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ORIGINAL CONTRIBUTION

Physical Activity and Quality of Life in Adults With Spinal Cord Injury

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Abstract

Background/Objective: To document the relationship between level of physical activity and quality of life in persons with spinal cord injury.

Design: Cross-sectional investigation.

Participants/Methods: Men (n = 32) and women (n = 30) with complete and incomplete spinal cord lesions below C6 volunteered to participate in this study. The average length of time since the onset of disability was 9 years (range, 1.5–40 years). Using an interview-formatted survey (Quality of Well-Being Scale), a measure of quality of life was obtained for each participant. Physical activity levels were determined using the Physical Activity Scale for Individuals with Physical Disabilities.

Results: A strong positive association ($r = 0.75$; $P < 0.05$) was observed between level of physical activity and quality of life. Multiple regression analysis also showed that when level of physical activity, anatomical location of the injury, completeness of injury, and time since injury were used as explanatory variables, level of physical activity was the only significant predictor of quality of life, accounting for 56% of the total variation in quality of life.

Conclusions: Results from this study show that a significant and moderately strong positive relationship exists between level of physical activity and quality of life in adults with spinal cord injury. From a clinical perspective, these findings suggest that interventions aimed at promoting physical activity may be effective in improving quality of life in this population.

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Key Words: Spinal cord injuries; Disability, physical; Quality of life; Rehabilitation, physical; Tetraplegia; Paraplegia

INTRODUCTION

Spinal cord injury (SCI) typically results in impaired motion and loss of function, both of which are associated with a decrease in quality of life (1). Rehabilitation interventions that promote recovery of lost function through the implementation of compensatory techniques and equipment have been positively correlated with improvements in quality of life for persons with SCI (2). However, quality-of-life scores remain significantly below the level observed in similar populations without SCI. In a study by Kannisto et al (3), for example, individuals with SCI showed quality-of-life scores nearly 10% below those recorded for healthy adults. Similar results were also noted by Post et al (4), who reported overall quality-of-life scores that were lower than values found in the general population. Given these findings, the identification of variables related to the low quality of life experienced by persons with SCI may be useful in modifying rehabilitation protocols and reducing the discrepancy in quality-of-life scores between people with and without SCI.

Although increased physical activity improves function after neural injury (5), lower physical activity levels have been observed after SCI (6). Decreased physical activity after SCI may result from psychological factors, lost motor function, and lack of training during acute rehabilitation, as well as from decreased access to fitness equipment, exercise facilities, and activity programs (7). Hence, a physically active lifestyle may not emerge spontaneously after SCI, and patients report that their rehabilitation experiences do not typically lead to increases in physical activity (7).

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The primary focus of treatment during acute rehabilitation for persons with SCI is to address immediate functional limitations. Acute rehabilitation begins immediately after the precipitating event has occurred and is focused on increasing function through training in the use of compensatory techniques and adaptive equipment. Rehabilitation approaches include training with assistive devices to improve mobility, environmental adaptations, and/or modifications in self-care tasks. Although these interventions are helpful, compensatory rehabilitation techniques may interfere with neural reorganization and result in learned disuse, muscle disuse atrophy, and decreased firing rates of Ia nerve fibers (8). After compensation occurs, stimulation from the attempted use of impaired muscles and nerves is diminished, limiting the potential for neurogenesis (9). As function decreases, secondary health concerns and related quality-of-life issues tend to further reduce physical activity, thus continuing the cycle of disuse (1). Conversely, when appropriate stimulation is provided through physical activity, recovery of function has been observed (9–11). This implies that directional relationships may exist between physical activity and quality of life in persons with neurologic damage (Figure 1).

Against this backdrop, the purpose of our study was to quantify the relationship between level of physical activity and quality of life in persons with SCI. It was hypothesized that, after controlling for specific injury-related factors, increased levels of physical activity would be statistically associated with a higher quality of life.

METHODS

Male ($n = 32$) and female ($n = 30$) adults 18 to 50 years of age volunteered to participate in this study. Eligibility for participation included SCI at or below C6 for at least 12 months and the absence of a progressive medical disease that might have adversely affected quality of life and participation in physical activity. Participants were asked to provide demographic, medical, and injury-related information. These data were used to ensure appropriate distribution of the sample with regard to age, sex, and type of injury, as well as to identify participants with medical histories that would exclude them from participating in the study. Injury-related questions addressed level of SCI, injury status (eg, complete or incomplete), and date of injury onset.

