Return to work after spinal cord injury: the potential contribution of physical fitness

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The history, physical characteristics and fitness status of 60 persons who had sustained a spinal cord injury at least 3 years previously were considered in relation to current occupation. All subjects had completed their education, 39 being gainfully employed and 21 unemployed. The general characteristics of the sample, mainly beneficiaries of the Quebec Automobile Insurance Plan, were typical of spinal cord injured individuals in North America. The working group had a significantly higher current level of education than those who were unemployed ($p < .01$). In terms of physical fitness, the workers were lighter, with a lower body mass index and a higher aerobic power ($p < .05$). Isokinetic testing suggested a trend toward a higher peak torque in the workers. The total work performed ($\text{Nm} \cdot \text{kg}^{-1}$) during an isokinetic endurance test (25 biphasic contraction at $180^\circ \cdot \text{sec}^{-1}$) was significantly higher in the workers, suggesting that such muscular endurance might be even more useful than greater peak isokinetic strength during vocational activities. However, the likelihood of employment was unrelated to habitual patterns of either aerobic exercise or overall physical activity. No significant differences of physical fitness or physical activity habits were found between workers holding sedentary versus physically demanding jobs. The results verified the positive relationship between physical fitness (body composition, aerobic power, muscular endurance) and the gainful employment of paraplegics, but failed to show any significant relationship between physical fitness and the acceptance of physically demanding work by such individuals.

Key words: spinal cord injury; work; employment; physical fitness; physical training.

Introduction

A return to gainful employment is a major goal of overall rehabilitation for many people who have developed a physical disability,¹ in part because paid work restores financial independence. However, the employment rate of those with spinal cord injury (SCI) does not usually exceed 50%, and in many regions of North America it is much lower.² Such figures may be compared with the overall employment rate in Quebec, currently about 90%.

Current age, marital status, time since injury, education and work experience before SCI seem the most powerful social

factors influencing employment after SCI.^{1–3} Psychological variables such as locus of control and motivation also affect successful vocational rehabilitation and the process of adjustment to the disability.^{4–6}

Little has been published on the relationships between physical fitness, habitual physical activity, and employment status after SCI. An exhaustive literature search revealed only one specific article on this topic.⁷ Nonetheless, habitual leisure time physical activity and/or its potential consequences (gains of aerobic power, muscular strength and mobility) might enable paraplegics to match able bodied standards of

fitness, realizing productive activities with an appropriate mechanical efficiency while avoiding excessive fatigue. Thus, it might be hypothesized that an active lifestyle would reduce the functional consequences of both impairment (spinal cord injury) and disability (inability to walk) relative to a specific situation of potential handicap, increasing the likelihood that the person with SCI would fulfill the desired productive role. The present study examined whether there were indeed any associations between the levels of aerobic and muscular fitness and the employment status following SCI.

Methods

Subjects

The target population comprised the group of SCI persons ($n = 274$) compensated by the Quebec car insurance plan since 1978, together with a group of former patients of a large rehabilitation centre (the Centre François-Charon in Quebec City). The sample was drawn from regions of the province (both urban, suburban and rural) where occupational retraining is available in rehabilitation centres or sheltered workshops. Sociodemographic data regarding these individuals were available from administrative and medical files.

Basic criteria for potential inclusion in the study were: (1) age 16–59 years; (2) traumatic lesion; (3) lesion level T1 or lower (corresponding to the International Stoke Mandeville Games Federation classes II–V); (4) at least 3 years post injury; and (5) free of any major medical complications that could influence physical working capacity. From the 274 individuals thus selected, 95 people indicated their willingness to participate in a study under conditions approved by the University of Toronto Committee on the Ethics of Human Experimentation.

A series of questionnaires was mailed to each subject. The formats of the questionnaires were similar to those used in the Health and Activity Limitation Survey conducted in 1987 by Statistics Canada. Individual items included (1) an informed consent form; (2) a questionnaire on personal, educational, vocational and medical

characteristics; (3) the Modified Barthel Index assessing performances in activities of daily living;⁸ and (4) a modified physical activity readiness questionnaire. The last was used in order to exclude subjects who might develop medical complications during the fitness testing session. Each section of the questionnaire was reviewed with individual subjects at the beginning of the laboratories testing session.

