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Objective and Self-Reported Physical Activity Measures and Their Association With Depression and Satisfaction With Life in Persons With Spinal Cord Injury

Sara J. Mulroy, PhD, PT^a, Patricia E. Hatchett, DPT^a, Valerie J. Eberly, PT^a, Lisa Lighthall Haubert, MPT^a, Sandy Conners, PTA^a, JoAnne Gronley, DPT^a, Eric Garshick, MD, MOH^{b,c}, and Philip S. Requejo, PhD^a

^aRancho Los Amigos National Rehabilitation Center, Pathokinesiology Laboratory, Downey, CA

^bPulmonary, Allergy, Sleep, and Critical Care Medicine Section, Medical Service, Veterans Affairs Boston Healthcare System, Boston, MA

^cChanning Division of Network Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, MA

Abstract

Objective—To identify associations between objective and self-reported measures of physical activity (PA) and relationships with depression and satisfaction with life (SWL) in persons with spinal cord injury (SCI).

Design—Retrospective, cross-sectional study of objectively measured wheelchair propulsion (WCP) from 2 studies in which an odometer was attached to participants' wheelchairs to record daily speed and distance. Self-reported data were collected in a separate study examining dyspnea, PA, mood, and SWL.

Setting—Outpatient clinic in a rehabilitation center.

Participants—Individuals (N=86) with traumatic SCI who use a manual wheelchair.

Interventions—Not applicable.

Main Outcome Measures—Objective measures of PA included average daily distance and speed of WCP measured by an odometer. Self-report questionnaires included demographics, the 24-hour recall of transfers, Physical Activity Recall Assessment for People with SCI, the Patient Health Questionnaire-2 (PHQ-2) to document depressive symptoms, and the Satisfaction With Life Scale (SWLS).

Results—Both objective measures of WCP, average daily distance and speed, were predicted by the combination of self-reported daily time away from home/yard and lower frequency of car transfers ($r=.367$, $P=.002$) and ($r=.434$, $P<.001$), respectively). Daily distance of WCP was

Corresponding author: Sara J. Mulroy, PhD, PT, Pathokinesiology Laboratory, 7601 E Imperial Hwy, Downey, CA 90242. smulroy@dhs.lacounty.gov.

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negatively correlated with depression (PHQ-2) ($r=-.309$, $P=.004$). Time in leisure PA was the only significant predictor of SWLS scores ($r=.321$, $P=.003$).

Conclusions—Short-term recall of hours away from home/yard not spent driving or riding in a vehicle is suggested as a self-report measure that is moderately related to overall WCP PA in this population. Results of this study suggest that depression is related to decreased PA and WCP activity, while SWL is related to leisure PA.

Keywords

Motor activity; Quality of life; Rehabilitation; Spinal cord injuries

Physical activity (PA) is receiving international attention because of its influence on health-related concerns and quality of life (QOL). After spinal cord injury (SCI), PA levels decline as much as 40% compared with those of persons without a disability.¹ Among researchers, a wide variety of tools are used to quantify PA. Objective assessment tools of PA such as accelerometers are more accurate than subjective self-report, but typically are more expensive than recall questionnaires because they can require specialized equipment, staff for setup, and participant involvement for equipment operation and maintenance.

Consequently, studies using wearable technology to measure PA typically do so over a brief period,^{1–5} which may not accurately represent an individual's overall activity level.¹ Use of a device mounted to the person's wheelchair, such as an odometer, reduces participant burden by eliminating the need to don a device, therefore facilitating longer-duration measurements.^{6–9} Subjective PA measures are reliant on the respondent's recall for accuracy, which tends to decline with longer periods.¹⁰ Among the challenges that exist in collecting accurate self-reported data regarding PA is under- or over-reporting.^{10,11} Vigorous activities tend to be more reliably reported than lower-intensity activities often performed in short bouts throughout the day.¹⁰ A systematic review¹² of 187 articles comparing direct measurement versus self-reported PA in adults showed low to moderate correlations. Trends were influenced by the assessment tool used, level of PA, and sex. However, this has received scant attention in the SCI population.¹³

Satisfaction with life (SWL) and depression are contributors to QOL. Persons with SCI reported lower QOL scores compared with those without a disability.^{14–17} Understanding factors that influence QOL such as PA or time spent performing leisure activities can lead to targeted interventions to improve QOL. Findings regarding the relationship between self-reported PA and QOL for persons with SCI have been inconsistent, with some studies^{18–21} reporting large, statistically significant positive associations between the 2 variables, and other studies^{22,23} reporting much smaller and even nonsignificant associations. Use of objectively measured PA could clarify the relationship between PA and QOL.

