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Disclosures:

Funded by National Institute on Disability and Rehabilitation Research (NIDRR) grant H133B031114, the NRH Rehabilitation Research and Training Center on SCI: Promoting Health and Preventing Complications Through Exercise.
A related publication detailing the development of the SCI Exercise Self-efficacy Scale has been published in the *International Journal of Behavioral Nutrition and Physical Activity* (online, August 30, 2007; doi: 10.1186/1479-58-68-4-34).
Financial disclosure statements have been obtained, and no conflicts of interest have been reported by the authors or by any individuals in control of the content of this article.

0894-9115/12/9108-0640/0
American Journal of Physical Medicine & Rehabilitation

DOI: 10.1097/PHM.0b013e31825a12cd

ORIGINAL RESEARCH ARTICLE

Perceived Exercise Self-efficacy as a Predictor of Exercise Behavior in Individuals Aging with Spinal Cord Injury

ABSTRACT

Kroll T, Kratz A, Kehn M, Jensen MP, Groah S, Ljungberg IH, Molton IR, Bombardier C: Perceived exercise self-efficacy as a predictor of exercise behavior in individuals aging with spinal cord injury. Am J Phys Med Rehabil 2012;91:640–651.

Objective: The purpose of this study was to test the hypothesized association between exercise self-efficacy and exercise behavior, controlling for demographic variables and clinical characteristics, in a sample of individuals with spinal cord injuries.

Design: A cross-sectional national survey of 612 community-dwelling adults with spinal cord injury in the United States ranging from 18 to 89 yrs of age was conducted. Sample consisted of 63.1% men with a mean (SD) duration of 15.8 (12.79) yrs postinjury; 86.3% reported using a wheelchair.

Results: Self-efficacy was the only independent variable that consistently predicted all four exercise outcomes. Self-efficacy beliefs were significantly related to frequency and intensity of resistance training (R^2 change = 0.08 and 0.03, respectively; $P < 0.01$ for all) and aerobic training (R^2 change = 0.07 and 0.05, respectively; $P < 0.01$ for all), thus explaining between 3% and 8% of the variance. Hierarchical linear regression analysis revealed that controlling for other demographic and physical capability variables, the age-related variables made statistically significant contributions and explained between 1% and 3% of the variance in aerobic exercise frequency and intensity (R^2 change = 0.01 and 0.03, respectively; $P < 0.01$ for all). Clinical functional characteristics but not demographic variables explained participation in resistance exercise.

Conclusions: Self-efficacy beliefs play an important role as predictors of exercise. Variations in exercise intensity along the age continuum have implications for exercise prescription and composition. Future research should replicate findings with objective activity measures.

Key Words: Spinal Cord Injuries, Exercise, Self-efficacy, Aging

Self-efficacy is a widely researched concept in health and exercise studies and is defined as a belief "…in one's capabilities to organize and execute the courses of action required for producing given attainments."[1] These beliefs are hypothesized to play an important role in determining actions; specifically, higher self-efficacy beliefs regarding specific behaviors contribute to a decision to engage in those behaviors.[1] Consistent with this hypothesis, research has shown that high self-efficacy beliefs before starting personal unsupervised or supervised exercise regimens are predictive of greater adherence to exercise.[2] Exercise self-efficacy has further been examined in a variety of clinical and disability populations, including those with cancer,[3–5] stroke,[6–8] and spinal cord injury (SCI),[9–11] among others. Demographic-focused research studies have examined self-efficacy beliefs related to physical activity in women with disabilities[12] and in older women.[13] The relevance of exercise-related coping self-efficacy beliefs has been studied in relation to forming leisure-time physical activity plans among people with SCI.[14] Self-efficacy is one of the principal Social Cognitive Theory constructs, and it plays a key role in determining engagement in physical activity after SCI.[15] As a group, the results of the aforementioned studies have highlighted the importance of perceived exercise self-efficacy, but research in this area has not yet examined the importance of exercise self-efficacy in individuals aging with SCI.

Physical activity is thought to contribute to "healthy aging." Evidence supports the beneficial role of exercise for senior athletes in terms of muscle strength,[16,17] bone mineral density and coronary risk factors in older women,[18] and cognitive function.[19] Physical activity in midlife has also been linked to greater longevity of women.[20]

People with SCI may be at risk for accelerated aging processes,[21,22] characterized by greater frequency of, more advanced presentation of, and/or earlier onset of chronic secondary health conditions.[23] For example, because of the neurologic impairment and paralysis, profound body composition changes characterized by an increase in fat mass[24–28] and a decrease in bone and lean muscle mass[29] occur rapidly after SCI. These body composition changes correlate with a heightened risk of fractures, obesity and overweight, skin breakdown, inflammation, and subsequent cardiovascular disease,[30] all of which can persist through the lifetime of the individual. A recent survey study from Canada found that age was the strongest predictor of secondary health conditions in a sample of individuals with SCI.[31] The elevated prevalence of chronic secondary health conditions among persons with SCI has focused considerable attention on their poor levels of physical conditioning[32–34] because physical activity can potentially ameliorate some of these negative long-term consequences.

