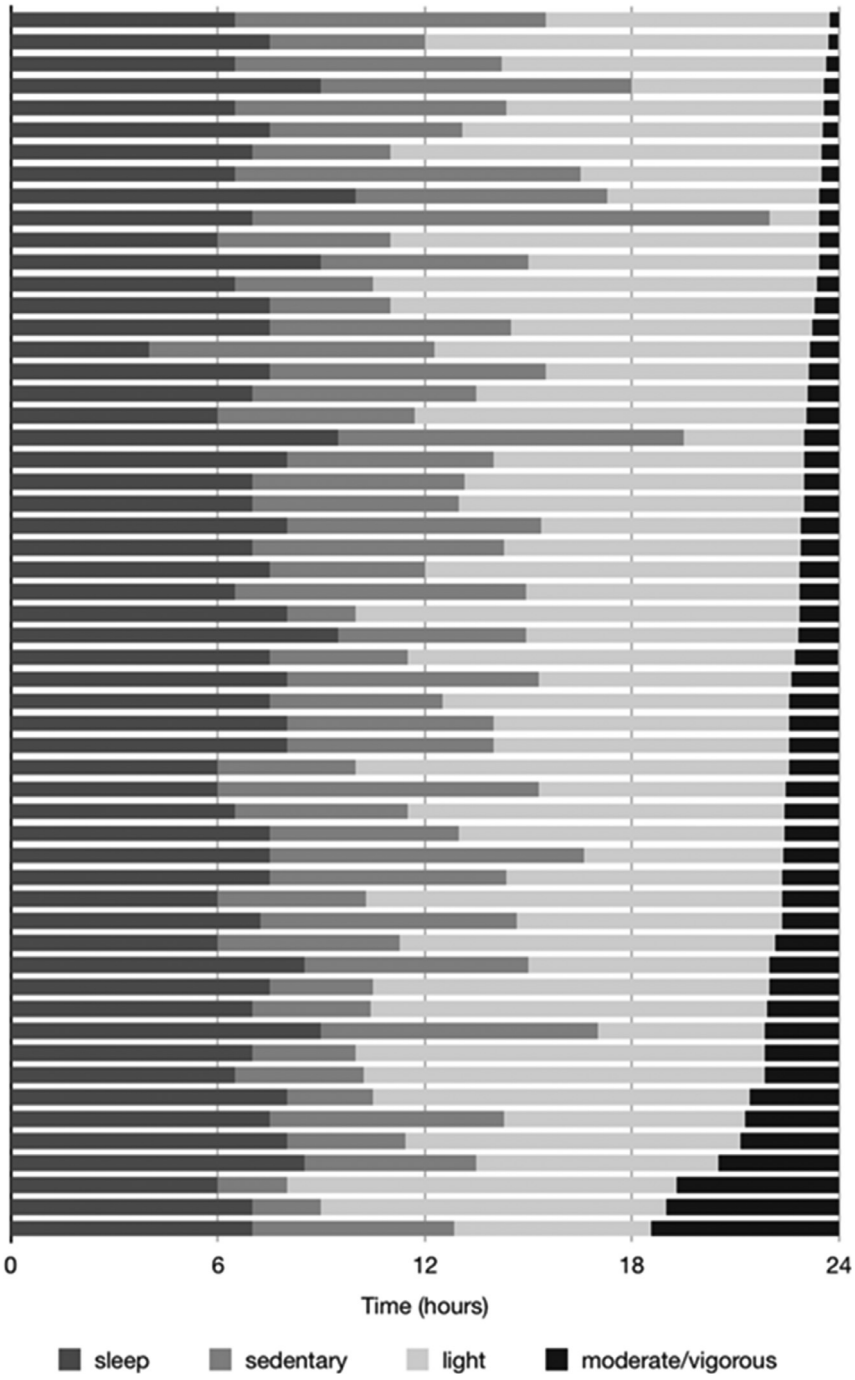

Figure 2. *Continued*

volume) of physical activity necessary to provide the most optimal health benefits for patients with a history of stroke. Nevertheless, even a small move from the category of "no activity" to "some level" of activity may be effective.[2]

Though the study population adhered to the recommendations on physical activity prestroke, this effort was not reflected in the objective cardiorespiratory fitness measure, the GCT-TT power output. The patients included in this study showed a similar GCT-TT power output as that of patients included in our previous reliability study of GCT-TT in lacunar stroke.[15] In the test/retest reliability study, we included both inpatients and outpatients (after 3 months) with lacunar stroke and found a mean GCT-TT power output of 114.8 ± 37.0 W in the first test and 114.0 ± 35.6 W in the retest.[15] Showing that patients with lacunar stroke have almost an identical cardiorespiratory fitness level (GCT-TT power output) from prestroke to 3 months poststroke. Furthermore, our study population had a similar GCT-TT power output

(mean 114.3 ± 49.7 W) compared with patients with ischemic heart disease (mean 104.3 ± 30.4 W).[25]

This study has certain limitations that should be considered when interpreting the results. First, there is a potential for selection bias as patients included in this study were participants in a randomized controlled trial where patients were randomized to 3-month high-intensity interval training or usual treatment, this may attract patients who are already more physical active than an unselected population of patients with lacunar stroke. Second, including only patients with lacunar stroke who tend to be younger[26] than the stroke population in general may limit the generalizability of the results to other categories of stroke patients. Also, many of the recruited patients were men, which may limit the generalizability. However, the sex difference seen in this study reflects the higher stroke incidence in younger men compared to aged-matched women.[27] Additionally, as reported in a validation study on PAS in healthy individuals,[28] our patients showed difficulties in recalling the time spent on sedentary behavior and light-intensity activity, as the total number of hours reported in the PAS2 rarely added up to 24 hours. This may skew the results toward under-reporting minor activity. Similarly, it was found that healthy individuals typically recall the duration of physical activity but overestimate the intensity of the activity.[28] The same study also found a trend toward overestimation of physical activity in 24-hour MET score when using PAS2.[28] Of note, the validity of self-reported questionnaires is debatable, and this type of questionnaire is prone to significant bias. Though, self-reported questionnaires reveal the patient perspective, they should be supplemented by more objective measures. In our study, the use of self-report questionnaires can lead to overestimation of volume as well as intensity of physical activity. The surprisingly positive result of the present study may represent an optimistic estimate of prestroke physical activity, thus results should be interpreted with caution.

Conclusions

Contrary to our hypothesis, most of the patients (≈80%) in the present study exhibited self-reported prestroke physical activity in agreement with or exceeding the international recommendations on physical activity for health. However, only 1 in 3 patients reported that they engaged in any vigorous-intensity activity prior to their stroke, and the average cardiorespiratory fitness level of the patients was only slightly better compared to patients with ischemic heart disease from the same geographical area. Studies on the potential beneficial effect of exercise as a secondary prevention strategy to individuals with lacunar stroke with a special emphasis on vigorous-intensity activity are warranted.

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Author Contributions

All the authors contributed to the study conception and design. R.S.K. and C.K. contributed to obtain funding. R. S.K., A.V., and C.K. drafted the manuscript. All authors reviewed the manuscript, provided comments and revisions as well as read, and approved the final manuscript.

Conflicts of Interest

The authors have no conflicts to declare.

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