Ambulation and complications related to assistive devices after spinal cord injury

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Objective: To evaluate long-term health outcomes including pain intensity, pain interference, and fatigue among ambulatory persons with spinal cord injury (SCI).

Design: Prospective cohort study.

Setting: Data were analyzed at a major medical university in the southeast USA.

Participants: Participants included 783 ambulatory adults with SCI of traumatic origin, who were at least 1-year post-injury. Participants were identified through three sources of records at a large specialty hospital in the southeastern USA.

Interventions: Not applicable.

Outcome measures: Pain intensity and interference (Brief Pain Inventory) and fatigue (Modified Fatigue Impact Scale Abbreviated Version 5).

Results: Examining assistive devices used for ambulation, 66% of the population used at least one device. In the logistic model, wheelchair and cane usage were significantly related to the outcomes after controlling for age, gender, and race. Wheelchair usage 50% of the time or less was significantly related to pain intensity (odds ratio (OR) 2.05, 95% confidence interval (CI) = 1.39–3.03), pain interference (OR 2.11, 95% CI = 1.43–3.12), and fatigue (OR 1.99, 95% CI = 1.12–1.43). Additionally, unilateral cane use was significantly related to the outcomes; pain intensity (OR 1.86, 95% CI = 1.35–2.56), pain interference (OR 2.11, 95% CI = 1.52–2.93), and fatigue (OR 2.49, 95% CI = 1.52–4.08).

Conclusions: Among ambulatory persons with SCI, increased pain intensity, pain interference, and fatigue are associated with minimal wheelchair usage (50% or less) and less supportive assistive device (unilateral cane) usage.

Keywords: Spinal cord injuries, Ambulation, Assistive devices, Pain, Fatigue, Outcomes, Wheelchair, Cane

Introduction

Spinal cord injury (SCI) is a traumatic, sudden event resulting in chronic motor and sensory deficits as well as a host of changes within body systems. In the USA, the incidence of SCI is approximately 12 000 cases per year, with an estimated 265 000 persons living with SCI.¹ Recently, an increase in the percentage of incomplete injuries has been reported, which is attributable to acute medical treatment advancements as well as demographic trends in age and etiology of injury.¹

Due to the increase in incomplete injuries, a greater number of individuals maintain or regain the ability to ambulate to varying degrees.^{2,3} According to the American Spinal Injury Association (ASIA)

Impairment Scale (AIS), an incomplete SCI is defined as preservation of motor or sensory function below the level of injury and is scaled B, C, or D. Scivoletto and Di Donna⁴ presented a prediction of functional walking according to AIS impairment, concluding that the percent recovery of community ambulation at 1 year post-injury varies greatly. Among those classified as AIS A, between 0 and 8.5% gain ambulatory ability. In persons with AIS B, the overall ambulation rate is 33%, and in persons with AIS C, ambulation is influenced by classification as tetraplegia or paraplegia, initial AIS score, and age, with ranges from approximately 20–91%.^{4,5} Persons with AIS D have between an 80 and 100% chance of regaining community ambulation, depending on age.

Ambulation is regarded as a primary functional outcome in SCI research. Ambulation after SCI depends greatly on the level of injury, sensory

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preservation, proprioception, muscle strength, spasticity, and mechanics of locomotion.⁶ Improvements in ambulation have been noted following locomotor and task-oriented training, including body weight-supported treadmill training, over-ground walking, functional electrical stimulation, and strength training programs.⁷⁻⁹ When provided with locomotor training, recovery can continue even years after injury.⁸ Additionally, the use of assistive devices including orthotics, crutches, canes, and walkers enables persons with SCI to regain, maintain, and improve their ability to ambulate, but research in the area is under-investigated.¹⁰ Locomotor and task-oriented training programs in rehabilitation research demonstrate short-term improved quality of life and life satisfaction among other physiological and psychological benefits.¹¹⁻¹⁵