A delay of a few weeks between recruitment and data collection led to the withdrawal of 21 subjects, leaving a sample of 74 individuals. Preliminary analyses showed that the sample was typical of the base population (see results). The 60 subjects who had completed their formal education (39 employed and 21 unemployed) provided material for the present study.

Dependent variables

Two dependent variables were measured: gainful employment and intensity of work. Gainful employment was treated as a discrete variable, subjects being classified as 0 if unemployed, and 1 if gainfully employed. The intensity of work was categorized on a 4-point scale (1 = sedentary, 2 = light, 3 = moderate, 4 = strenuous), based upon the Canadian Classification and Dictionary of Occupations (a standard tool used by vocational rehabilitation units across Canada in order to describe and to analyse different jobs). Preliminary analysis showed that most subjects fell into category 1, and for statistical analysis, subjects in categories 2, 3 and 4 were thus pooled to form a second substantial group of 'active' employees.

Independent variables

The independent variables included anthropometric estimates of body composition, an assessment of static and dynamic lung function, selected measurements of isokinetic muscular strength, peak $\dot{V}O_2$ and peak power output, and measures of leisure time physical activity.

Anthropometry

The height was measured supine, using a measuring tape. Body mass was determined by transfer of the subject to a chair of known

mass mounted on a clinical scale. Skinfold thicknesses (biceps, triceps, subscapular, suprailiac and calf) were measured at the sites described by Fitness Canada,⁹ using Harpenden calipers. The percent body fat was estimated from the first 4 of these skinfolds, using the formulae proposed by Womersley and Durnin.¹⁰

Lung function

FVC, FEV1.0, and MMEF were determined by a mechanical bellows spirometer (McKesson Scott Vitalograph)¹¹ with the subjects sitting in a wheelchair; the largest of 3 readings was recorded in each case.

Strength measurements

Upper body strength was evaluated using an isokinetic system (Cybex II, Lumex Inc). Measurements (made with an appropriate damping setting of 2 or 3 and a gravitational correction) included peak torque, average power and total work for shoulder flexion-extension, shoulder abduction-adduction, and elbow flexion-extension. After a 15–20 second warm up, each subject made maximal biphasic dynamic contractions over 6 revolutions at an angular velocity of $60^\circ \cdot \text{sec}^{-1}$. A resting period of 2 minutes was followed by a series of 25 biphasic

dynamic revolutions at $180^\circ \cdot \text{sec}^{-1}$. In order to develop a general index of muscular strength, 15 global indices of strength were computed. Peak torque, total work performed and average power output were computed for each joint and for each specific movement (Table I). All results were reported per unit of body mass ($\text{Nm} \cdot \text{kg}^{-1}$ or $\text{Watt} \cdot \text{kg}^{-1}$).

Wheelchair ergometry

After clinical examination and recording of a resting electrocardiogram, subjects performed a progressive exercise test to exhaustion, using a wheelchair ergometer designed by one of us (LN). Subjects breathed through a low resistance mouthpiece and a 2-way valve connected to a metabolic analyser (Morgan) that determined respiratory minute volume, oxygen consumption and CO_2 output. The ECG was monitored throughout exercise, using a unipolar CM5 lead. Indications to terminate exercise prior to subjective exhaustion were as specified by the American College of Sports Medicine.¹²