To date, most exercise behavior studies in SCI have been smaller scale interventions, often laboratory-based studies, and have not examined the role of exercise self-efficacy as a key concept for different aging cohorts. Furthermore, the role of exercise self-efficacy in predicting types, intensity, and frequency of exercise while controlling for a range of sociodemographic, clinical, and functional variables has not been investigated to date.

Hence, the primary aim of this study was to determine whether perceived exercise self-efficacy predicts exercise behavior, controlling for demographic variables and SCI clinical characteristics, in a sample of individuals with SCI. On the basis of previous research on self-efficacy as well as self-efficacy theory, we hypothesized a positive association between self-efficacy and exercise frequency and intensity above and beyond the effects of demographic and clinical variables. A secondary aim was to examine the extent that age-related variables, specifically chronological age and years since SCI, were associated with exercise outcomes above and beyond the influence of demographic and clinical characteristic variables. On the basis of the discussion above, we anticipated that older individuals and individuals with a longer SCI duration would report lower levels of exercise frequency and intensity.

METHOD

Sampling

Individuals with SCI were recruited nationwide to participate in a 2-yr longitudinal mail-in survey study. Participants were recruited through membership mailings by the National Spinal Cord Injury Association, the Independent Living Research Utilization, and the Edward Hines, Jr., Veterans Administration Hospital in Hines, IL. These mailings were sent to approximately 5000 individuals with SCI. The National Spinal Cord Injury Association database contained a mix of members including caregiving relatives (e.g., of those <18 yrs of age; people continuing to support the organization after the patient member had died) and supporters of the organization.

Procedure

Potential participants were invited to contact the research team if they were interested in taking part in the study. Individuals who contacted the team were screened for eligibility. Eligibility criteria included (1) being at least 18 yrs of age, (2) having an SCI, (3) being at least 2 yrs postinjury, (4) living in the United States, and (5) having a working knowledge of English. Participants were then mailed informed consent and Health Insurance Portability and Accountability Act documents for signature, along with a copy of the survey with instructions. These mailings included staff contact information in the case of questions or concerns and a prepaid return envelope. All participants were assigned a randomly selected identification number that accompanied their survey to maintain anonymity. All of the study procedures were approved by the MedStar Research Institute Institutional Review Board.

Measures

The questions included on the survey used in this study were selected through an iterative process that incorporated input from individuals with SCI. The research team invited consumer input from people with SCI using Internet-based audiocast technology. Listeners were encouraged to provide feedback on content and format of the instrument via Email. Emails were reviewed, and suggestions about questions discussed by the research team were incorporated in the initial item formulation. Cognitive interviews were then conducted with six participants with SCI who were selected to represent a variety of sexes, incomes, ages, ethnic backgrounds, and SCI clinical characteristics. Based on the interviews, survey questions were refined to ensure that the format was accessible and understandable and the wording of instructions and items, response options, and layout were appropriate. Reliability and concurrent validity were established for self-efficacy items.

Demographics

Basic demographic information, including age, sex, four levels of education, income, marital status, and date of SCI, was collected from all participants.

SCI Clinical Characteristics

Participants were asked about injury level, completeness, and the extent to which they were able to use their arms and legs and rated these on three-point scales, where 1 = full, 2 = partial, and 3 = no use. These values were reversed coded so that higher values indicated greater ability to use the limbs. Self-reported arm and leg use was chosen because it provided a clearer indication for motor function than does injury level or self-reported incompleteness/completeness of injury. Wheelchair use was assessed with three questions, "Do you use a wheelchair? Yes/No," "What type of wheelchair do you most often use? Power chair or scooter/Manual," and for manual wheelchair users, "Who pushes you most of the time? I push myself/somebody pushes me." These three items were combined into a single wheelchair use variable with four levels: 0 = does not use wheelchair, 1 = self-propelled manual chair, 2 = power wheelchair, 3 = other-propelled manual chair.