The majority of research is focused on relatively short-term benefits of gait interventions, with little research on the outcomes accompanying long-term ambulation. Preliminary research suggests reliance on others for ambulation is associated with greater pain interference and depressive symptoms among a community sample of participants with SCI who averaged 15.5 years post-injury.^{16,17} Additionally, persons dependent in ambulation (relying on others for assistance) reported worse health outcomes than those who used a wheelchair but were independent in wheelchair mobility.¹⁵ Haubert *et al.*¹⁸ found an increased demand on the shoulder joints of persons with incomplete SCI who walked with assistive devices; such demand may increase the risk for potential joint degeneration, strains, and overuse injury. Jain *et al.*¹⁹ examined the association of shoulder pain with the use of mobility devices in individuals with SCI, finding shoulder pain to be prevalent among those with overuse injury as a result of wheelchair use and walking device use. Another adverse consequence of walking with assistive devices is the potential to impede ambulation. In 2010, Amatachaya *et al.*²⁰ concluded that independent ambulators who walk with walking devices have an increased chance of failing to clear obstacles, suggesting an increase in the risk for falls and a threat to gait safety. While not focused on assistive devices, Brotherton *et al.*²¹ reported 75% of ambulatory persons with SCI sustained a fall within the previous year, and Krause²² reported higher odds of sustaining an injury within the past year among persons AIS D.

Ambulation is now a much more common outcome among people with SCI, as the portion of neurologically incomplete injuries has increased over time and gait interventions have improved short-term outcomes. At the same time, limited evidence suggests long-term

ambulation may be associated with potential complications, particularly when ambulation is limited in terms of functionality. Considering the potential complications from the use of assistive devices, including increased energy and strength demands, injury risk, pain, and risk of falls, it is necessary to examine the effects of assistive device use by ambulatory persons with SCI. The purpose of this study is to assess long-term health outcomes (pain intensity, pain interference, and fatigue) among persons with SCI who are ambulatory.

Methods

Participants

After approval from an institutional review board, participants were identified through the following three different sources of records at a large specialty hospital in the southeastern USA: (1) SCI Model Systems database, (2) Model Systems registry, and (3) outpatient directory. Although participants were identified through one of the SCI Model Systems, our data were specifically collected for this study, and we did not use any of the data routinely collected by the SCI Model Systems. Inclusion criteria were: (1) traumatic SCI, (2) minimum of 1-year post-injury, and (3) 18 years or older at assessment. Out of 3669 potential participants meeting these criteria, 2614 responded (71.2% response rate). After participation, 65 persons were determined ineligible for participation due to full recovery ($n = 16$), non-traumatic injury ($n = 46$), or less than 1 year post-injury at survey ($n = 3$); this resulted in a sample size of 2549. Additionally, this study focused on persons who were ambulatory, of whom 10 did not answer any of the questions on ambulation, leaving 783 for analysis.

Procedures

All data were collected through mail-in survey. Potential participants were sent a cover letter describing the study and alerting them that materials would be sent 4–6 weeks later. After the initial survey was sent, a second survey was sent to non-responders. Phone calls were made to non-responders, and additional surveys were sent to those who had misplaced or discarded materials but expressed interest in participating during the phone call. Extensive efforts were made to identify current addresses of potential participants, including using multiple search engines. Participants were offered \$50 remuneration for participation.

Measures

Demographic variables were collected, including age and gender. Race was categorized as black, white, and other.

Assistive devices

Participants were initially asked a screening question of “are you able to walk at all” (yes vs. no). Those who responded “yes,” went on to answer follow-up questions about their ambulation ability. Information on assistive devices used during ambulation was obtained, including: walker (yes, no), crutches (none, 1, or 2), canes (none, 1, or 2), short leg braces (yes, no), and long leg braces (yes, no). Additionally, participants were asked if they required assistance from people to walk. Assistive devices were grouped as bilateral (walker, two canes or two crutches), unilateral (one cane or one crutch), or none (no devices used). Braces were grouped as bi-lateral (two short leg or long leg braces), unilateral (one short or long leg brace), or none (no lower extremity braces used). Persons were allowed to report the use of multiple devices, thus we also created a variable of the total number of assistive methods used based on the sum of the following (0 = no, 1 = yes); walker (0,1), crutch(es) (0,1), cane(s) (0,1), short leg brace(s) (0,1), long leg brace(s) (0,1), and people (0,1). Lastly, participants reported the percentage of time they used a wheelchair to get around: (1) none, (2) half the time or less, or (3) more than half the time.