Activity measurements

Leisure time physical activity (outside of any employment) was assessed using a

Table I Computed indices of isokinetic strength

Variable	Movement	Angular velocity $\text{deg} \cdot \text{sec}^{-1}$
Peak torque-1	[elbow (flex) + elbow (ext)]/2	60
Peak torque-2	[shoulder (flex) + shoulder (ext)]/2	
Peak torque-3	[shoulder (abd) + shoulder (add)]/2	
Total work-1	[elbow (flex) + elbow (ext)]/2	180
Total work-2	[shoulder (flex) + shoulder (ext)]/2	
Total work-3	[shoulder (abd) + shoulder (add)]/2	
Average power-1	[elbow (flex) + elbow (ext)]/2	180
Average power-2	[shoulder (flex) + shoulder (ext)]/2	
Average power-3	[shoulder (abd) + shoulder (add)]/2	
Peak torque-4	[elbow (flex) + shoulder (flex) + shoulder (add)]/3	60
Peak torque-5	[elbow (ext) + shoulder (ext) + shoulder (abd)]/3	
Total work-4	[elbow (flex) + shoulder (flex) + shoulder (add)]/3	180
Total work-5	[elbow (ext) + shoulder (ext) + shoulder (abd)]/3	
Average power-4	[elbow (flex) + shoulder (flex) + shoulder (add)]/3	180
Average power-5	[elbow (ext) + shoulder (ext) + shoulder (abd)]/3	

specific physical activity questionnaire having a format similar to that used in the Canada Fitness Survey¹³ and a general index estimating the intensity of physical activity;¹⁴ both of these instruments have had substantial validation in various regions of Canada.

Statistical significance

Significance for all statistical analyses was fixed at the .05 level of probability. Chi-square tests of independence and t-tests were used to determine the potential association between the different variables and employment status. One-way analyses of variance with specific covariates assessed differences of fitness and of leisure time physical activity between working and unemployed subjects, and between sedentary and active employees.

Results

Sociodemographic characteristics

The sample comprised 52 male and 8 female subjects (86.7% vs 13.3% respectively). The mean age of the subjects was 35.8 ± 9.1 years and the average time since injury was 12.7 ± 8.6 years; 7 subjects had been injured more than 20 years previously, including an extreme case who had become paraplegic in 1949 (40 years prior to testing). Two thirds of the subjects had sustained their injury between 13 and 32 years of age. The workers tended to be younger than the unemployed subjects (Table II). The mean age of injury was significantly lower in working subjects, but the number of years since the onset of disability did not differ significantly between the 2 groups.

The percentage of male subjects did not differ significantly between the workers and the unemployed (87.1% vs 85.7% respectively, $X^2 = .25$, $p = .87$). Likewise, we did not observe any significant interaction between employment status and ISMGF classification ($X^2 = .50$, $p = .77$). The percentages of workers in classes II, III and IV were 65%, 70% and 58% respectively, and the corresponding figures for the unemployed were 35%, 30% and 42%.

The preinjury educational level did not differ between the workers and the unemployed but the current level of education was significantly associated with return to work after SCI ($p < .05$) (Table III). The average level of education among subjects who were already working at the time of their injury was only 10.4 years, suggesting that most of this subgroup had held a job requiring only a limited level of education prior to injury.

Generality of the sample

Available information was used to compare subjects of the sample with the target population ($n = 274$). Age at injury did not differ significantly between the groups ($\bar{X} = 23.1 \pm 9.0$ vs 24.7 ± 10.2 , $p > .05$). However, the mean age of the sample was significantly higher than that of the target population ($\bar{X} = 35.8 \pm 9.1$ vs 30.6 ± 10.1 , $p < .01$), since no students were included in the sample. Chi-square tests showed no significant differences between the sample and the population in terms of ISMGF classification ($X^2 = 1.59$, $p > .05$), gender ($X^2 = .001$, $p > .05$), or marital status ($X^2 = 2.1$, $p > .05$).

Table II Age at injury, current age and time since injury; comparisons between workers and unemployed

Variable	Workers (n = 39)		Unemployed (n = 21)		Prob. ^a
	$\bar{X}$	SD	$\bar{X}$	SD	
Age at injury	21.0	8.9	27.4	9.5	.01
Current age	34.4	8.2	38.4	10.3	.13
Time since injury	13.4	8.8	11.0	8.1	.46

^a p value for an unpaired t-test of difference between workers and unemployed.