Exercise Frequency and Intensity

Participants were asked to identify up to three aerobic activities and up to three resistance training exercises that they had engaged in during the past 12 mos for increasing or maintaining physical fitness. For each exercise noted, they were asked to indicate the number of days per week spent on that activity in the past 12 mos. The maximum number of days per week spent doing one of the aerobic exercises was used as the value representing aerobic exercise frequency in the analyses. The maximum number of days per week spent doing a resistance training exercise was used as the value representing resistance training frequency. For each aerobic and resistance training exercise, participants were asked to rate the intensity of the exercise on a 3-point scale, from 1 (light) to 3 (vigorous). An example of a completed aerobic exercise survey is depicted in Figure 1. For this hypothetical case, the value for frequency of aerobic exercise would be 4 because this is the highest number of days per week spent doing aerobic activity. Operational definitions and illustrative examples were provided for all types of exercise (aerobic, strengthening, flexibility) akin to the example displayed in Figure 1 for aerobic exercise. The mean exercise intensity across all types of aerobic exercise was used as the value for aerobic exercise intensity and the mean across all types of resistance training was used as the value for resistance training intensity. For example, the aerobic exercise intensity score for the example case in Figure 1 would equal 1.5, which is the mean of 1 and 2, the intensity scores for arm cycle and swimming.

Exercise self-efficacy was defined in this study as "the confidence of individuals with SCI to plan and carry out physical activities and/or exercise based on their own volition." This construct was assessed using the Exercise Self-efficacy Scale.[35] The Exercise Self-efficacy Scale contains 10 items that ask respondents to rate how confident they are with regard to carrying out regular physical activity. Sample items include the following: I am confident "…that I can overcome barriers and challenges

PHYSICAL ACTIVITY/EXERCISE
In this section, we want to know about the types of physical activity and exercise that you do.

7a. Please complete the following table as best you can and list any **Aerobic Activities** that you have done mainly for increasing or maintaining fitness in the **Past 12 Months**.

Type of Activity in the Past 12 Months	Intensity**	Frequency		Duration
A = Aerobic activities may cause sweating and an increase in heart and breathing rates, or make it hard to talk. Examples include basketball, walking, tennis, etc.	1 = Light 2 = Moderate 3 = Vigorous	Number of minutes per day spent on this activity	Number of days per week spent on this activity	Number of months in the last 12 months spent on this activity
Example: Basketball	*3*	*45*	*2*	*12*
Arm cycle	1	30	4	12
Swimming	2	45	1	12

**For the columns labeled "Intensity," we want to know, on average, how intensely you are exercising. For this column, please mark either 1, 2, or 3 based on the following descriptions:

1 = Light physical activity or exercise (can easily talk while exercising; with or without light sweating);
2 = Moderate physical activity or exercise (breathing harder and/or moderate sweating);
3 = Vigorous physical activity or exercise (talking is difficult; breathing hard and/or heavy sweating).

FIGURE 1 *Survey item sample.*

with regard to physical activity and exercise if I try hard enough," "…that I can be physically active or exercise even when I am tired," and "…that I can be physically active or exercise without the help of a therapist or trainer." Participants responded to the Exercise Self-efficacy Scale items on a 4-point Likert scale from 1 (not at all true) to 4 (always true). The self-efficacy score was calculated as the average of the 10 self-efficacy items. The scale demonstrated excellent reliability in the current sample (Cronbach $\alpha = 0.92$).

Data Analyses

Data were first entered into a Microsoft Access Database for cleaning purposes and then transferred to SPSS for statistical analysis (SPSS for Windows, Rel. 17.0.1. 2008; SPSS Inc, Chicago, IL). We then computed descriptive statistics for the study variables. A series of hierarchical linear regression analyses were used to test the contributions of demographic variables, SCI clinical factors, time variables, and exercise self-efficacy to the prediction of four measures of aerobic and resistance training exercise frequency and intensity. Demographic variables were entered in the first step; clinical characteristics, in the second step; chronological variables, in the third step; and self-efficacy, in the fourth step. The shape of the relation (linear, quadratic, or cubic) between age/years since injury and exercise behavior was examined. In some cases, quadratic associations between time and exercise variables were found and quadratic functions of the predictor were entered into the regression equation. To test the moderating effects of age on self-efficacy, an interaction term (age × self-efficacy or age × age × self-efficacy in cases where age had a quadratic association with the exercise outcome) was added to the fourth step.