Health outcomes

Three pain-related parameters were measured using the the Brief Pain Inventory (BPI)²³: pain intensity, total pain symptoms, and pain interference. The BPI was originally developed for use with people living with cancer and to fill the void in the limited number of pain measures and assessment tools.²³ The BPI has subsequently been evaluated as a valid and reliable measure for use with the SCI population.²⁴ For *pain intensity*, we used the single item asking the individual to rate average pain on a scale from 0 to 10 (0 = no pain; 10 = worst pain imaginable). Participants were required to indicate the extent to which *pain interfered* with activities during the previous week using a level of interference scale from 0 to 10 (0 = does not interfere; 10 = completely interferes) for the following items: (a) general activity, (b) mood, (c) normal work (both work outside the home and housework), (d) relations with others, (e) sleep, (f) walking, and (g) enjoyment with life. The average score of the items was calculated for persons who answered over half of the items.²³

We used the Modified Fatigue Impact Scale Abbreviated Version (MFIS-5) for our outcome.²⁵ The MFIS-5 is a five-item shortened measure from the MFIS 21-item measure. Each item is scored on a scale of 0–4 (0 = never; 4 = almost always) and total score ranges from 0 to 20. The MFIS has been shown to have good reliability ($\alpha = 0.80$).²⁶

Analysis

Using SAS v. 9.2 (SAS System for Windows (Version 9.2), SAS Institute, Cary, NC, 2008), we first assessed the relationship of pain intensity, pain interference, and fatigue with each: number of devices, time using a wheelchair, help from people, and the grouped assistive devices and lower braces variables. After looking at assistive devices and lower braces grouped, we looked at specific devices and braces. As all three outcomes were not normally distributed, we used the Kruskal–Wallis test.

Next, we assessed the relationships between devices and our outcomes while controlling for age, gender, and race. Previous research in persons with central nervous system trauma has shown relationships of pain with demographic factors.^{27,28} We did assess the years post-injury in relation to the outcomes, and it was non-significant; therefore, only age, gender, and race were included in each model. For each device related to our outcomes through the Kruskal–Wallis test with $P < 0.10$, we assessed the relationship of that device with each outcome controlling for age, gender, and race. As our outcomes were not normally distributed, we used cut-points defined in the literature to categorize meaningful groups. We used a cut-point of 15 or more to represent disabling fatigue.²⁹ The relationship of devices with disabling fatigue controlling for age, gender, and race was assessed using binary logistic regression. Hosmer–Lemeshow goodness of fit was used to assess model fit. For pain intensity and interference, we used three categories: mild (0–3), moderate (4–6), and severe (7–10),^{30,31} and used an ordinal logistic regression model, which allows for a three-level outcome. Proportional odds were tested for both models (pain intensity and pain interference), and the assumption of proportional odds was not rejected. Deviance and Pearson chi-square statistics were used to assess goodness of fit. Odds ratios (OR) and 95% confidence intervals (CI) are reported for each model. For the ordinal logistic regression models, a single equation is estimated, thus the ORs are interpreted in a cumulative sense (i.e. a common OR is estimated for each cut-point). An alpha of $P < 0.05$ was used for statistical significance.

Results

The majority of participants were male (71%) and white (72%). Fifty-three percent of the participants reported a cervical injury. On average, participants were 10.5 ± 8.6 years post-injury; the average age at injury was 36.5 ± 15.1 years and 47.1 ± 14.6 years at enrollment.

When looking at assistive devices used for ambulation (Table 1), 66.5% used at least one assistive device including walkers (29.0%), crutches (18.2%), canes (31.0%), short or long leg braces (27.9%), or people (13.1%). Just over half (56.4%) of participants reported no use of a wheelchair, 15.7% reported using a wheelchair half the time or less, and 27.8% reported use of a wheelchair over half the time. Except for among cane users, persons who used other devices, braces, or people were

more likely to also use a wheelchair than persons who did not use a device, brace, or people (Table 2).

When looking at results from the Kruskal–Wallis test (Table 3), the percentage of time using a wheelchair was related to all three outcomes. Those who used the wheelchair half the time or less had the highest scores on each outcome when compared with those who did not use a wheelchair at all and those who used a wheelchair the majority of the time. The grouped variable of assistive devices was also related to each outcome, where those who used only a unilateral device had the poorest outcome for each of the measures. Braces were associated with pain interference with those who used one brace having the worst outcome. Use of people for assistance in ambulation just missed significance with pain intensity ($P = 0.0796$). Total number of devices and use of people for assistance were not associated with any of the outcomes.

After breaking down the assistive devices into canes, crutches, and walkers, the only device significantly related to each of the three outcomes was use of a cane. As a group, braces were only significantly related to pain interference ($P = 0.0434$). However, when broken down into individual braces, use of long leg braces was significantly associated with both pain intensity and pain interference, with the highest scores seen in the unilateral brace use. Short leg braces were not significantly related to the three outcomes (Table 3).

