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Inflated Perceptions of Physical Activity After Stroke: Pairing Self-Report With Physiologic Measures

Barbara Resnick, Kathleen Michael, Marianne Shaughnessy, Eun Shim Nahm, Susan Kopunek, John Sorkin, Denise Orwig, Andrew Goldberg, and Richard F. Macko

Background: Self-report measures of physical activity have well-known drawbacks, and physiologic measures alone do not account for behavioral variables important in the perception and performance of physical activity. Therefore, we considered multiple measures to quantify physical activity in community-dwelling men and women with chronic stroke. ***Methods:*** This analysis included data from a volunteer sample of 87 individuals at least 6 months poststroke. Physical activity was measured using self-report questionnaires, step activity monitors, self-efficacy expectations related to exercise, and VO_2peak from treadmill testing, and a model of physical activity was tested. ***Results:*** Most of the variance in objective physical activity was explained by VO_2peak, and most of the variance in subjective physical activity was explained by self-efficacy expectations. There were significant discrepancies between subjective and objective findings. ***Conclusion:*** This study helps to understand the perspective of stroke survivors with regard to physical activity.

Keywords: aging, exercise psychology, gerontology, health, health promotion

Physical activity is any bodily movement produced by skeletal muscles that results in an expenditure of energy (www.cdc.gov/nccdphp/dnpa/physical/terms). Exercise, described as a moderate level of physical activity, is a subset of physical activity that is planned or structured and involves repetitive bodily movement done to improve or maintain 1 or more of the components of physical fitness (aerobic fitness, muscular strength, muscular endurance, flexibility, and body composition). Participation in physical activity is believed to decrease disease incidence and symptoms, maintain function, and improve quality of life in older adults.[1-7] In the presence of stroke, inactivity exacerbates the normal decline in aerobic capacity and muscle strength, worsens neurological deficits, and compromises individuals' ability

Resnick and Nahm are with the School of Nursing, and Orwig the School of Medicine, University of Maryland, Baltimore MD 21201. Michael, Shaughnessy, Kopunek, Sorkin, Goldberg, and Macko are with the Baltimore Veterans Administration Medical Center and Geriatrics Research, Education, and Clinical Center, Baltimore, MD 21201

to meet the elevated energy demands of hemiparetic gait.[8-10] Recent research[9,11-16] further affirms the important benefits of physical activity after stroke, particularly with regard to functional performance.

A major challenge in studies focused on physical activity in chronic stroke patients is the ability to accurately and realistically measure this activity. Survey measures are the most practical method, but there is limited evidence for their reliability and validity.[17-19] Pedometers and accelerometers are not always reliable and valid when used with older adults,[17,19,20-22] and might not accurately capture hemiparetic gait. Accelerometers have been noted to underestimate energy expenditure (EE) as workload increases[23-25] and overestimate the EE of walking when compared with indirect calorimetry.[26-29] The relationship between accelerometry and intensity during different activities is also variable.[30-33] In previous work, we have shown that with gait variability associated with stroke, the Step Activity Monitor (SAM) is a reliable and valid measure of number of strides taken.[34]

Heart rate has likewise been used to measure intensity of physical activity, although heart-rate monitoring is limited by factors such as age, gender, training state, medications, stroke volume, hemoglobin concentration, mental stress, ambient temperature, hydration, and quantity of muscle mass involved in the activity. Alternatively, VO_2peak can be used as an indirect measure of the individual's peak aerobic capacity. Given the lack of a single optimal measure of physical activity in stroke patients, the purpose of this study was to consider a multifaceted approach to quantify physical activity in community-dwelling chronic stroke patients.

Quantifying physical activity in individuals with stroke presents challenges in both methodology and interpretation. Self-report measures of physical activity have well-known drawbacks, and physiologic measures alone do not account for behavioral variables important in the perception and performance of physical activity. Therefore, we considered multiple measures to quantify physical activity in community-dwelling men and women with chronic stroke.