The purpose of this study was 2-fold: (1) to determine the associations between objective measures of PA using a wheelchair odometer and self-reported PA measures; and (2) to identify the relationships between objective and self-reported PA and depression and SWL. We hypothesized that (1) there would be agreement between objective and self-reported measures of PA in persons with SCI; and (2) depression would be inversely related and SWL would be positively related to PA.

Methods

Design

Self-report questionnaires regarding dyspnea, PA, depressive symptoms, and SWL were collected from 140 individuals who participated in 1 site of the SCI Model System multisite study of dyspnea designed to evaluate relationships between dyspnea, PA, and life satisfaction after SCI. Eighty-six of the 140 participants in the dyspnea study had also participated in 1 of 2 three-year longitudinal studies of shoulder function at this site: (1) the SCI Model System site-specific study to evaluate shoulder pain prevention programs; or (2) an observational study to identify predictors of shoulder pain development for persons with SCI. Objectively measured wheelchair propulsion (WCP) activity and self-reported transfer frequency (24-h recall) from the shoulder studies were combined with the self-report measures from the dyspnea study. Thirty-two participants (37%) had the dyspnea data collection occur concurrently within the 3-year period of WCP and transfer frequency monitoring. Ten participants (12%) had the dyspnea collection on the day objective measurement began. Forty-four participants (51%) had a gap between the data collection of the dyspnea study and the closest odometer reading, with a mean $\pm$ SD of 657 ± 421 days.

Participants

Participants were recruited from the outpatient center at the study site. Primary inclusion criteria for the multisite dyspnea study were that the SCI had to be caused by trauma and that persons had to be aged ≥ 18 years. Additional inclusion criteria from the shoulder studies were as follows: persons had to be ≥ 2 years post-SCI; they had to have an absence of shoulder pain at study entry with a total score of ≤ 12 on the Wheelchair User's Shoulder Pain Index; and they had to be a manual wheelchair user ($\geq 50\%$ of locomotion). Equipment used for the shoulder studies had a weight limit of 250lb. Thus, persons were excluded if their body weight was greater than this weight.

Participants read and signed informed consents for the dyspnea study and either of the shoulder studies that had been approved by the hospital's institutional review board. Combining data from these 3 studies was approved by the hospital's institutional review board.

Procedures and equipment

Objective PA—Objective PA variables including average daily distance and speed of WCP were collected during participation in the shoulder studies. Wheelchair usage was measured using the Topeak bicycle odometer system.^a Each participant's manual wheelchair was equipped with a sensor mounted onto the wheelchair frame, magnets mounted to the wheels, and an odometer computer that was calibrated according to the wheelchair wheel circumference (fig 1). Participants who used an additional manual wheelchair for >4 h/wk, such as for sports, had the second wheelchair similarly equipped. Participants were contacted by phone every 1 to 2 months over 3 years to report their odometer information

^aTopeak bicycle odometer system; Topeak Inc.

and 24-hour recall of transfer frequency (see below). Average daily values were calculated for both distance and speed.

Demographic and SCI lesion characteristics—Demographic and SCI lesion information was collected at entry into the dyspnea study. Economic status was documented at entry into the shoulder studies.