In the logistic model, we examined each device related to our outcomes from the Kruskal–Wallis test with $P < 0.10$. Wheelchair usage, using people for assistance, cane usage, and long leg braces were used as predictors

Table 1 Frequency of device use among ambulatory persons with SCI

Assistive devices	N	%
Number of devices	783	
0	262	33.5
1	240	30.7
2	180	23.0
3	81	10.3
4+	20	2.6
Walker	740	
No	525	71.0
Standard	75	10.1
Rolling	140	18.9
Crutch	763	
No	624	81.8
1	46	6.0
2	93	12.2
Cane	762	
No	526	69.0
1	207	27.2
2	29	3.8
Short leg braces	763	
No	614	80.5
1	91	11.9
2	58	7.6
Long leg braces	767	
No	679	88.5
1	40	5.2
2	48	6.3
People	775	
No	674	87.0
1 person	92	11.9
2 people	9	1.2
Assistive devices	779	
None	305	39.2
One	185	23.8
Two	289	37.1
Braces	775	
None	559	72.1
One	112	14.5
Two	104	13.4
% time spent using wheelchair	768	
None	434	56.4
1–50%	121	15.7
51%–100%	214	27.8

Table 2 Wheelchair users by assistive device

	Wheelchair		P value
	No	Yes	
Row percent			
Crutch(es)			
Yes	26.6	73.4	<0.0001
No	64.4	35.6	
Cane(s)			
Yes	61.4	38.6	0.1981
No	43.5	56.5	
Walker			
Yes	15.4	84.6	<0.0001
No	74.3	25.7	
Long leg brace(s)			
Yes	6.8	93.2	<0.0001
No	63.9	36.1	
Short leg brace(s)			
Yes	34.2	65.8	<0.0001
No	63.7	36.3	
People			
Yes	12.9	37.1	<0.0001
No	63.7	36.4	

Table 3 Pain intensity, pain interference and fatigue by device use (Kruskal–Wallis)

	Pain intensity	P value	Pain interference	P value	Fatigue	P value
Device groups						
Number of devices						
0	3.31 (2.40)	0.3142	3.10 (2.73)	0.5669	7.10 (5.15)	0.2733
1	3.61 (2.48)		3.47 (3.02)		7.90 (5.42)	
2+	3.64 (2.66)		3.23 (2.96)		7.43 (5.32)	
Wheelchair usage*						
None	3.29 (2.42)	0.0021	3.16 (2.79)	0.0001	7.34 (5.30)	0.0014
50% or less	4.22 (2.69)		4.24 (3.08)		8.79 (5.35)	
51% or more	3.29 (2.35)		2.74 (2.68)		6.59 (4.94)	
People						
No	3.36 (2.40)	0.0796	3.16 (2.81)	0.2344	7.26 (5.23)	0.3093
Yes	3.95 (2.83)		3.57 (3.02)		7.84 (5.32)	
Assistive devices						
None	3.11 (2.39)	0.0004	2.85 (2.76)	0.0002	6.52 (5.12)	<0.0001
Unilateral	4.12 (2.55)		3.86 (2.80)		8.85 (5.23)	
Bilateral	3.44 (2.40)		3.21 (2.91)		7.29 (5.25)	
Braces						
None	3.46 (2.45)	0.3198	3.31 (2.85)	0.0434	7.44 (5.18)	0.1316
Unilateral	3.65 (2.62)		3.40 (3.10)		7.73 (5.61)	
Bilateral	3.15 (2.46)		2.57 (2.52)		6.43 (5.28)	
Specific devices						
Cane						
None	3.11 (2.38)	<0.0001	2.82 (2.72)	<0.0001	6.61 (5.00)	<0.0001
Unilateral	4.26 (2.50)		4.23 (2.94)		9.22 (5.51)	
Bilateral	3.81 (2.61)		3.68 (3.04)		7.76 (5.67)	
Crutches						
None	3.43 (2.47)	0.5210	3.22 (2.84)	0.5714	7.49 (5.27)	0.1350
Unilateral	3.99 (2.92)		3.80 (3.14)		7.78 (5.61)	
Bilateral	3.37 (2.34)		3.02 (2.87)		6.37 (5.15)	
Walker						
No	3.35 (2.45)	0.2303	3.11 (2.83)	0.7556	7.27 (5.31)	0.3719
Yes	3.59 (2.48)		3.23 (2.98)		7.64 (5.16)	
Long LB						
None	3.42 (2.46)	0.0323	3.26 (2.86)	0.0323	7.48 (5.28)	0.0697
Unilateral	4.54 (2.74)		4.00 (3.24)		7.41 (5.59)	
Bilateral	3.13 (2.29)		2.31 (2.28)		5.64 (4.82)	
Short LB						
None	3.44 (2.46)	0.7568	3.25 (2.84)	0.7568	7.27 (5.20)	0.3885
Unilateral	3.56 (2.53)		3.40 (2.16)		8.11 (5.72)	
Bilateral	3.29 (2.64)		2.78 (2.68)		7.04 (5.59)	