Methods

Procedure

The volunteer sample of men and women with chronic hemiparetic stroke (at least 6 months poststroke) was recruited through advertisement, clinic referral, community presentations, and word of mouth. Subjects were required to be minimally ambulatory. All were permitted to use assistive devices for over-ground walking, which was then used to calculate speeds for treadmill testing. All subjects were required to be able to walk >0.2 mph continuously for 3 minutes in order to be enrolled in the exercise intervention group. Exclusion criteria were defined to protect patients' safety and to control for factors other than hemiparetic stroke that might impact outcome variables. Participants were excluded from the sample if they had congestive heart failure (New York Heart Association class ≥ II), unstable angina, peripheral arterial occlusive disease (Fontaine class ≥ II), global or major receptive aphasia, screening criteria consistent with dementia (Mini-Mental Status Exam < 23), current untreated major depression, or other major medical, neurological, orthopedic, or chronic pain conditions precluding participation in study activities. Participants provided informed consent in accordance with the approved Institutional Review

Board procedures of the University of Maryland. The data used in these analyses were part of the baseline assessment. Survey measures were completed on the same day as the VO_2peak test and Step Activity Monitors were worn for 48 hours.

Sample

A total of 87 individuals, 51 men (59%) and 36 women (41%), with an average age of 63.7 (SD = 12.3) years participated in the study. Thirty-six (44%) of the participants were Caucasian, 41 (53%) were African American, and 2 were Hispanic (3%). The largest percentage of participants were married (n = 28, 41%), and 18 (21%) were divorced, 7 (10%) were never married, 14 (16%) were widowed, and 2 (2%) were cohabiting.

Measures

Survey measures included the Short Self-Efficacy for Exercise Scale (SSEE)[35] and the Yale Physical Activity Survey (YPAS).[36] The SSEE scale is a 4-item measure with the items addressing challenges associated with exercise, particularly walking, for adults poststroke. Specifically included are items about engaging in exercise when having pain, having to exercise alone, feeling tired, or feeling depressed. Response options range from 1 (*not confident*) to 5 (*very confident*). Previous use of this measure demonstrated evidence of reliability based on internal consistency (alpha coefficient of .88), and R^2 values were greater than .50. Evidence of validity of the SSEE was based on confirmatory factor analysis with all items loading significantly on the construct self-efficacy and a good fit of the model to the data. In addition, there was a statistically significant relationship between self-efficacy expectations and physical activity in community-dwelling stroke participants.[37]

The Yale Physical Activity Survey (YPAS) was used as the subjective report of physical activity. The YPAS is an interviewer-administered questionnaire that includes 5 categories of common types of work (housework and yard work), exercise, and recreational activities performed during a typical week. Evidence of reliability and validity has been demonstrated in older adults,[36] including those who use assistive devices and have gait abnormalities.[38] Total time (hours per week) as well as estimates of kilocalories were calculated using the assigned MET value reported by Ainsworth.[39]

VO_2peak, which is related to VO_2max and represents the level of oxygen consumption recorded at peak workload, was used to measure aerobic capacity. VO_2peak is expressed as the peak or optimal amount of oxygen in milliliters one can use in 1 minute per kilogram of body weight. Those who are more fit have higher VO_2peak values and can engage in more intensive physical activity than those who are not as well conditioned.

VO_2peak testing was done following a modified Bruce protocol.[40] After a resting ECG was obtained, an ECG monitoring pack and a gait belt were secured around the participant's abdominal region. A facemask was fitted, attached to the valve and VO_2 system, and held in place with a headpiece. The treadmill belt was started at 0.1 mph, and the speed was slowly increased according to individual self-selected gait speed parameters. ECG recordings were taken each minute during the test, and the test continued until the participant requested testing be stopped, demonstrated gait instability, reached a plateau in VO_2 with increased workload, respiratory exchange rate of 1.10, or until the individual stopped because of fatigue, shortness of breath, or inability to continue to ambulate safely secondary to balance impairments. Blood pressure was measured immediately after the test ended, and ECG recording was done during the recovery period at 1, 3, 5, and 10 minutes postexercise or until the heart rate was less than 100 beats per minute and blood pressure was within 15 mm Hg of resting levels. Final VO_2 values were averaged from the final 40 seconds of exercise, and all ECG tracings were submitted to be reviewed by a cardiologist.

In addition to the VO_2peak, an evaluation of economy of gait, which estimates the energy demands of the hemiparetic gait, was used to characterize physiologic capacity for exercise.[41] Participants completed treadmill testing at submaximal effort with open circuit spirometry to measure energy consumption. This test consisted of constant-load, submaximal-effort treadmill walking, representative of slow hemiparetic ambulation. Because untrained patients with hemiparetic stroke cannot typically sustain their self-selected floor-walking velocity, we conducted treadmill testing with no incline at approximately 75% of each individual's self-selected floor-walking velocity. This protocol allowed calculation of the rate of oxygen consumption (VO_2) under steady state conditions, expressed as economy of gait.