Table III Years of education (preinjury and current), classified by the current employment status of subjects ($n = 60$)

Date	Workers ($n = 39$)		Unemployed ($n = 21$)		Prob. ^a
	$\bar{X}$	SD	$\bar{X}$	SD	
Preinjury	10.4	4.1	9.4	2.6	.26
Current	13.7	2.8	11.0	3.1	.003
Prob. ^b	.001		.04		

^a p value for an unpaired t-test of difference between workers and unemployed. ^b p value for a paired t-test of difference between preinjury and current level of education.

Functional and fitness variables

Despite a trend for a higher modified Barthel index score in workers than in unemployed (64.6 ± 9.4 vs 61.8 ± 9.0), the difference was not statistically significant ($t = 1.1$, $p = .27$).

When relating physical characteristics and fitness variables to current employment status (Tables IV, V and VI), current age and the reported level of leisure time physical activity were included as covariates.

Body mass and body mass index differed significantly between workers and the unemployed. The mean (unadjusted) BMI for the unemployed group ($\bar{X} = 25.0 \pm 5.2$) was at the upper limit of the normal range (20–25). Furthermore, a higher proportion of the unemployed (7/21) than of the workers (4/39) showed a BMI equal to or exceeding the clinically acceptable limit of 27 ($p < .05$). There was also a trend toward a higher percentage of body fat in the unemployed group, although the average difference was relatively small.

The maximal power output and the maximal oxygen intake, expressed per unit of body mass, were both significantly related to employment status, even after adjustment for leisure time physical activity (Table V). Of the 15 indices of isokinetic strength calculated (Table I), only the total amount of work performed during the high velocity endurance test (25 biphasic repetitions at $180^\circ \cdot \text{sec}^{-1}$) differed significantly between workers and unemployed after adjustment for leisure time physical activity ($p < .05$), although peak torque and average power also tended to favor the employed (Table VI).

Leisure time physical activity and physical demands of employment

Although we took the precaution of covarying our data for potential effect of leisure activity, there were in fact no statistically significant reported differences of participation in aerobic exercise or overall exercise between working and unemployed subjects

Table IV Comparisons of body composition between workers and unemployed (adjusted values)

Variable	Workers ($n = 39$)		Unemployed ($n = 21$)		Prob. ^a
	$\bar{X}$	SD	$\bar{X}$	SD	
Body mass (kg)	67.3	14.1	75.7	15.9	.05
BMI ($\text{kg} \cdot \text{m}^{-2}$)	22.4	3.4	24.9	5.2	.04
Body Fat (%)	22.7	6.3	24.2	6.3	.38

^a p value for oneway ANCOVA comparing workers and unemployed, and controlling for the effects of age and level of leisure time physical activity.

Table V Comparisons of aerobic fitness variables between workers and unemployed (adjusted values)

Variable	Workers (n = 39)		Unemployed (n = 21)		Prob. ^a
	$\bar{X}$	SD	$\bar{X}$	SD	
Peak power output (watts)	32.5	14.6	25.7	10.3	.06
(watts · kg ⁻¹)	0.48	0.21	0.35	0.17	.01
Peak $\dot{V}O_2$ (ml · kg ⁻¹ · min ⁻¹)	21.4	6.3	17.5	4.8	.01

^a *p* value for oneway ANCOVA comparing workers and unemployed, and controlling for the effects of age and level of leisure time physical activity.

Table VI Comparisons of isokinetic strength between workers and unemployed (adjusted values)

Variable	Workers (n = 39)		Unemployed (n = 21)		Prob. ^a
	$\bar{X}$	SD	$\bar{X}$	SD	
Peak torque (60° · sec ⁻¹) ^b (nm · kg ⁻¹)	.90	.19	.81	.20	.08
Total work (180° · sec ⁻¹) ^b (nm · kg ⁻¹)	20.9	5.7	17.3	4.8	.02
Avg. power (180° · sec ⁻¹) ^c (watts · kg ⁻¹)	1.32	.36	1.15	.34	.10

^a *p* value for oneway ANCOVA comparing workers and unemployed, and controlling for the effects of age and level of leisure time physical activity. ^b[shoulder (abd) + shoulder (add)]/2. ^c[elbow (flex) + shoulder (flex) + shoulder (add)]/3.