Physical Activity

Establishment of an objective standard for measuring physical activity levels in nonambulatory populations has proven difficult. Warms and Belza (12) measured the activity level of wheelchair users with SCI using actigraphy, a technique that uses accelerometers to detect wrist, trunk, or ankle motion. These researchers concluded that self-report measures of activity intensity and frequency validated actigraphy as a measure of physical activity in wheelchair users. A primary limitation of using actigraphy as an activity measure in the SCI population is that motion must occur for the movement receptor to record activity. Consequently, isometric activity is not recorded. In addition, water can damage the Actigraph, making aquatic activity difficult to monitor. Hence, physical activity studies with mobility-impaired individuals that feature isometric and water-based activities (which were the preferred forms of exercise reported by 32% of our participants) must continue to rely on self-report measures to assess physical activity.

The Physical Activity Scale for Individuals with Physical Disabilities (PASIPD) was used to quantify the physical activity levels of our participants. The PASIPD, which is a modification of the Physical Activity Scale for the Elderly (PASE), is a self-report instrument (13). Similar to the PASE, the PASIPD requests information concerning (a) leisure activities, such as walking and wheeling outside the home, light, moderate, and vigorous sport and recreation activities, and exercise to increase strength and endurance; (b) household activities, including light and heavy housework, home repair, lawn work, and outdoor gardening; and (c) occupational activity. Physical activity is quantified as a function of mode, frequency, intensity, and duration, and a numeric score is calculated that reflects the overall level of physical activity. Using this scoring procedure, the highest score possible is 199.5.

The PASIPD was validated based on evaluations of 372 individuals with a variety of physical disabilities (13). Factor analysis showed 5 latent factors (home repair and lawn/garden work, housework, vigorous sport and recreational activity, light and moderate sport and recreational activity, and occupational and transportation activity) that accounted for 63% of the total item variance. Correlations between subcomponents of each latent factor and the total PASIPD score were statistically significant ($P < 0.05$) (13). Further validation provided by correlating PASIPD scores with self-assessments of physical activity and health indicated that persons who self-reported greater levels of activity and good health exhibited higher PASIPD scores (13).

Quality of Life

The Quality of Well-Being Scale (QWB) was completed by each participant. The QWB is an interview-formatted survey developed as a generic index of population health status (14). The QWB combines preference-weighted values for symptoms and physical performance in daily living skills. Preference weights were obtained from the responses of 856 people drawn from the general population. These responses were used to rate the desirability of health conditions on a continuum between death (0.00) and optimum health (1.00). The QWB assesses health from responses to questions related to the presence or absence of different conditions and symptoms. Daily living skill performance is quantified by a series of questions designed to record functional limita-

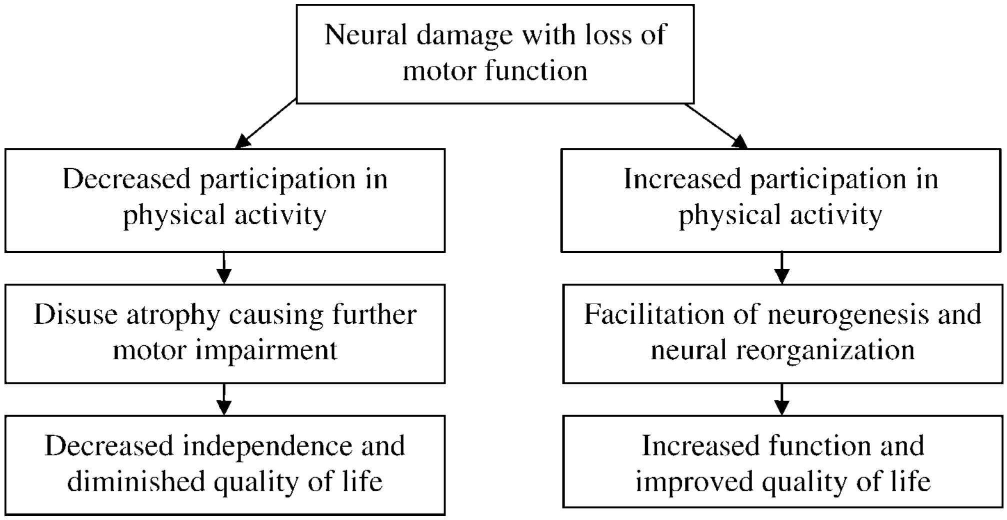

Figure 1. *Hypothesized relationships among neural damage, physical activity, and quality of life in individuals with SCI.*