The SAM accurately counts strides taken at specified intervals and was demonstrated to be reliable and valid when used with stroke patients.[32,34,42] Unlike accelerometers, the SAM does not estimate the metabolic or mechanical demands on the body. Similar to the pedometer, the SAM measures the vertical movements associated with ambulation. The SAM was worn on the ankle, and participants were instructed to keep the monitor on at all times during the 48-hour period of testing. Since the SAM measures strides taken, or number of heelstrikes of the extremity wearing the device, data were converted and reported as steps to benchmark against public health recommendations. Steps are defined as twice the stride count.[32] To establish self-selected gait speed, subjects were instructed to walk at a comfortable pace between 2 traffic cones set up 30 feet apart. The average speed of 3 trials was then converted to miles per hour.

Using these measures, a measurement model of physical activity (Figure 1) was developed that included both subjective and objective measures of physical activity. Subjective and objective physical activity were hypothesized as exogenous variables in the model. Exogenous variables are those that are not measured directly but are determined by other variables. Subjective physical activity was hypothesized to be measured, or explained by, self-efficacy expectations related to exercise and the participants' verbal report of physical activity based on the YPAS. Objective physical activity was hypothesized to be measured, or explained by, VO_2peak and the SAM total number of steps taken in a 48-hour period. We anticipated that the proposed combination of subjective and objective physical activity would fit the measurement model of physical activity and optimally describe all aspects of physical activity for individuals poststroke.

Data Analysis

Descriptive analyses and bivariate correlations of the study variables using Pearson correlations were completed using the SPSS statistical program. The measurement