Subjective PA

- *One-day recall:* During shoulder study phone contacts, participants were asked to report the number of car transfers and other transfers performed in the previous 24 hours, and the frequencies were averaged.
- *Three-day recall:* Participants in the dyspnea study were asked to recall their activities over the previous 3 days during an interview based on the Physical Activity Recall Assessment for People with Spinal Cord Injury.^{24,25} Information collected included hours per day spent away from their home or yard; inside their home or yard (excluding sleep time); doing yard activities, housework, child care or pet care, or other activities; exercising; shopping; engaging in employment or volunteer work; and frequenting a restaurant or bar. Time spent performing leisure-time PA (LTPA) was calculated by summing the hours per day spent in the leisure activities reported above (excluding employment).

Depression and SWL measures—The Patient Health Questionnaire-2 (PHQ-2)^{26,27} and the Satisfaction With Life Scale (SWLS)^{26–28} were administered as part of the dyspnea study. The PHQ-2 is a depression screen that asks 2 questions: “Over the past 2 weeks, how often have you been (1) bothered by little interest or pleasure in doing things, and (2) bothered by feeling down, depressed, or hopeless?” Responses are based on a scale from 0 to 3 for each question (0, not at all; 1, several days; 2, more than half the days; 3, nearly every day).

The SWLS measures well-being, a component of QOL.^{28,29} Participants are asked to rate how much they agree or disagree with 5 statements, such as “In most ways, my life is close to ideal,” using a 7-point Likert scale ranging from strongly disagree (1) to strongly agree (7). Responses were summed to create a total score.

Statistics

Data were analyzed using SPSS 12.0 software.^b Stepwise regression analyses were conducted to identify predictors of WCP distance and speed from 5 self-reported PA measures including time spent away from and inside home/yard, LTPA, car transfers, and all other transfers. Individual activities were not included as separate independent variables in the regression models because the number of participants who engaged in each activity was low (eg, only 16% of participants were employed, and only 30% participated in planned outside exercise). Since the PHQ-2 has only 7 potential values, nonparametric Spearman

^bSPSS 12.0 software; SPSS, Inc.

rank correlations were calculated to identify the relationship between WCP distance and speed, the 5 self-report PA measures listed above, and the PHQ-2. Finally, stepwise regression analysis was conducted to identify predictors of SWLS from the 5 self-reported PA measures listed above and WCP distance and speed. Stepwise regression analyses were conducted using a .05 probability of F to enter and a .10 probability of F to remove. Age, sex, and level of injury were evaluated as covariates for the model of SWL. Effect modification by presence of a time gap between assessments on the relationships between PA predictor variables and dependent variables was tested by including the interactions between the gap and the independent variables in each of the models. Significance was set at a *P* value of .05.

Results

Participant recruitment and demographics

Eighty-six participants (men, 77 [89.5%]; women, 9 [10.5%]) participated in the current research. The mean age $\pm$ SD of participants was 37.4 $\pm$ 16.2 years, and the mean time $\pm$ SD since SCI was 11.1 $\pm$ 7.5 years. Demographic and SCI lesion information is detailed in table 1.

Regression models of objective PA measures

Means and SDs of the objectively measured WCP variables and subjective recall measures of PA are listed in table 2. Hours spent away from home/yard was the strongest predictor of daily WCP distance ($R=.242$, $P=.025$) (see table 2; table 3). In the second and final step of the regression model, daily number of car transfers was added ($R=.367$, $P=.002$). Time away from home/yard was positively related and car transfer frequency was negatively related to WCP distance.

LTPA was the strongest single predictor in the stepwise regression model of WCP speed ($R=.272$, $P=.012$) (see tables 2 and 3). Daily number of car transfers and hours spent away from home/yard entered the model on steps 2 and 3, respectively. With all 3 predictors in the model, LTPA was redundant as a predictor and was removed in the final step ($R=.434$, $P<.001$). Again, number of car transfers was negatively related and hours away from home/yard was positively related to WCP speed.

None of the interaction terms of time gap between assessments and the independent variables were statistically significant and did not enter either model for WCP distance or speed.

Depression and SWL

Participants reported depressive symptoms for several days over the past 2 weeks, with a mean score $\pm$ SD of 1.16 $\pm$ 1.14. On average, participants felt slightly satisfied with life, with a score of 23.3 $\pm$ 6.4 on the SWLS.