tions over the previous 6 days within the domains of mobility, physical activity, and social activity. The health and activity domain scores are combined into a total score that yields a numerical point-in-time expression of well being ranging from 0 (0.00) for death to 1 (1.00) for asymptomatic optimum performance of daily living skills (14).

The validity of the QWB has been shown in a study by Anderson et al (15). In this study, the performances of 5 quality of life surveys (Behavioral Risk Factor Surveillance System Health Related Quality of Life, Instrumental Activities of Daily Living Measure, Medical Outcomes Short Form 12, Medical Outcomes Short Form 36, and Quality of Well-Being Scale) were compared (15). Although this measure has not been validated with SCI, it was concluded that all of these surveys displayed potential for use in research studies on persons with SCI. Although these survey instruments embrace a variety of domains, exhibit high respondent acceptability ratings, and display acceptable levels of validity when used with individuals with SCI, the QWB can be administered in an interview format. From a practical standpoint, the ability to obtain accurate information from a population with limited writing ability may increase when using a survey instrument (like the QWB) that allows participants to respond verbally to questions.

Sample Collection

Approval for this project was obtained from the University Institutional Review Board. All procedures for this study complied with regulations established by the Institutional Review Board for research using human subjects. A description of the project and a formal request for volunteers were presented to members of local SCI support groups and athletic clubs during regularly scheduled meetings. Volunteers who met eligibility requirements received an investigation packet containing an informed consent form, a copy of the physical activity assessment, and information describing how to contact the primary investigator. Once a signed informed consent form was received, an interview was conducted by the primary investigator to collect demographic information. These data were used to ensure appropriate distribution of the sample with respect to age, sex, and type of injury. The QWB was completed during this initial interview. After the interview, participants received instructions on the use and completion of the physical activity scale.

Data Analysis

For each participant, information was collected that identified the anatomical level at which the spinal cord was injured. Cervical injuries were coded as 1 plus the number of the injured cervical segment. For example, a C7 injury was coded 1.7, whereas a C8 injury was coded 1.8. This coding process was used to specify level of injuries to the thoracic and lumbar regions of the spine, with thoracic injuries coded 2 and lumbar injuries coded 3. Using a continuous scale to specify the injury location enabled level of injury to be included in the correlational analysis.

The mean, SD, and range were calculated for each dependent variable. Distributions of selected data were examined for normalcy using the Kolmogorov-Smirnov test. Variables examined for normality included time since injury, age, level of injury, level of physical activity, and quality of life. Of these 5 variables, only time since injury was not normally distributed. The natural log of time since injury, however, was distributed in a normal fashion. Consequently, two sets of statistical analyses were conducted: one using time and the other using the natural log of time. Both sets of analyses yielded identical conclusions regarding statistical significance, so results based on time since injury were reported to simplify interpretation. Completeness of injury was not examined for normalcy because it was a categorical variable.

Table 1. Age and Time Since Injury Onset of Study Participants

Variable	Mean	SD	Range
Age (years)	35	10	20–49
Length of time since injury (years)	9	9	1–40

Relationships among level of physical activity, level of injury, time since injury, and quality of life were determined using Pearson product moment correlation coefficients. The proportion of variation in quality of life accounted for by level of physical activity, level of injury, time since injury, and completeness of injury was evaluated using multiple regression analysis. For all analyses, statistical significance was established at $P < .05$.