Hierarchical linear regression was the analytical approach selected because it allows for the sequential analysis of the contribution of "sets," or groups of predictors from a common substantive category, in a linear regression equation. In addition, hierarchical linear regression allows for examination of the amount of variance accounted for in the outcome of interest by each set of predictors (R^2). The hierarchical linear regression also provides values for R^2 change, which indicates the change (increase) in total variance accounted for in the outcome with inclusion of each set of predictors, and an F change statistic, which is a test of the significance of the addition of the set of variables in predicting the outcome. Variables were selected as predictors based on previous findings that they were associated with exercise behavior. Predictors were clustered into sets based on similar substantive categories (i.e., demographics, clinical variables, time variables). Order of entry of sets into the regression equation was based on presumed causal primacy, where variables in later sets could not have feasibly caused variables in previous sets.[36]

RESULTS

Sample Characteristics

The recruitment drive with the assistance of the National Spinal Cord Injury Association in Bethesda, MD, the Independent Living Research Utilization in Houston, TX, and the Veteran Administration Hospital in Hines, IL, produced 1274 responses. The composition of the National Spinal Cord Injury Association database as described above explained why several mailing list members were found ineligible after the screening. Of the 987 individuals found eligible after screening, 627 returned and completed the survey. Of those who answered the survey, 612 individuals had complete data on the variables of interest for this study and were included in the analyses. Compared with those with incomplete data, participants included in the analyses were not statistically significantly different in terms of age, sex, years since injury, exercise self-efficacy, exercise frequency, or level of SCI.

The sample characteristics are presented in Table 1.

As shown, most of the sample were white and men. Just more than half of participants were married and most were not working at the time of the study. Age ranged from 18 to 89 yrs. Median income for the sample was between $20,000/yr and $60,000/yr. Nearly three quarter of the participants reported college or technical school training. The majority lived in their own homes or apartments. Duration of injury ranged from 1 to 63 yrs. Vehicular accidents were the most common cause of injury. A complete SCI was reported by more than half of the respondents, and for more than three quarter, a wheelchair was the primary means of locomotion.

TABLE 1 Sample characteristics ($n = 612$)

Variable	*n* %
Sex	
Female	226 (36.9)
Male	386 (63.1)
White	542 (88.5)
Age, mean (SD), yrs	48.5 (13.54)
Education	
No high school completed	8 (1.3)
High school completed	144 (23.6)
Technical school of college	319 (52.1)
Master's or higher degree	141 (23.0)
Currently not working	361 (59)
Median income category, $	20,000–60,000
Married/cohabitating	326 (53.3)
Living in personal home/apartment	598 (97.7)
Living in a group home/nursing home	14 (2.3)
SCI duration, mean (SD), yrs	15.88 (12.79)
Etiology	
Vehicular accidents	319 (52.1)
Falls	106 (17.4)
Sports accidents	79 (12.9)
Medical/surgical	68 (11.2)
Violence	40 (6.5)
Paraplegia	300 (49)
Complete SCI	356 (58.2)
Arm use	
Full	357 (58.3)
Partial	237 (38.7)
No use	18 (2.9)
Leg use	
Full	38 (6.2)
Partial	187 (30.6)
No use	387 (63.2)
Wheelchair use as primary mode of locomotion	
Does not use wheelchair	90 (14.4)
Pushes self in manual wheelchair	327 (52.2)
Uses power wheelchair	193 (30.8)
Pushed by somebody else in manual wheelchair	17 (2.7)

SCI indicates spinal cord injury.

Zero-order correlations between predictor and outcome variables are depicted in Table 2. Median, mean, and standard deviations for these variables are also depicted along the bottom of this correlation table. Few of the correlations exceeded $r = 0.20$. Moderate positive correlations were found between education and income, arm use and exercise self-efficacy, and age and years since injury. Leg and arm use had moderate negative correlations with wheelchair use. Exercise self-efficacy was significantly and moderately correlated with higher levels of exercise frequency and intensity.

Distributions for aerobic and resistance training exercise frequency and intensity are depicted in Figure 2. The modal frequency for both types of exercise was 0 days per week. The sample engaged in aerobic exercise an average of 2.4 days (SD, 2.33 days) per week and in resistance for training an average of 2.15 days (SD, 2.14 days) per week. Of those who reported exercise activities, most of the participants reported only one type of aerobic activity (61.8%) and one type of strength training activity (58.4%); 29.3% endorsed two aerobic and 37.2% endorsed two strength training activities. The sample, on average, rated their aerobic exercise and resistance training intensity to be "moderate" (mean [SD], 1.94 [0.63] and 1.81 [0.64], respectively). For the four exercise outcomes, the maximum skew was 0.58 and the maximum kurtosis was −0.82. Based on the criteria that skew greater than 2 or kurtosis greater than 7 indicates a substantial nonnormal distribution,[37,38] these variables were deemed to have acceptable levels of nonnormality, and regression analyses were performed.