Association between PA and depression

A statistically significant negative correlation was found between WCP distance and depression (PHQ-2) in that persons who pushed farther reported fewer depressive symptoms ($r=-.309$, $P=.004$) (table 4). There were no other statistically significant correlations between any PA measures and PHQ-2 scores.

Regression model for SWLS

None of the variables evaluated as potential covariates were related to SWLS and thus were not included in the model. LTPA was the only significant predictor of SWLS ($r=.321$, $P=.003$); persons who reported more LTPA also reported higher SWL (see table 3). None of the interaction terms of time gap between assessments and the independent variables were statistically significant and did not enter the model for SWLS.

Discussion

This study is unique in that we documented objectively measured WCP PA over a long duration in a relatively large cohort of persons with SCI and related that activity to self-reported PA, depression, and SWL. Those who pushed their wheelchair farther reported spending more time away from their home/yard and fewer car transfers per day. Thus, our hypothesis that there would be agreement between objective and subjective measures of PA was supported, though the R values of the 2 predictive models were moderate at .367 and .434.³⁰ This level of agreement is similar to or greater than results reported in 2 multistudy reviews^{11,12} of objective versus self-report PA measures in the nondisabled adult population and in 2 studies^{13,31} of persons with disabilities. However, the moderate prediction of the models indicates that the subjective and objective measures are reflecting separate but overlapping constructs and cannot be used as evidence of concurrent validity.

One might expect that persons who perform a greater number of car transfers would be more active in the community and therefore more likely to push their wheelchair a greater distance compared with those who do not perform as many car transfers. In contrast, we identified that fewer car transfers predicted higher levels of WCP activity. This negative relationship likely reflects that the time spent away from home/yard while driving in a car did not add to WCP activity. Consequently, when direct measurement of PA is not feasible, we suggest asking respondents to recall hours spent away from home/yard and subtracting hours spent riding or driving in a vehicle for a self-report estimate that is related to overall PA in persons who use a manual wheelchair for mobility.

In contrast to recall of hours spent away from home/yard, the sum of all LTPA was not a significant predictor of daily WCP distance. This likely relates to the fact that many leisure PAs are performed using the upper extremities in a quiet sitting position with no wheelchair movement (ie, weightlifting and hand cycling if the cycle is not attached to their wheelchair), and would not be captured by the wheelchair odometer. An attempt to include sports and distance pushing activities was made by equipping sports WCs with an odometer and combining average WCP distance. However, to fully capture upper extremity activities,

it may be necessary to use an accelerometer on the wrist. Future studies could investigate the relationship between PA recorded by an accelerometer and subjective recall of PA.

In support of our second hypothesis, daily distance of WCP was correlated with fewer depressive symptoms. LTPA and time away from home/yard, however, were not related to depressive symptoms. The link between higher PA and reduced depressive symptoms has been previously documented in persons with SCI when evaluating wheelchair sports,³² total PA,^{33,34} and planned exercise,³⁵ suggesting that physical exertion is critical to reducing depressive symptoms. Although WCP distance is not a direct measure of physical exertion, it does reflect a minimum level of physical exertion that is required to propel the wheelchair. A recent study³⁶ identified that a physical exercise program was the most preferred treatment option compared with medication and psychotherapy in individuals with SCI who had major depression. Our results suggest that an increase in overall WCP activity could be a possible alternative to planned exercise to reduce depressive symptoms.

We also hypothesized that there would be a positive relationship between PA and SWL. Our results partially support this hypothesis, since LTPA was a significant predictor of greater SWL. Distance and speed of WCP and time spent away from home/yard, however, were not significant predictors of SWL. These results indicate that time spent performing activities meaningful and pleasurable to the individual, rather than overall PA, exerts a positive influence on SWL.

Discrepancies in results of studies examining the relationship between PA and QOL or SWL may be explained by variations in measures used for both activity and QOL.¹⁶ A meta-analysis²⁰ found that sports or fitness-related PA had a modest impact on subjective well-being and life satisfaction among people with SCI, with a small effect size (.24). Kemp³⁷ identified a moderate positive correlation ($r=.36$) between life satisfaction and community activities in a sample of persons with a variety of impairments (postpolio, SCI, cerebral palsy, stroke, etc). This is similar to the strength of the predictive relationship found in this study between LTPA and SWL ($r=.321$). In a study by Stevens et al,²¹ overall PA accounted for 56% of the total variation in QOL, which was a stronger relationship than identified in this study.