RESULTS

Of the 73 individuals who volunteered to participate in this study, 11 dropped out before completing both the QWB and PASIPD, yielding an overall retention percentage of 85% (N = 62). The descriptive characteristics of the study sample are found in Tables 1 and 2. Table 3 depicts participants' scores on the PASIPD and the QWB. As noted previously, the PASIPD scores reflect physical activity levels associated with self-care, work, home management, and leisure activities, whereas the QWB assessed quality of life.

Pearson product correlation coefficient analysis showed a strong positive association between level of physical activity and quality of life ($r = 0.75$, $P < 0.05$), indicating that participants who reported higher levels of physical activity also exhibited higher QWB scores. A scatterplot of this relationship is presented in Figure 2. As shown in Table 4, aside from the relationship identified between level of physical activity and quality of life, weaker, nonsignificant associations were observed among quality of life, level of injury, and time since injury.

Level of physical activity, level of injury, time since injury, and completeness of injury were entered into a multiple regression model. Studentized deleted residuals were inspected, and none exceeded the Bonferroni-adjusted critical values. Partial regression plots confirmed nonlinearity and heteroscedasticity was not present. Collinearity diagnostics were inspected for each model. The largest condition index found was 15, so collinearity was not a concern. To represent level of injury more functionally, this variable was recoded as a dichotomous variable. This data transformation used T1 as the marker separating tetraplegia (motor impairment evident in all 4 extremities) from paraplegia (motor impairments evident only in the lower extremities). This categorization was used to stratify participants into 2 groups, according to physical performance.

Table 2. Participant Injury Characteristics

Variable	N	Percentage*
Level of spinal injury		
Tetraplegia	23	37
Paraplegia	39	63
Completeness of injury		
Complete	38	61
Incomplete	24	39

*Percentage of total number of study participants (N = 62).

Table 3. PASIPD and QWB Scores of Study Participants

Variable	Mean	SD	Range
PASIPD	26.40	8.32	6.25–47.50
QWB	0.46	0.14	0.21–0.73

Results from this analysis showed that level of physical activity was a significant predictor of quality of life when controlling for injury level, time since injury, and completeness of injury ($t = 8.71$, $P < 0.001$). Aside from level of physical activity, all other variables were excluded from the model because of failure to meet inclusion criteria (Table 5). A follow-up test was conducted to determine whether a regression model containing all 4 variables significantly improved the prediction of quality of life compared with a model that included only physical activity ($R^2 = 0.567$). Results indicated that the full regression model did not significantly improve the prediction of quality of life beyond that accounted for by physical activity alone [R^2 change = 0.009, F change (3,57) = 0.38, $P = 0.77$).

DISCUSSION

The relationship between physical activity and quality of life in persons with physical disabilities is an important public health issue that has received inadequate attention

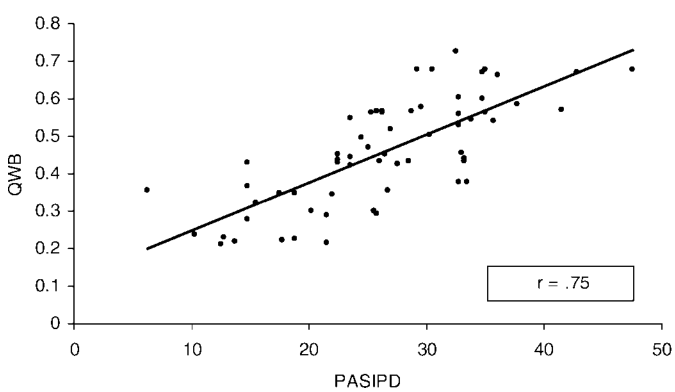

Figure 2. *Scatterplot of PASIPD and QWB scores in adults with SCI.*

Table 4. Correlations Among Level of Physical Activity, Level of Injury, Time Since Injury, and Quality of Life

	Level of Physical Activity	Level of Injury	Time Since Injury	Quality of Life
Level of physical activity	—	0.20	−0.11	0.75*
Level of injury		—	0.06	0.13
Time since injury			—	−0.02

*$P < 0.05$ level (2-tailed).

in the scientific literature (16). With this in mind, this study was designed to quantify the level of physical activity in individuals with SCI and to determine whether physical activity, an adaptable variable, is related to quality of life in this physically challenged population.