Predicting Aerobic Exercise Behavior

Table 3 contains the hierarchical linear regression results predicting aerobic exercise frequency and intensity. Demographic variables and clinical characteristics both made significant contributions to the prediction of aerobic exercise frequency, whereas clinical but not demographic variables accounted for a significant proportion of variance in aerobic exercise intensity. In terms of contributions of individual variables, for aerobic exercise frequency, leg use was positively associated and wheelchair use was negatively associated with exercise frequency. In terms of aerobic exercise intensity, no individual demographic or clinical variables were significant predictors.

Controlling for other demographic and physical capability variables, the age-related variables contributed a statistically significant but modest proportion of variance to the prediction of aerobic exercise frequency and intensity (1% and 3%, respectively). Of the two age-related variables, years since injury made an independent contribution to the prediction of frequency of aerobic exercise and chronological age made a significant contribution to the prediction of the intensity of aerobic exercise. Specifically, years since injury demonstrated a negative quadratic association with aerobic exercise frequency, which indicates an upside-down U shape where frequency of exercise is relatively higher in the midrange of years since injury compared with shorter and longer intervals of years since injury. Chronological age had a negative quadratic association with aerobic intensity, with those in the middle of the age range reporting relatively greater exercise intensity compared with younger and older individuals.

Controlling for the contributions of demographic variables, clinical characteristics, and time variables, self-efficacy was related to greater frequency and intensity of aerobic exercise and accounted for 7% of the variance in aerobic exercise frequency and 5% of the variance in aerobic exercise intensity. The single self-efficacy variable accounted for more variance in aerobic exercise outcomes than blocks of demographic, clinical characteristic, or time variables, which accounted for between 2% and 7% of variance in outcomes.

Predicting Resistance Training Exercise Behavior

Table 4 contains the hierarchical linear regression results for resistance training exercise frequency and intensity. The block of clinical characteristics made significant contributions to the prediction of resistance training frequency, although none of the individual variables were significant independent predictors of exercise frequency. Neither clinical characteristics nor demographics contributed significantly to the prediction of resistance training intensity, and only sex demonstrated a significant association with resistance training intensity, with men reporting a higher frequency.

TABLE 2 Zero-order correlations of participant demographic, clinical, and key study variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Sex	–												
2. Income	0.15[a]	–											
3. Education	−0.04	0.33[a]	–										
4. Arm use	−0.12[a]	0.07	0.04	–									
5. Leg use	−0.04	−0.01	0.04	0.10[b]	–								
6. Wheelchair use	−0.04	−0.06	−0.06	−0.42[a]	−0.39[a]	–							
7. Age	0.20[a]	0.16[a]	0.10[b]	0.09[b]	0.18[a]	−0.03	–						
8. Years since injury	0.09[b]	0.17[a]	0.14[a]	−0.02	−0.10[b]	0.02	0.41[a]	–					
9. Exercise self-efficacy	0.04	0.13[a]	0.16[a]	0.29[a]	0.01	−0.19[a]	0.03	0.04	–				
10. Aerobic frequency	0.08[b]	0.10[b]	0.02	0.12[a]	0.22[a]	−0.23[a]	0.04	−0.10	0.30[a]	–			
11. Aerobic intensity	0.04	0.01	0.10[b]	0.12[b]	−0.14[b]	−0.04	−0.16[a]	0.06	0.30[a]	0.01	–		
12. Resistance training frequency	−0.02	−0.02	0.05	0.11[b]	0.04	−0.07	0.13[a]	−0.08[b]	0.32[a]	0.25[a]	0.07	–	
13. Resistance training intensity	0.08	0.01	−0.05	0.08	−0.01	−0.03	−0.11[b]	0.01	0.20[a]	0.11[b]	0.40[a]	−0.05	–
Mean	—	$20,000–$60,000	13th–16th grade	"Full use"	"No use"	Yes	48.55	15.88	3.20	2.41	1.94	2.15	1.81
Median							49.00	12.00	3.33	2.00	2.00	2.00	2.00
SD	—						13.54	12.79	0.71	2.32	0.63	2.14	0.64
Min–Max	—						18–89	1–63	0–4	0–7	1–3	0–7	1–3

Sex, 1 = male, 0 = female; wheelchair use, 0 = does not use a wheelchair, 1 = pushes self in manual chair, 2 = uses power wheelchair, 3 = pushed by somebody else in manual chair. For income, education, arm use, leg use, and wheelchair use, the value for the median is the same as the value for the mode.

[a] $P < 0.01$.

[b] $P < 0.05$.