Several factors specific to our population may have influenced their levels of PA and resulted in a low to moderate relationship between activities and SWL. Only 16% of our study population (compared with 28% reported in the National SCI Database) reported that they are employed or do volunteer work,³⁸ and most report an annual income of \$20,000 or less. Our participants only spent 4.5 hours on average away from their home/yard. Unemployment and low income imply a lack of resources and help explain why approximately 70% of their day is spent inside the home.

Study limitations

A limitation of this study is that data were collected from 3 separate studies. The self-report assessments were collected on a single day and reflected PA over a 3-day period, whereas the objectively measured WCP data were collected over a 3-year period that captured the participant's "typical" behavior. These studies were conducted either concurrently or with an

average gap of over a year between the self-report and odometer assessments. In their review of direct versus self-report measures for assessing PA, Prince et al¹² found no clear pattern when they looked at different time lags and periods of measurement. In this study, effect modification analysis indicated that the time gap between assessments did not affect the strength of the relationships between objectively measured PA and self-reported variables or between PA measures and SWL.

A limitation of odometers attached to the wheelchair is that they do not distinguish between self-propulsion and pushing by another person. Assistance from others with WCP likely is more common in persons with tetraplegia than in those with paraplegia (the majority in this study). Some assisted propulsion probably occurred in our participants and would have been recorded by the odometer.³⁹

Conclusions

Self-reported PA measures were moderate predictors of objective measures of PA using a wheelchair odometer. Short-term recall of hours away from home/yard not spent driving or riding in a vehicle is suggested as a self-report measure that is related to overall WCP PA in this population when objective PA measures are not practical. Measurement of nonpropulsion activity would require wearable technology.

While SWL and depression both contribute to QOL, it is important to distinguish between the two when designing an intervention. Based on our study results, an intervention to improve depression would focus on increased PA and WCP activity. In contrast, to improve SWL, the intervention should be targeted to LTPA, activities that are meaningful to the person.

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List of abbreviations

LTPA	leisure-time physical activity
PA	physical activity
PHQ-2	Patient Health Questionnaire-2
QOL	quality of life
SWL	satisfaction with life
SWLS	Satisfaction With Life Scale
SCI	spinal cord injury
WCP	wheelchair propulsion

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Fig 1.
Example of the wheelchair odometer setup. Each wheelchair was equipped with a sensor (*circled*), 2 magnets (*arrows*), and an odometer containing a computer chip (*rectangle*).

Table 1

Demographics and lesion characteristics

Characteristics	Values
Sex	
Male	77 (89.5)
Female	9 (10.5)
Ethnicity	
Hispanic	56 (65.1)
Not Hispanic	30 (34.9)
Race	
White	58 (67.4)
African American	21 (24.4)
Asian	3 (3.5)
American Indian/Alaska Native	1 (1.2)
Other	3 (3.5)
Age * (y)	37.4±16.2
Duration of SCI * (y)	11.1±7.5
Level of injury	
Tetraplegia	11 (12.8)
Paraplegia	75 (87.2)
Completeness of injury (AIS)	
A	61 (70.9)
B	9 (10.5)
C	12 (14.0)
D	4 (4.7)
Income range	
\$0–20,000	71 (82.6)
\$20,001–40,000	8 (9.3)
\$40,001–60,000	3 (3.5)
\$60,001–80,000	1 (1.2)
\$80,001	1 (1.2)
Missing	2 (2.3)

NOTE. Values are n (%) or mean ± SD.

Abbreviation: AIS, American Spinal Injury Association Impairment Scale.

* At time of dyspnea study data collection.