The mean score for the sample population used in the development of the PASIPD was 20.20, with an SD of 14.50 (13), whereas the mean score for the sample in this study was 26.40, with an SD of 8.32. Based on this comparison, it seems that the average physical activity score observed in our sample of adults with SCI is generally reflective of typical physical activity levels reported in a larger population of persons with various physical disabilities (13). It should be noted that the mean physical activity value of 26.40 obtained in this study was substantially lower than the instrument ceiling of 199.5. This suggests that a large potential exists for marked increases in physical activity among individuals with SCI. This assertion is based on the stable nature of SCIs compared with other types of disabling conditions, as well as the fact that persons with SCI are typically young, healthy men who were often physically active before being injured (17).

Results from this study showed a statistically significant and strong positive relationship between level of physical activity and quality of life among persons experiencing motor impairments secondary to SCI. This finding is in agreement with limited data showing a lower quality of life in the presence of progressive disease and disability. For instance, Gruenewald et al (18) measured quality of life in persons diagnosed with multiple sclerosis. Results from this study indicated that the mean quality of life score for ambulatory persons diagnosed with multiple sclerosis was significantly higher than a group of nonambulatory persons diagnosed with multiple sclerosis. Kaplan et al (19) also measured quality of life in a group of control subjects and in symptomatic patients and asymptomatic patients with human immune deficiency virus. These investigators reported lower quality-of-life scores in the symptomatic group compared with the asymptomatic group. Moreover, the difference in quality of life scores increased significantly when the symptomatic group was compared to the control group. Taken together, these results imply that as human immune deficiency virus progresses, physical activity becomes more limited, and quality of life decreases (19).

Table 5. Regression Analysis Summary for Variables Predicting Quality of Life in Persons With SCI

Variable	B	SE B	β
Constant	0.12	0.071	—
Complete or incomplete injury	0.010	0.027	0.035
Level of injury	0.007	0.044	0.021
Tetraplegia/paraplegia	−0.019	0.029	−0.059
Time since injury	0.001	0.001	0.079
Level of physical activity	0.013	0.002	0.77

Variable contribution to quality of life: complete or incomplete injury, $R^2 = 0.003$; tetraplegia/paraplegia, $R^2 = 0.008$; time since injury, $R^2 = 0.013$; level of physical activity, $R^2 = 0.57$.*
*$P < 0.05$.

A limitation of existing research involving persons with disabilities is that factors affecting quality of life have often not been identified. To address this concern, this study was designed to examine the role of specific variables as they relate to quality of life. Persons with SCI were selected as the target population in an attempt to control for age-related health declines and the progressive nature of disabling conditions found in other neurologically impaired populations. Multiple regression analysis indicated that more than one half of the variation in quality of life was attributable solely to variation in physical activity level. Interestingly, a negative correlation was shown between quality-of-life measures and time since injury. This is in contrast to other research saying that there is an adjustment period after SCI and quality of life improves over time. It should be noted that factors such as community support, depression, caregiver support, and socioeconomic status may influence access to and participation in physical activity and may have mediating or moderating effects on the relationship between physical activity and quality of life in the SCI population. The direct and indirect pathways associated with these relationships remain to be explored.

Although physical activity associated with work, recreation, and self-care were components of the total physical activity measure for each participant, the influence of each subcategory of physical activity on quality of life is unclear, as is the degree to which changes in a particular subcategory may affect optimal levels of function. Hence, further research should be conducted to quantify the dose–response relationship between level of physical activity and quality of life and to identify physical

activities which are most effective in achieving improvements in quality of life among individuals who have experienced SCI.

Last, although our data showed that quality of life for persons with SCI is influenced to a large extent by physical activity, it bears mentioning that 44% of the variation in quality of life remained unexplained, even after accounting for a number of injury-related variables. In considering this latter point, Hampton et al (20) has suggested that altered bowel and bladder functioning and chronic neuropathic pain may have a negative impact on quality of life in the SCI population. Data showing that premorbid personality can influence adjustment to physical disability also suggest that psychological makeup may affect quality of life among individuals with SCI (21).