*Percentage of time use a wheelchair (among persons who are ambulatory).

for the three outcomes in the model. Only wheelchair usage and cane usage were still significantly related to all three outcomes after controlling for age, gender, and race. The relationship between use of long leg braces and pain intensity, interference, and fatigue became non-significant (Table 4).

Three of the four predictors were significantly associated with the pain intensity outcome. For those using a wheelchair 50% of the time or less, the odds of high pain intensity were 2.05 (95% CI = 1.39–3.03) times higher than for those who did not use a wheelchair. No significant relationship was found between using a wheelchair 51% of the time or more compared to no wheelchair use. After controlling for demographics, the relationship between use of people for assistance and pain intensity became significant ($P = 0.0442$). Those who used at least one person for assistance in ambulation were 1.51

(95% CI = 1.01–2.27) times more likely to report high pain intensity compared to those who did not use at least one person for assistance. Lastly, for those who used one cane (unilateral), the odds of high pain intensity were 1.86 (95% CI = 1.35–2.56) times higher than for those who did not use a cane. A significant relationship was not observed for bilateral cane usage compared to no cane.

Pain interference was significantly related to wheelchair use and unilateral cane usage. For those using a wheelchair 50% of the time or less, the odds of high pain interference were 2.11 (95% CI = 1.43–3.12) times higher compared to those who did not use a wheelchair. Using a wheelchair 51% of the time or more, compared to no wheelchair use, was not significantly related to pain interference. The odds of pain interference were also 2.11 (95% CI = 1.52–2.93) times higher for those

Table 4 Logistic models for pain severity, pain interference, and fatigue controlling for age, gender, and race

	Pain intensity* (high and medium vs. low)	P value	Pain interference* (high and medium vs. low)	P value	Fatigue** (severe vs. no severe fatigue)	P value
Wheelchair usage	N = 763	0.0010	N = 761	<0.0001	N = 754	0.0186
None	Ref		Ref		Ref	
50% or less	2.05 (1.39–3.03)		2.11 (1.43–3.12)		1.99 (1.12–3.52)	
51% or more	1.04 (0.75–1.44)		0.72 (0.51–1.02)		0.79 (0.44–1.43)	
People	N = 769	0.0442	N = 767	0.1232	N = 762	0.4057
No	Ref		Ref		Ref	
Yes	1.51 (1.01–2.27)		1.38 (0.92–2.09)		1.31 (0.69–2.48)	
Cane	N = 757	0.0006	N = 754	<0.0001	N = 749	0.0014
None	Ref		Ref		Ref	
Unilateral	1.86 (1.35–2.56)		2.11 (1.52–2.93)		2.49 (1.52–4.08)	
Bilateral	1.61 (0.78–3.32)		1.67 (0.79–3.46)		1.78 (0.58–5.43)	
Long LB	N = 762	0.0625	N = 759	0.0959	N = 753	0.2323
None	Ref		Ref		Ref	
Unilateral	2.06 (1.21–3.77)		1.60 (0.86–2.95)		1.56 (0.63–3.90)	
Bilateral	0.95 (0.52–1.73)		0.60 (0.30–1.19)		0.37 (0.09–1.56)	

*Ordinal logistic regression models where: low = 0–<4, medium = 4–<7, high = 7–10.

**Binary logistic regression models where: no severe fatigue = 0–<15, severe fatigue = 15+.

who used a cane unilaterally compared to those who did not use a cane. This relationship was not seen when comparing those who used two canes (bilaterally) to those who did not use a cane. Neither use of people nor long leg braces were significantly associated with pain interference.