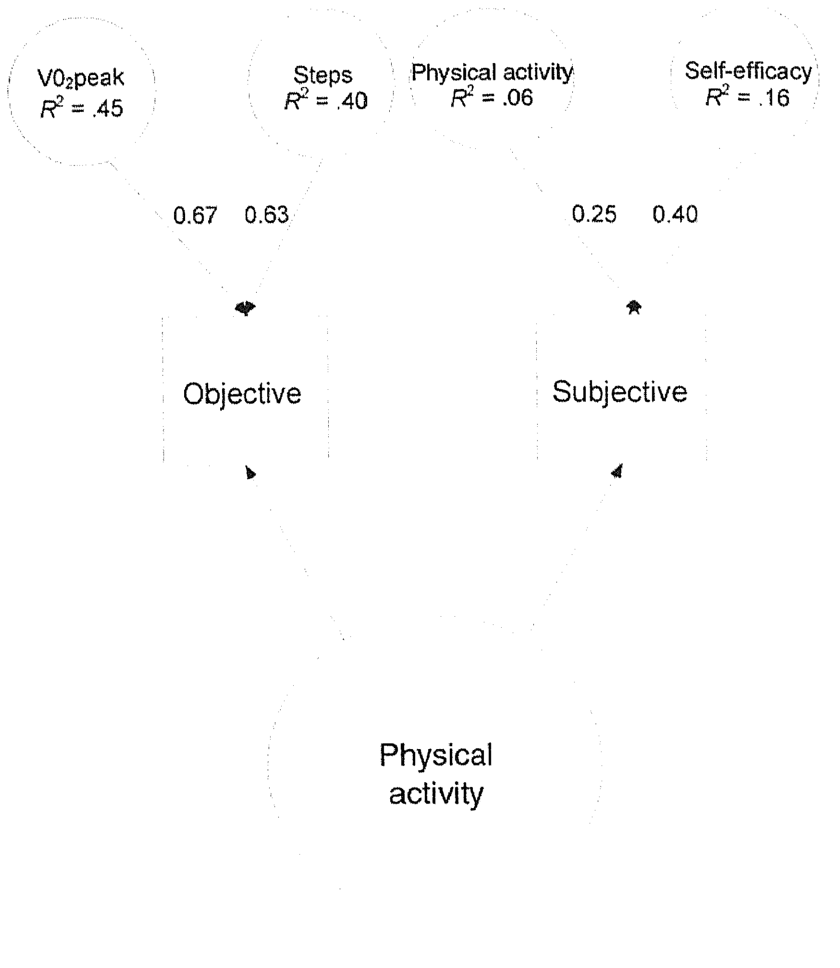

Figure 1 — Measurement model of physical activity

model of physical activity was tested using the AMOS statistical program. For model testing, the sample covariance matrix was used as input and a maximum likelihood solution sought. The chi-square statistic and chi-square divided by degrees of freedom, the Normed Fit Index (NFI) and Root Mean Square Error of Approximation (RMSEA) were used to estimate model fit. The larger the probability associated with the chi-square, the better the fit of the model to the data. The NFI tests the hypothesized model against a reasonable baseline model and ideally should be 1.0. The RMSEA is a population-based index and consequently is insensitive to sample size. A RMSEA of ≤.06 is considered acceptable and ≤.08 considered fair. Item significance was based on the Critical Ratio (CR), which is the parameter estimate divided by an estimate of the standard error. A CR >2 in absolute value was considered significant.[43] A $P \leq .05$ level of significance was used for all analyses.

Results

As shown in Table 1, the participants in this study reported engaging in 3021.8 (SD = 2539.9) minutes per week of physical activity, with 753.9 (SD = 950.7) minutes of the total time in physical activity reported specifically as being spent in a moderate level of physical activity (ie, exercise). They took 4055.2 (SD = 2401.2) steps in a 48-hour period and had a mean self-efficacy score for exercise of 3.6 (SD = 1.1) out of a range of 1 to 5. The mean VO_2peak was 13.0 ml/kg/min (SD = 4.4). The energy costs of a hemiparetic gait in this sample were high (9.3 ± 1.7 ml/kg), representing 68% of physiologic fitness reserve. The bivariate correlations between the subjective and objective measures of physical activity indicated that there was not a statistically significant correlation between self-efficacy expectations and time in physical activity based on the YPAS (r = .23, P = .07). Self-efficacy expectations were related to the exercise subscale of the YPAS (r = .26, P = .04). There was a statistically significant correlation between the objective measures of physical activity, total number of steps taken in 48 hours, and VO_2peak (r = .40, P = .01). Gait economy (ie, the energy costs associated with gait) was positively correlated with VO_2peak (r = .70, P = .01) and self-efficacy expectations (r = .40, P = .01).

The proposed measurement model of physical activity was tested as shown in Figure 1. The model fit the data with a χ^2 of 4.2, degrees of freedom (df) of 2, a χ^2/df ratio of 2.1, a nonsignificant P value of .12, NFI of .84, and RMSEA of .06. The path values are shown in Figure 1. The Lamda value, or path coefficient, for the path between the exogenous variable objective physical activity and number of steps was .63 (P = .03), and the path between the exogenous variable objective physical activity and VO_2peak was .67 (P = .03). The path between the exogenous variable subjective physical activity and self-efficacy expectations was .40 (P = .04), and the path between the exogenous variable subjective physical activity and reported physical activity based on the YPAS was .25 (P = .16). The R^2 values, a measure of the amount of variance accounted for by each variable, were .17 for self-efficacy expectations, .06 for subjective reports of physical activity as measured by the YPAS, .40 for the recorded steps from the SAM, and .45 for VO_2peak measures. The amount of variance of objective physical activity explained by the number of

Table 1 Descriptive Results of Study Variables

Variable	Minimum	Maximum	Mean	SD
Step, activity monitor steps	66	13,429	4055.17	2401.20
Outcome expectations	1.00	5.00	4.09	0.64
Moderate-level physical activity	0.00	5670.00	753.94	950.72
Self-efficacy expectations	1.00	5.00	3.66	1.09
Total physical activity	0.00	9967.50	3021.84	2539.92
VO_2peak	5.5	28.3	13.0	4.4

steps from the SAM and the measure of VO_2 peak was similar. Most of the variance in subjective physical activity was explained by self-efficacy expectations.