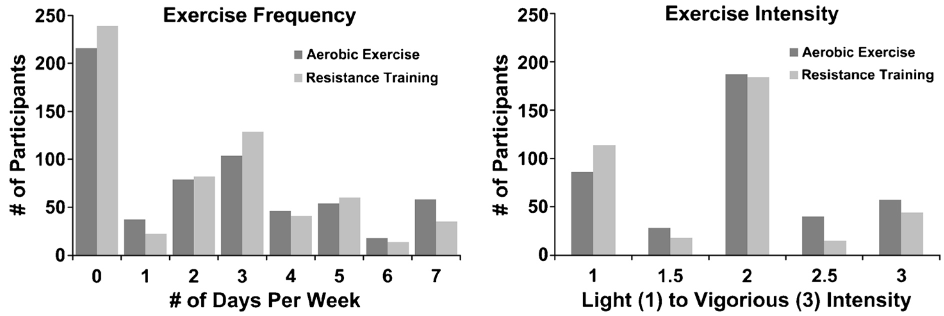

FIGURE 2 *Distribution of exercise frequency (maximum days per week) and exercise intensity (1 = light, 2 = moderate, 3 = vigorous) for aerobic exercise and resistance training. Bars depict 1.5 and 2.5 values for exercise intensity representing the values 1.33–1.67 and 2.33–2.67, collapsed into one category for readability.*

Accounting for the demographic and physical capability variables, the time variables contributed a significant amount of variance to the prediction of resistance training frequency and intensity (4% and 2%, respectively). Chronological age made an independent contribution to the prediction of both frequency and intensity of resistance training exercise, and years since injury made a significant contribution to the prediction of the frequency of resistance training exercise. Specifically, the associations of time variables with resistance training frequency were quadratic such that those who were in the middle of the age range reported relatively less frequency compared with those who were younger or older. Conversely, those who were in the middle of range of years since injury reported relatively higher frequency compared with those whose injuries occurred more recently or more distantly.

As with the aerobic exercise outcomes, self-efficacy was significantly related to greater frequency and intensity of resistance training and accounted for the most variance in resistance training frequency and intensity, 8% and 3%, respectively, compared with and controlling for the demographic

TABLE 3 Hierarchical linear regression analyses predicting aerobic exercise frequency and intensity from key demographic variables, spinal cord injury clinical characteristics, time variables, and exercise self-efficacy

Steps and Variables	Total R^2	R^2 Change	F Change	SE	β
Aerobic exercise frequency (n = 575)					
1. Sex	0.02	0.02	3.38[a]	0.19	0.07
Income				0.13	−0.03
Education				0.10	0.07
2. Arm use	0.09	0.07	15.38[b]	0.19	−0.03
Leg use				0.16	0.17[b]
Wheelchair use				0.15	−0.11[a]
3. Chronological age	0.10	0.01	3.78[a]	0.01	0.06
Years since injury[Q]				0.01	−0.13[b]
4. Exercise self-efficacy	0.17	0.07	45.87[b]	0.13	0.27[b]
Aerobic exercise intensity (n = 373)					
1. Sex	0.02	0.02	1.87	0.07	0.08
Income				0.05	0.09
Education				0.03	−0.06
2. Arm use	0.05	0.03	4.40[b]	0.07	0.09
Leg use				0.06	−0.07
Wheelchair use				0.05	−0.02
3. Chronological age[Q]	0.08	0.03	6.29[b]	0.00	−0.18[b]
Years since injury				0.00	0.10
4. Exercise self-efficacy	0.13	0.05	21.42[b]	0.06	0.23[b]

Predictors denoted with a [Q] subscript are quadratic terms. Sex, 1 = male, 2 = female; wheelchair use, 0 = does not use a wheelchair, 1 = pushes self in manual chair, 2 = uses power wheelchair, 3 = pushed by somebody else in manual chair.

[a] $P < 0.05$.

[b] $P < 0.01$.

TABLE 4 Hierarchical linear regression analyses predicting resistance training exercise frequency and intensity from key demographic variables, spinal cord injury clinical characteristics, time variables, and exercise self-efficacy