Similar to the results of pain interference, severe fatigue was significantly associated with the use of a wheelchair 50% of the time or less and with unilateral cane usage; the odds of severe fatigue were significantly higher (OR = 1.99, 95% CI = 1.12–3.52 and OR = 2.49, 95% CI = 1.52–4.08) compared to those who did not use a wheelchair and who did not use braces, respectively. These relationships did not hold when comparing those who used a wheelchair more than 50% of time or those who used two canes (bilateral) to those who did not. Again, neither use of people nor long leg braces were significantly associated with severe fatigue.

Discussion

Previous research has found associations between ambulation training and short-term improved quality of life, life satisfaction, and health benefits for persons with incomplete SCI.³² However, our study is the first examining the long-term health outcomes among these individuals. The long-term health outcomes chosen for analysis in this study include pain intensity, pain interference, and fatigue because of the potential for these factors to affect the quality of life of ambulatory persons with SCI.

Individuals who use a wheelchair 50% of the time or less and those who use assistive devices providing less support have higher scores on pain intensity, pain interference, and fatigue. This suggests that, with less

wheelchair use and greater reliance on walking as the primary means of mobility, persons with SCI may experience more pain and fatigue due to increased efforts to compensate for strength and sensory deficits associated with their injury. Likewise, those who use less supportive assistive devices, such as a cane, may also experience greater pain and fatigue because of increased demands placed on a compromised musculoskeletal system during ambulation. A review by Bateni and Maki³² concluded that while the use of canes and walkers can help with balance and mobility, they place increased physiologic demands on the body. Additionally, a review by Fisher and Gullickson³³ concluded that the more disabled a person, the less efficient they are in their ambulation, which could increase fatigue.

We found that after accounting for age, gender, and race, use of one or more persons for ambulation resulted in increased odds of higher pain intensity but was not related to pain interference. Previous research has found relationships between dependent ambulation and interference where lack of independence in locomotion was associated with higher pain interference, specifically among those who were not independent in walking.^{15,17} Interestingly, Riggins *et al.*³⁴ found persons who transitioned from ambulatory to wheelchair users within the first year post-injury had higher pain scores than others. However, they could not decipher if the participant switched modes of locomotion because of pain. Additionally, it is unclear as to if some of the wheelchair users were partially ambulatory, thereby possibly leading to increased levels of pain as we have seen in this study.

Walking distance may also affect pain and fatigue for ambulatory persons with SCI. Previous research

indicates reliance on a single cane or crutch is associated with walking longer distances.³⁵ Longer distances for walking may contribute to an increase in pain and fatigue reported by those who use a single cane for assistance. Conversely, reliance on people for assistance is associated with walking shorter distances.²⁹ Those who relied on people for assistance with walking in our study, did not have an increase in pain and fatigue. This finding, however, is inconsistent with a prior study showing reliance on others is associated with greater pain interference.¹⁷

Limitations

Several limitations must be considered when interpreting the results of this study. First, data concerning type and number of assistive devices and braces used, assistance by other people, and wheelchair usage are all collected by self-report. However, self-report was necessary because of the large number of participants. Second, data are cross-sectional, which does not allow us to examine change in ambulation patterns over time. Third, the participants are 10.5 years post-injury, and thus, the results may not generalize well to those with injuries that are more recent.

Future research

Additional research is needed to better understand the health and quality of life outcomes for ambulatory individuals with SCI. Longitudinal research may provide insight into change in ambulation over time and how change affects long-term quality-of-life outcomes. Additionally, future research should delineate the amount of use of each device and the situations under which each device is used. A better understanding of complications associated with device use may also help rehabilitation professionals and individuals with SCI make appropriate choices for assistive device use to minimize pain intensity, pain interference, and fatigue.

Conclusion

Pain intensity, pain interference, and fatigue are important indicators of quality of life and were used to assess the long-term effects of assistive device use for ambulatory persons with SCI. Higher scores on these outcome measures are associated with minimal wheelchair use and use of assistive devices that provide less support during ambulation. Both of these factors may contribute to increase in pain intensity, pain interference, and fatigue in an attempt to compensate for the deficits in strength and sensation commonly seen among ambulatory persons with SCI.

Acknowledgements

The contents of this publication were developed under grants from the Department of Education, NIDRR grant numbers H133G090059, H133G050165, and the National Institutes of Health, grant number 1R01 NS 48117. However, those contents do not necessarily represent the policy of the Department of Education or NIH, and endorsement by the Federal Government should not be assumed.

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