CONCLUSION

Results from our study indicate that a strong positive association exists between level of physical activity and quality of life in adults with SCI. Additionally, more than one half of the variation in quality of life was explained by differences in physical activity level. Because no cures are presently available for individuals with SCI, the development of interventions and programs to increase physical activity in this population is a promising approach that is cost-effective and has few negative side effects. Given the high benefit-to-cost ratio of participating in regular physical activity, health care professionals should encourage and support initiatives to promote physically active lifestyles in persons with SCI.

REFERENCES

1. Boswell B, Dawson M, Heininger E. Quality of life as defined by adults with spinal cord injuries. *J Rehabil.* 1998;64:27–32.
2. World Health Organization. *Measuring Quality of Life*. Geneva, Switzerland: World Health Organization; 2004.
3. Kannisto M, Merikanto J, Alaranta H, Hokkanen H, Sintonen H. Comparison of health-related quality of life in three subgroups of spinal cord injury patients. *Spinal Cord.* 1998; 36:193–199.
4. Post M, VanDijk A, Asbeck F, Schrijvers A. Life satisfaction of persons with SCI compared to a population group. *Scand J Rehabil Med.* 1998;30:23–30.
5. Merzenich M, Taub P, Greenough T. Neural plasticity. *Harvard Brain.* 1999;16:16–20.
6. Buchholz AC, McGillivray CF, Pencharz PB. Physical activity levels are low in free-living adults with chronic paraplegia. *Obes Res.* 2003;11:563–570.
7. Levins S, Redenbach D, Dyck I. Individual and societal influences on participation in physical activity following spinal cord injury: a qualitative study. *Phys Ther.* 2004;84: 496–510.
8. Lundy-Ekman S, Nottebohm F. Neurogenesis in the adult brain. *J Neurosci.* 2002;22:624–628.
9. Maenpaa H, Jaakkola R, Sandstrom M, Airi T, von Wendt L. Electrostimulation at sensory level improves function of the upper extremities in children with cerebral palsy: a pilot study. *Dev Med Child Neurol.* 2004;46:84–90.
10. Dobkin B, Barbeau H, DeForge D, et al. The evolution of walking-related outcomes over the first 12 weeks of rehabilitation for incomplete traumatic spinal cord injury: the multicenter randomized spinal cord injury locomotion trial. *Neurorehabil Neural Repair.* 2007;21:25–35.
11. Fouad K, Pearson K. Restoring walking after spinal cord injury. *Prog Neurobiol.* 2004;73:107–126.
12. Warms C, Belza B. Actigraphy as a measure of physical activity for wheelchair users with spinal cord injury. *Nurs Res.* 2004;53:136–143.
13. Washburn R, Zhu W, McAuley E, Frogley M, Figoni S. The physical activity scale for individuals with physical disabilities: development and evaluation. *Arch Med Rehabil.* 2002; 83:193–200.
14. Kaplan R. *Quality of Well-being User's Manual.* Waltham, MA: Medical Outcomes Trust; 1994.
15. Anderson E, Fouts B, Romeis J, Brownson C. Performance of health related quality of life instruments in a spinal cord injured population. *Arch Phys Med.* 1999;80:877–884.
16. Centers for Disease Control and Prevention. Physical activity and health. A report of the Surgeon General. 2000. Available at: www.cdc.gov/nccdphp/sgr/disab.htm. Accessed May 29, 2007.
17. Faghri PD, Yount J. Electrically induced and voluntary activation of physiologic muscle pump: a comparison between spinal cord-injured and able-bodied individuals. *Clin Rehabil.* 2002;16:878–885.
18. Gruenewald D, Higginson I, Vivat B, Edmonds P, Burman R. Quality of life measures for the palliative care of people severely affected by multiple sclerosis: a systematic review. *Mult Scler.* 2004;10:690–725.
19. Kaplan R, Ganiats T, Sieber W, Anderson J. The quality of well-being scale: critical similarities and differences with SF-36. *Int J Qual Health Care.* 1998;10:509–520.
20. Hampton NZ. Subjective well-being among people with spinal cord injuries: the role of self-efficacy, perceived social support, and perceived health. *Rehabil Couns Bull.* 2004;48: 31–38.
21. Falvo D. *Medical and Psychosocial Aspects of Chronic Illness & Disability.* 2nd ed. Gaithersburg, MD: Aspen Publishers; 1999.