Steps and Variables	Total R^2	R^2 Change	F Change	SE	β
Resistance training exercise frequency (n = 575)					
1. Sex	0.01	0.01	0.93	0.18	−0.06
Income				0.12	0.03
Education				0.09	−0.08
2. Arm use	0.02	0.01	3.41[a]	0.17	0.01
Leg use				0.15	−0.04
Wheelchair use				0.14	−0.06
3. Chronological age[Q]	0.06	0.04	11.04[b]	0.01	0.23[b]
Years since injury[Q]				0.01	−0.14[b]
4. Exercise self-efficacy	0.14	0.08	57.66[b]	0.12	0.31[b]
Resistance training exercise intensity (n = 347)					
1. Sex	0.01	0.01	1.27	0.07	0.12[a]
Income				0.05	−0.06
Education				0.04	−0.02
2. Arm use	0.02	0.01	0.65	0.07	0.07
Leg use				0.06	0.04
Wheelchair use				0.06	0.03
3. Chronological age	0.04	0.02	4.10[a]	0.01	−0.14[a]
Years since injury				0.01	0.07
4. Exercise self-efficacy	0.07	0.03	10.97[b]	0.07	0.18[b]

Predictors denoted with a Q subscript are quadratic terms. Sex, 1 = male, 0 = female; wheelchair use, 0 = does not use a wheelchair, 1 = pushes self in manual chair, 2 = uses power wheelchair, 3 = pushed by somebody else in manual chair.

[a] $P < 0.05$.

[b] $P < 0.01$.

and clinical characteristic variables, which accounted for between 1% and 4% of variance in the resistance training outcomes.

The results of a series of regression analyses indicate that self-efficacy is the only independent variable that consistently predicted all four exercise outcomes. Furthermore, tests of the moderation of self-efficacy by age were nonsignificant for all outcomes.

DISCUSSION

The purpose of this study was to examine the roles of perceived exercise self-efficacy and age-related variables in predicting exercise behavior in individuals with SCI. As hypothesized, self-efficacy was consistently related to increased frequency and intensity of aerobic and resistance training exercise in the sample. Furthermore, self-efficacy was a significant predictor of exercise outcomes after controlling for a large number of demographic and SCI clinical characteristics and time-related variables. In fact, self-efficacy individually accounted for more variance in exercise outcomes than did any other group of variables in the analyses. This is consistent with evidence that self-efficacy may be a key mediating factor in the maintenance of long-term physical activity.[14,39–42]

Sex was the only demographic variable that demonstrated individual predictive ability, with men reporting greater resistance training intensity than women did. This finding is consistent with previous research that has also found that women have lower rates of participation in vigorous physical activity and strengthening exercises.[43] Individual clinical characteristics, although less powerful predictors than self-efficacy, did predict three of the four outcome variables. Greater use of legs and more independent mobility, as indicated by the wheelchair use variables, were related to higher aerobic exercise frequency. Interestingly, being a wheelchair user had no significant impact on the intensity of aerobic or the frequency or intensity of resistance training exercise behaviors. Similarly, injury level (paraplegia/tetraplegia), although not included in the final equations, was also tested as a predictor and was found not to predict any of the self-reported exercise behaviors. These findings are consistent with an earlier study[44] that demonstrated that whereas demographic variables were not significant predictors, exercise self-efficacy did predict adherence to exercise during follow-up in a nonclinical sample of older adults.

Both chronological age and time since SCI were predictive of physical activity outcomes, although they predicted different aspects of exercise. Moreover, the effects of age and years since injury often had a nonlinear, quadratic association with exercise frequency and intensity. Consistent with the study hypotheses, older age was associated with less intense resistance training exercise, but age also presented a somewhat complex picture in terms of exercise behavior. Those who were in the middle of the age range reported lower resistance training frequency and higher aerobic exercise intensity compared with those who were younger or older. Those whose injury happened relatively recently or in the distant past reported less frequent exercise of both types compared with those whose time since injury is in the midrange. These findings have important clinical implications for developing interventions to increase and maintain physical activity and exercise in individuals aging with SCI. It is possible that preinjury activity[45] and age at injury[46] contribute, although not necessarily in linear ways, to whether a physically active lifestyle endures postinjury. Age at injury seems to be an important factor, although age effects are not yet fully understood, especially in terms of psychosocial adjustment.[47]

The study findings regarding age effects are interesting given that the results suggest that with increased age comes a "mixed bag" of both benefits and disadvantages when it comes to physical activity. In a recent qualitative examination of the barriers and facilitators of exercise after SCI, the motivation to exercise was low in some respondents who were highly physically active before their injury.[48] They explained this with a diminished "return on investment" in that the perceived benefits or aerobic gains were not the same as they were before the injury. Consequently, these individuals have made "investments" in other life domains. Thus, it may not only be age per se but changes in life priorities and roles that shift the focus away from or toward exercise.

