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ORIGINAL RESEARCH

Characterizing Energy Expenditure During Sedentary Behavior After Stroke

Olaf Verschuren, PhD,[a] Femke de Haan, MSc,[b] Gillian Mead, MD,[c] Ben Fengler, MPA,[d] Anne Visser-Meily, PhD[a]

From the [a]Brain Center Rudolf Magnus and Center of Excellence for Rehabilitation Medicine, University Medical Center Utrecht, Department of Rehabilitation, Utrecht, The Netherlands; [b]De Hoogstraat Rehabilitation, Utrecht, The Netherlands; [c]Center for Clinical Brain Sciences, University of Edinburgh, Edinburgh, UK; and [d]Department of Rehabilitation, University Medical Center Utrecht, Utrecht, The Netherlands.

Abstract

Objectives: To measure and calculate the energy expended by people with stroke during near sedentary behaviors (lying, supported and unsupported sitting, standing, wheelchair propulsion, walking), under controlled laboratory conditions, and to compare these values with the energy expenditure of 1.5 metabolic equivalent task (MET) within the definition of sedentary behavior.

Design: Cross-sectional cohort study.

Setting: Rehabilitation institutions.

Participants: People with stroke (N=27; mean age, 61.0±11.7y), categorized at Functional Ambulation Categories (FAC) 0 to 5.

Interventions: Not applicable.

Main Outcome Measures: Energy expenditure (measured using indirect calorimetry) expressed in METs. The recorded values were calculated for every participant and averaged for each activity: lying, supported and unsupported sitting, standing, wheelchair propulsion, and walking. Calculations were done for the total group and categorized by the FAC.

Results: For the total group the mean METs ± SDs were 1.04±.11 for sitting supported, 1.09±.15 for sitting unsupported, 1.31±.25 for standing, 1.91±.42 for wheelchair propulsion, and 2.52±.55 for walking. People with stroke in all FAC had METs values >1.5 when propelling a wheelchair or walking.

Conclusions: Energy expenditure during typical sedentary behaviors (ie, sitting) is narrowly bounded at approximately 1.0 MET. Energy expenditure during sitting and standing was ≤1.5 MET for all FAC, with the exception of FAC 0 (1.6 MET during standing). Independent wheelchair propulsion and walking can be categorized as light activities (≥1.5 MET).

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Physical activity can modify several predisposing vascular risk factors (eg, high blood pressure, abnormal blood lipids, high-density lipoprotein cholesterol, obesity, diabetes mellitus).[1] This can reduce the risk of a first-ever or recurrent stroke. Therefore, the American Heart Association recommends that patients with stroke should participate in structured physical activity programs to improve health.[2]

The patients are advised to participate in moderate to vigorous physical activity (eg, brisk walking, running).[3] However, patients with stroke develop or return to an inactive lifestyle after rehabilitation because of the different physical, cognitive, and environmental barriers,[2,4,5] and they often become deconditioned and predisposed to a sedentary lifestyle that may contribute to an increased risk for recurrent stroke.[2,6] Furthermore, in the general population, prolonged periods of sedentary behavior are associated with several metabolic risk factors and all-cause mortality, independent of participation in physical activity. Therefore, and based on the findings of previously published studies,[7,8] patients with stroke should not only participate in physical activity but also try to reduce or break up sedentary time because this might reduce the high risk of health problems (eg, stroke recurrence).[2,4,5] However, there is a lack of knowledge about sedentary behavior in people with stroke.

Recently, there was a consensus group recommending that journals require authors to define sedentary as any waking behavior characterized by an energy expenditure ≤1.5 metabolic equivalent

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task (MET) while in a sitting or reclining posture.[9] The MET is a physiological measure expressing the energy expenditure of physical activities against a reference of the metabolic cost or rest, and it is very well established that the basal metabolic rate is typically 1.0 MET.[10] Previously, the definition of sedentary behavior did not include energy expenditure but muscle (in)activity. This was based on the theoretical assumption that a lack of muscle activity contributes to the negative health outcomes associated with sedentary behavior. Activities that require a large proportion of the body's muscles to be active are assumed to be reflective of higher energy demands. Therefore, because of the lack of demand for recruitment of larger muscle groups, activities that require 1.0 to 1.5 MET are considered to be sedentary behaviors, and activities that require >1.5 MET are considered light physical activities. However, despite sitting being an omnipresent behavior in all people, there are relatively few well-controlled studies actually assessing the energy expenditure of sitting and standing in the general population and people with stroke. Moreover, energy expenditure rates assigned to rest, walking, leisure, and occupational activities have been reported to differ within population subgroups, including people aged ≥60 years.[11-13]