Table 2

Means and bivariate correlations between objective and subjective PA measures

Measures	Mean $\pm$ SD	Pearson Correlations	
		Daily Distance of WCP	Average Speed of WCP
Objective PA measures (odometer reading)			
Distance (km/d)	2.35 $\pm$ 1.45	NA	$r=.492$, $P=.001$
Speed (km/h)	2.72 $\pm$ 1.07	$r=.492$, $P=.001$	NA
Subjective PA measures (self-report)			
Transfers per day	8.10 $\pm$ 5.46	$r=-.121$, $P=.134$	$r=.020$, $P=.429$
Car transfers per day	3.82 $\pm$ 3.69	$r=-.146$, $P=.090$	$r=-.263$, $P=.007^*$
Time spent away from home/yard (h/d)	4.54 $\pm$ 3.10	$r=.242$, $P=.012^*$	$r=.200$, $P=.033^*$
Time spent inside home (h/d)	11.65 $\pm$ 3.01	$r=-.139$, $P=.100$	$r=-.156$, $P=.077$
LTPA (h/d)	4.89 $\pm$ 3.78	$r=.136$, $P=.105$	$r=.272$, $P=.006^*$

Abbreviation: NA, not applicable.

* Indicates significant value, $P<.05$.

Table 3

Regression models for WCP distance and speed, and satisfaction with life (SWLS)

Variables	B	SE	Standardized B	t	P	R	R ²	Adjusted R ²	SEE	F	P
WCP distance											
Step 1											
Constant	1.835	0.272		6.75	.000						
Time spent away from home/yard	0.113	0.050	.242	2.28	.025	.242	.058	.047	1.418	5.21	.025
Step 2											
Constant	2.016	.271		7.45	.000						
Time spent away from home/yard	0.174	0.053	.372	3.29	.001						
Car transfers	-0.12	0.044	-.305	-2.70	.008	.367	.134	.114	1.367	6.45	.002
WCP speed											
Step 1											
Constant	2.334	0.186		12.53	.000						
LTPA	0.077	0.030	.272	2.57	.012	.272	.074	.063	1.035	6.616	.012
Step 2											
Constant	2.633	0.225		11.70	.000						
LTPA	0.069	0.030	.244	2.35	.021						
Car transfers	-0.067	0.030	-.234	-2.25	.027	.357	.128	.106	1.011	6.006	.004
Step 3											
Constant	2.419	0.229		10.57	.000						
LTPA	0.041	0.030	.143	1.35	.182						
Car transfers	-0.111	0.030	-.386	-3.41	.001						
Time spent away from home/yard	0.114	0.040	.328	2.83	.006	.454	.206	.177	.970	7.006	.000
Step 4											
Constant	2.580	0.196		13.14	.000						
Car transfers	-0.123	0.032	-.425	-3.87	.000						
Time spent away from home/yard	0.132	0.038	.381	3.47	.001	.434	.188	.168	.975	9.510	.000
SWLS											
Step 1											
Constant	20.727	1.104		18.77	.000						

Variables	B	SE	Standardized B	t	P	R	R ²	Adjusted R ²	SEE	F	P
LTPA	0.544	0.177	.321	3.07	.003	.321	.103	.092	6.078	9.45	.003

Abbreviations: B, unstandardized coefficient; SEE, standard error of the estimate; Sig, significance.

Table 4

Bivariate correlations between PA measures and symptoms of depression (PHQ-2) and SWLS

Measures	PHQ-2 Spearman Correlations	SWLS Pearson Correlations
Objective PA measure (odometer reading)		
Distance (km/d)	$r = -.309, P = .004^*$	$r = -.096, P = .193$
Speed (km/h)	$r = -.033, P = .761$	$r = .015, P = .447$
Subjective PA measures (self-report)		
Transfers per day	$r = .174, P = .109$	$r = -.218, P = .023$
Car transfers per day	$r = .018, P = .872$	$r = .020, P = .397$
Time spent away from home/yard (h/d)	$r = -.067, P = .540$	$r = .110, P = .159$
Time spent inside home (h/d)	$r = -.059, P = .587$	$r = -.080, P = .233$
LTPA (h/d)	$r = -.026, P = .814$	$r = .321, P = .001^*$

* Indicates significant value, $P < .05$.