Discussion

The stroke participants in this study reported fairly high self-efficacy expectations for exercise and reported that they engaged in over 8 hours daily of physical activity and 2 hours of exercise (ie, moderate-level physical activity) daily. This subjective data related to time spent in physical activity and exercise exceed that of the generally accepted public health recommendation to engage in 30 minutes of moderate-level physical activity at least 6 out of 7 days per week.[44] The objective measures of physical activity, however, do not support this subjectively reported level of activity. The mean number of steps in a 48-hour period obtained from the participants was 4055.2, which is less than the recommended 20,000 steps for a 48-hour period.[44] Moreover, the VO_2peak (mean of 13.0 ml/kg/min) indicated that these individuals were severely deconditioned and were not likely to be performing the amount of physical activity or exercise reported.

The discrepancies found in this study between subjective and objective reports of physical activity replicate previous research findings.[45-47] Survey results have frequently been noted to overestimate physical activity[17,19,21-22,48] and are generally not strongly related to physiological measures.[46,47,49] It is generally assumed that the subjective reports from participants are neither valid nor reliable. Our findings, however, suggest an alternative explanation. The stroke patients in this study were severely deconditioned, had high energy costs associated with gait, and used on average 68% of physiologic reserve to ambulate. It is possible, therefore, that they perceived their level of activity to be high given the exertion required to engage in the relatively limited number of steps they actually took in a 48-hour period. Adding a measure of perceived exertion, such as the Borg,[50] might help explain these findings.

Although the subjective reports of physical activity were not related to physical conditioning and might not reflect true time spent in physical activity, this information is important for the development of motivational interventions to increase physical activity and exercise activity among stroke survivors. If these individuals believe that they are already engaging in sufficient amounts of physical activity, motivational interventions geared toward increasing the amount of time they spend in physical activity might not be effective. Interventions to increase physical activity in stroke patients might need to focus first on accurate self-appraisals of their overall time spent in physical activity and, specifically, the time spent in exercise.

The objective information conceptualized to measure physical activity included the number of steps taken in 48 hours and the VO_2peak of the participants. Both measures explained essentially equal amounts of the variance in objective measurement of physical activity, with VO_2peak explaining just slightly more at 45% versus 40% of the variance being explained by the number of steps performed. VO_2peak testing via the treadmill has the advantage of being standardized and controlled and provides valid quantitative data related to aerobic capacity.[51] It is, however, costly, burdensome to the participant, and not practical for community-based studies. Moreover, treadmill testing, which was done in the assessment of VO_2peak, provides artificial assistance to gait and is not necessarily equivalent to walking on other level surfaces in terms of energy expenditure or mechanics. Other methods to obtain VO_2peak should be considered, such as using a recumbent cross-trainer or an elliptical trainer.[52]

Alternatively, the SAM might be a much more realistic measure of physical activity, especially when the focus of that activity is on walking. Moreover, we recommend the use of the SAM as a way to help stroke survivors learn how to more accurately report the amount of time they spend in physical activity. This is critical from a motivational perspective because a stroke survivor might believe he or she is already engaging in the recommended 30 minutes of moderate-level physical activity daily or exceeding the recommended 10,000 steps and, therefore, will not make any attempt to increase time in physical activity. Increasing physical activity in individuals poststroke is critical as it can help to optimize function and overall health and decrease the risk of a subsequent stroke.

Study Limitations

This study was limited by the small sample size of 87 participants. The SAM measures only steps and does not reflect other types of physical activity the participants might have engaged in and reported on in the YPAS. For example, the participant might have been going to a sitting exercise class focused on upper-extremity activities that would not be measured by the SAM.[53] The novelty of wearing the SAM might have motivated the participant to take as many steps as possible during the 2 days of testing and thus might not have been a true measure of number of daily steps taken. The inclusion of only 48 hours of monitoring of activity with the SAM might have further influenced the findings because the YPAS is a report of physical activity over a typical week.[53]

Measurement of physical activity in this study might have been influenced by social desirability because the study participants might have wanted to be perceived as physically active. Despite these limitations, the study provides an important perspective on the measurement of physical activity in stroke patients and demonstrates that there is some utility to considering subjective information (ie, how stroke survivors perceive their own physical activity) as well as the objective (ie, what physical activity is actually done). Capturing subjective and objective measures of physical activity in stroke survivors is optimal to understanding physical activity among these individuals. Moreover, this understanding will guide researchers and clinicians in the development of motivational interventions to help stroke survivors to at least achieve the basic recommendations for moderate-level physical activity of 30 minutes or 10,000 steps daily and thereby achieve their highest level of health and function.

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