(*p* > .05), nor did the leisure time physical activity index differ between the 2 groups. No differences of physical fitness or of leisure time physical activity were observed between subjects holding sedentary versus physically demanding jobs (.15 ≤ *p* ≤ .89).

Discussion

Desire to work

Many factors influence the success of comprehensive rehabilitation after SCI.^{3,15-17} The ability to undertake the activities of daily living, to participate in normal social life and to be productive are all important to the person's adjustment to disability. Nevertheless, for many people, participation in 'gainful work' is the most attractive component of overall productivity, because it usually allows financial independence. In this sense, many people with SCI value paid work similarly before and after injury.¹⁸

Physical fitness and gainful employment

An active lifestyle (and its usual consequence: a higher level of physical fitness) have a positive impact on the psychosocial and biological characteristics of both able bodied^{19,20,21} and disabled individuals.^{22,23,24} Sports participation develops self confidence following SCI, and it can thus become an avenue allowing a reentry into community life.²⁵ However, the contribution of physical fitness to employment status is less well established, and the present study seems the first substantial attempt to explore this topic.

Hughes and Goldman²⁶ noted that a poor maximal oxygen intake could limit work even in the able bodied; such individuals develop fatigue over a full day of work if the task demands more than 40% of the maximal oxygen intake. Upper body exercise imposes a greater physiological strain (a higher systemic blood pressure and a greater

local lactate accumulation) than lower body exercise at the same fraction of maximal oxygen intake,²⁷ so that the acceptable ceiling of arm effort is generally lower than the 40% established for leg work.

The SCI individual could be brought to the fatigue threshold either by the demands of work itself, or by the associated need for ambulation. But given the diminishing physical demands, even of traditional 'heavy' work, ambulation is more likely to be the limiting factor for most subjects. Paraplegics commonly use a manual wheelchair, propelled by the relatively small muscles of the upper body. Their ambulation is thus disadvantaged relative to the able bodied. Not only is the peak output smaller, but the mechanical efficiency is lower for arm than leg exercise.^{28,29} Nevertheless, locomotion is vital to successful completion of the journey to and from work, the negotiation of architectural barriers at work, and movement about the worksite.

A high level of muscular and/or aerobic fitness might allow paraplegics to obtain and sustain gainful employment, and might in turn lead to greater independence.²³ Our results support the hypothesis, showing that despite similar reported patterns of leisure time physical activity, subjects who were gainfully employed had a significantly higher level of cardiorespiratory and muscular fitness than those who were not employed. Aerobic power was closely correlated with strength. It thus remains unclear whether the aerobic variable is important in itself, or is serving as an indicator of strong upper body muscles. In support of the latter possibility, muscle strength was greater in those who were employed than in the unemployed ($.02 \leq p \leq .10$). Although the employed had a higher level of education, it seems unlikely that the greater aerobic power and muscle strength arose from an association between education and lifestyle, since data were covaried for activity pattern.

Strong arm muscles (whether constitutional or developed by leisure activity) are vital to activities such as curb or ramp mounting and the negotiation of architectural barriers. Do *et al*³⁰ demonstrated that activation of the upper body muscles was typically greater in voltage and longer in

duration in the person with SCI than in the able bodied when performing a similar physical task. This could be a further factor provoking local muscle overload and early fatigue in SCI, except in subjects who have strong muscles.

No significant differences of body composition, physical fitness or leisure time physical activity were observed between those holding sedentary and physically active jobs ($.15 \leq p \leq .89$). However, the interpretation of these findings must be cautious since the number of subjects holding physically demanding jobs was small ($n = 13$) and the Canadian Classification and Dictionary of Occupations was not specifically developed to classify employment patterns after SCI.

Leisure time physical activity and employment

Curtis *et al*⁷ observed no marked differences of vocational outcome between athletic and nonathletic subjects, although the athletes tended to work more hours and/or to have greater involvement in educational activities.