Study Limitations

The findings of this study should be examined against the background of various study limitations. First, the sampling was based on convenience sampling. Recruiting participants through national organizations may have produced a group of participants with higher than average self-efficacy beliefs. Related to this, the demographic profile of the sample shows that people from ethnic and racial minorities were underrepresented in the study despite various efforts (e.g., working with the Centers of Independent Living and the Veteran's Administration) to increase their representation. Moreover, the sample was fairly well educated. Findings may not be generalizable to individuals with lower levels of formal education. The sample in our survey was also slightly older and included more women and more individuals from a higher educational background than did samples typically reported for analysis of SCI Model System data. Furthermore, we were unable to determine potential differences in the demographic or clinical functional characteristics of those who were eligible but declined to participate compared with those who actually took part. This may have compromised the validity of our findings. On the other hand, our sample is one of the largest to date that examines the role of physical activity and self-efficacy in community-dwelling adults with SCI.

The study may also be limited in terms of the measures used to determine exercise behavior and exercise self-efficacy in SCI. A new measure, the SCI Exercise Self-efficacy Scale, which has initially performed well on several psychometric indicators, was used. It was developed to address the limitations of other measures of exercise self-efficacy, such as being focused either too narrowly on particular exercise modalities (e.g., treadmills) or too broadly on self-efficacy in general (e.g., generalized perceived self-efficacy). Further psychometric evaluations should be carried out on this measure. Although the present study supports the validity of the exercise self-efficacy measure, its cross-sectional nature limits its conclusions in terms of the measure's predictive validity. This would require longitudinal testing in the future. Finally, we assessed exercise activity using self-report. Self-report measures are prone to bias, possibly reflecting what respondents would like to be true rather than what may be true. The exercise behavior measure had some clear limitations. The fact that it required respondent to recall average exercise behavior over the past 12 mos may have presented respondents with a significant challenge in recalling exercise over such a long time and did not allow for reporting of variable activity levels over that time, such as different types and frequencies of activities from summer to winter. The 12-mo time frame was used across all questions in the survey with the aim of providing a set recall period. Estimating average minutes per day of a given activity may have also presented a challenge to respondents. Because the definition of exercise provided in the questionnaire as "[activity] that you have done mainly for increasing or maintaining fitness" is open to different interpretations, some individuals reported activities that fall into typical "workout" behaviors, whereas others reported daily tasks, such as house cleaning, as fitness activities. Although the measure could be considered a very thorough evaluation of aerobic and strength training activities, the structure of the data presents challenges to extrapolating clearly what the frequency and intensity of each activity is. Future research should benefit from these insights in choosing a self-report exercise measure, and more work is needed to confirm the links between self-efficacy and more objective physical activity measures (e.g., the use of accelerometers). A related problem is that we are unable to report on possible differences between study participants that resulted from differences in the amount of time that they spent using a manual *vs.* a power wheelchair.

Despite the study's limitations, the findings confirm the importance of self-efficacy beliefs as predictors of exercise behavior and provide important new information regarding the effects of age on the amount and intensity of exercise activity in persons with SCI. The relatively modest amount of variance that is explained (<22% across all models) by exercise self-efficacy may, however, require a more nuanced understanding of self-efficacy beliefs. A recent study has differentiated, for example, between the independent contributions of task and self-regulatory efficacy and found that the only significant direct relationship with physical activity may be the result of other sociocognitive concepts, such as self-regulation.[15] In that study, the direct contribution of self-efficacy beliefs did not exceed that found in our survey. Other factors with bearing on participation in exercise outcomes that were not examined in our study may relate to barriers and facilitators in the environment, costs, and the availability of appropriate assistance.[48] Our results also have clear clinical implications. Understanding that exercise intensity decreases with age, clinicians can use this information to develop more acceptable physical activity and exercise regimens that their patients can enjoy. Exercise physiologists recommend ample "volume" of exercise (defined by sets × repetitions × intensity or frequency × duration × intensity).[49] Therefore, for those aging with SCI, one might recommend a similar volume of exercise but accomplish this through cross-training that might include a mix of aerobic and resistance exercises with less intensity but greater duration and frequency. Rehabilitation therapists may be uniquely positioned to help patients early on and throughout the rehabilitation process identify meaningful exercise activities and (re)build their confidence in engaging in purposeful physical activity. Psychologic approaches such as cognitive behavioral therapy[50] and motivational interviewing[51] have been successfully used to improve exercise self-efficacy and adherence in various populations and may hold substantial promise for people with SCI.

CONCLUSION

Further research is needed to develop and then test the efficacy of tailored interventions that could increase participation in exercise programs for individuals with SCI, perhaps by increasing exercise self-efficacy, especially perhaps in those individuals who are aging with SCI, to minimize the negative health effects of inactivity in this population.

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