To be able to support people with stroke to engage in activities that generate light to moderate intensity energy expenditure and confer some health benefit, it is first necessary to know which activities generate the required physiological response. Therefore, when operationalizing sedentary behavior against low-intensity physical activities (eg, sitting, standing, walking), we have to rely on the energy expenditure. However, despite sitting being a universal behavior in people with stroke, there are no studies actually assessing the energy expenditure of sitting or near sedentary activities in people with stroke. This contrasts with the robust physical activity literature describing exercise and other more demanding forms of lifestyle activity for people with stroke.[2]

The levels of energy expenditure that represent sedentary behavior in people with stroke may be different from those described for the general population.[14] The severity of motor deficits between patients is extremely variable among adults with stroke; therefore, there may be heterogeneity in energy expenditure in different postures. For people with stroke who are wheelchair bound, propelling their wheelchair with their feet might be an exception in which an individual can be sitting, but still have a high enough level of energy expenditure to be considered nonsedentary. Therefore, an evaluation of energy expenditure during a range of activities that approximate sedentary behavior (ie, sitting, standing, walking, propelling a wheelchair) among people with stroke with a range of stroke severity would provide valuable information about the actual physiological demand during a range of activities. Despite the potential effectiveness of health-related physical activity in this population, an intuitive first-step out of chronic, sedentary lifestyles may be to simply focus on fragmenting sedentary time. The findings from this study will provide important new information about energy expenditure of different activities that will underpin the development of interventions to reduce sedentary behavior (>1.5 MET) after stroke. Therefore, the purpose of this study was to objectively measure and calculate the energy expended by people with stroke during lying, sitting, standing, walking, and wheelchair propulsion, under controlled laboratory conditions, and to compare these values to the energy expenditure of 1.5 MET within the definition of sedentary behavior.

List of abbreviations:

FAC	**Functional Ambulation Categories**
MET	**metabolic equivalent task**
6MWT	**6-minute walk test**
$\dot{V}O_2$	**oxygen uptake**

Methods

Design and participants

This cross-sectional observational study was conducted in 2 rehabilitation institutions from the Stroke Service University Medical Center Utrecht. The Institutional Review Board of the University Medical Center Utrecht approved the study. The medical ethics committees of the 2 participating institutes approved the study, and informed consent was obtained from all included patients.

Participants were selected from an inpatient and outpatient stroke rehabilitation program. They all had a first or a recurrent symptomatic stroke (ischemic or intracerebral hemorrhagic lesion confirmed by a neurologist and recorded in the medical file) at least 6 weeks earlier, were able to understand and perform simple tasks, and were able to understand and speak Dutch. Patients were excluded when the prestroke Barthel Index[15] was ≤19 points or when they had pulmonary problems that would interfere with the energy expenditure measurements. Based on clinical examinations, physical therapists who worked for the Stroke Service University Medical Center Utrecht approached all eligible patients.

Procedure

Demographic (sex, age, weight, height) and stroke-related factors (lesion type, side of stroke, stroke severity, weeks since diagnosis) and use of cardiac medication were extracted from the medical charts.

Ambulation categories

The severity of stroke was categorized using the Functional Ambulation Categories (FAC), an observational list validated for people with stroke.[16,17] It is an ordinal scale which distinguishes 6 categories of walking ability on the basis of the amount of physical support required. Category 0 indicates no walking ability or walking between parallel bars or with support of 2 persons, whereas category 5 indicates independent walking ability on all surfaces.[16,17]

Energy expenditure

The main study parameter was the METs, which were measured by indirect calorimetry during lying, supported and unsupported sitting, standing, wheelchair propulsion, and walking. Indirect calorimetry was used to assess the METs because it is noninvasive and accurate with high reproducibility.[18] It is based on the indirect measure of the free energy liberated from nutrients oxidation, which is estimated by monitoring oxygen consumption and carbon dioxide production for a given unit of time.[18,19]

Each measurement was completed at least 2 hours after a meal. The subjects wore a firmly fitted facemask attached to a calibrated mobile gas analysis system with a built-in gas analyzer, which allowed continuous gas analysis of cardiopulmonary variables throughout the test. The METAMAX[a] is a valid and reliable system for measuring ventilatory parameters.[20-22] The mobile gas analysis