Our questionnaires provided a more specific indication of habitual involvement in aerobic activity. The lack of influence of such activity upon employment status suggests that aerobic power was serving as a marker of muscle strength ($r = .65$) rather than as an independent determinant of employment status. Moreover, given that the effect of strength was seen after controlling for physical activity patterns, the difference may have been constitutional rather than a training response.

Influence of body mass

The physiological cost of wheelchair locomotion rises with body mass, and if the additional mass is fat rather than muscle, then ambulation is likely to be impeded. Conversely, any reduction of body mass should facilitate locomotion.

The fact that the unemployed were heavier than those who were working could be either a cause or a consequence of lack of locomotion. A limited need for ambulation while unemployed may have initiated a vicious cycle of increased physiological

demand and growing inactivity. Any significant excess of body mass could certainly limit the vocational activities of the person with SCI and increase the consequences of the impairment in situations of potential handicap.

Clinical implication of excess mass

The risk of health problems in the able bodied is significantly increased if the BMI exceeds $25 \text{ kg} \cdot \text{m}^{-2}$,³¹ and people with a score of more than $27 \text{ kg} \cdot \text{m}^{-2}$ are at a substantially increased risk of hypertension, hyperlipidemia and coronary vascular disease.³² Thus, Rabkin *et al*³² observed a morbidity ratio (observed/expected) of 1.28 for ischaemic heart diseases and 1.85 for sudden death in a cohort of about 4000 young able bodied North American men with a BMI higher than $27.5 \text{ kg} \cdot \text{m}^{-2}$. Considering the decrease of muscle and bone mass following SCI, the 'ideal' BMI is probably lower for our sample than the $20\text{--}25 \text{ kg} \cdot \text{m}^{-2}$ suggested for able bodied persons.

Nevertheless, 52% and 33% of the unemployed subgroup had a BMI exceeding 25 and $27 \text{ kg} \cdot \text{m}^{-2}$, respectively, compared to 39% and 24% in the general population.³³ DeJong³⁴ has emphasized the importance of a stable medical condition to independent living. Most of our group had not reached the age of clinical cardiovascular disease, and we deliberately excluded individuals with major medical complications (for example, known coronary disease); nevertheless the obesity of the unemployed group plainly exposed them to an increased risk of future ill health, with implications for their long term employment prospects.

Limitations of data

Certain limitations were inherent to our data, particularly the necessity to use volunteers and to rely upon self reports of employment and activity patterns. Volunteers, almost by definition, differ from non volunteers. However, our sociodemographic analyses suggests that those tested were reasonably typical of the target population. Thus, their volunteer status should not invalidate the comparison between

those who were employed and those who were not.

Although the particular instruments that we used have had extensive validation in normal subjects, they have not been specifically evaluated in persons with SCI. Moreover, the study was cross-sectional in type, and we are thus unable to assign cause and effect, or indeed to distinguish clearly between constitutional and acquired fitness. There are good reasons why fitness may have enhanced productivity, but the converse is also possible.

We were also unable to take account of monetary disincentives to employment, such as substantial pension payments. Most of our subjects were drawn from a population who had sustained a motor vehicle accident, and the Quebec motor vehicle insurance plan provides substantial compensation to such individuals, proportional to their assessed disability. We are concerned about the potential influence of such compensation upon employment prospects, because several authors^{36–38} have suggested that a quest for disability related benefits discourages vocational rehabilitation in the United States. However, we also recognize that in Quebec, pensions are determined within a few months of injury, whereas in the US litigation can continue for 10 or more years, during which period it is disadvantageous for the plaintiff to demonstrate material recovery. Finally, we had little information on environmental variables such as architectural barriers at home and in the worksite, problems of transportation, and unmet income needs. All of these factors can increase the physical demands of a typical day, and undoubtedly modify productivity.¹⁷

Despite these limitations, our results should encourage service providers, health care managers, and administrators to allow SCI persons increased access to those sport and exercise facilities that will develop muscle strength and cardiorespiratory fitness early during rehabilitation. Our findings also suggest the importance of maintaining the recommended body mass, both to reduce the energy cost of ambulation and decrease the risk of future cardiovascular disease.

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