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ORIGINAL REPORT

SELF-REPORTED PHYSICAL ACTIVITY AND RISK MARKERS FOR CARDIOVASCULAR DISEASE AFTER SPINAL CORD INJURY

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Objective: **To examine whether self-reported physical activity of a moderate/vigorous intensity influences risk markers for cardiovascular disease in persons with paraplegia due to spinal cord injury.**
Design: **Descriptive, cross-sectional study.**
Subjects: **A total of 134 wheelchair-dependent individuals (103 men, 31 women) with chronic (≥1 year) post-traumatic spinal cord injury with paraplegia.**
Methods: **Cardiovascular disease markers (hypertension, blood glucose and a blood lipid panel) were analysed and related to physical activity.**
Results: **One out of 5 persons reported undertaking physical activity ≥ 30 min/day. Persons who were physically active ≥30 min/day were significantly younger than inactive persons. Systolic and diastolic blood pressures were lower in the physically active group. When adjusting for age, the association between systolic blood pressure and physical activity disappeared. Physical activity ≥30 min/day had a tendency to positively influence body mass index and low-density lipoprotein cholesterol/high-density lipoprotein cholesterol ratio. Men had significantly higher systolic and diastolic blood pressures than women, lower high-density lipoprotein cholesterol, higher low-density lipoprotein cholesterol/high-density lipoprotein cholesterol ratio and higher triglycerides. No other significant differences between men and women were found.**
Conclusion: **Self-reported physical activity ≥30 min/day in persons with spinal cord injury positively influenced diastolic blood pressure. No other reductions in cardiovascular disease risk markers were seen after controlling for age. These results indicate a positive effect of physical activity, but it cannot be concluded that recommendations about physical activity in cardiovascular disease prevention for the general population apply to wheelchair-dependent persons with spinal cord injury.**

Key words: prevention; paraplegia; blood pressure.

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INTRODUCTION

Persons with post-traumatic paraplegia due to spinal cord injury (SCI) have an increased risk for, and prevalence of, cardiovascular disease (CVD) compared with the general population (1, 2). A recent study has shown that approximately 80% of persons with paraplegia have one or more risk markers for CVD, irrespective of body mass index (BMI) (3).

Structural, architectural, functional and psychological barriers all hamper ability to perform exercise in persons with SCI (4). Cowan et al. (5) found that intrinsic barriers, e.g. lack of motivation, not liking exercise, not feeling it could help, etc., had the strongest association with exercise participation, and socioeconomic factors might also be underappreciated.

Furthermore, in the general population, CVD risk is correlated with lifestyle and socioeconomic factors. According to the World Health Organization (WHO) (6), more than three-quarters of all CVD-related mortality may be prevented with adequate changes in lifestyle, such as engaging in regular moderate-intensity physical activity almost daily, healthy dieting and abstaining from tobacco. Thus, normal weight, blood pressure (< 140/90 mmHg), cholesterol (< 5 mmol/l) and glucose metabolism are key characteristics of people who tend to stay healthy, according to the European Heart Health Charter (6–8). Various guidelines on population health recommend 30 min or more of moderate to vigorous physical activity per day, 5 times or more per week. Physical activity above the minimum recommended amount increases the health benefits (8, 9).

Concerning physical activity, earlier studies have shown some positive effects of physical activity on CVD risk markers in persons with SCI. Physical activity guidelines have been developed to increase physical fitness in persons with SCI (10–12). However, no consensus exists for type, frequency, duration and intensity of training for this population (11, 13).

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It has not yet been established whether, or to what extent, the general recommendation of 30 min physical activity per day, for at least 5 days per week, is applicable to the SCI population regarding risk reduction for CVD.

Objective

The objective of the current study was to examine whether self-reported physical activity of a moderate/vigorous intensity influences risk markers for CVD in persons with paraplegia due to SCI.

METHODS

Participants in the study group were 134 wheelchair-dependent individuals (103 men, 31 women) with post-traumatic SCI (age range 18–79 years), with paraplegia for at least 1 year (range 1–48 years). All participants had a neurological level of lesion below Th1, and an American Spinal Injury Association Impairment Scale (AIS) grade of A, B or C. All persons were living in the greater Stockholm area, where data was collected by interview, physical examination and questionnaire, at consecutive annual check-ups in the regional SCI outpatient centre.

Study participants agreed to participate with the approval of the Central Ethical Review Board, Stockholm (No 2005/560-31/1).

Basic participant descriptors are presented in Table I. Socioeconomic descriptors recorded in this study were: educational level, civil status, smoking (operationalized as any smoking within 30 days of the study) and physical activity before injury. There were no significant differences in these descriptors between men and women.

Physical activity was assessed by a Swedish questionnaire, adapted and tested for this population. The questionnaire was modelled after 2 existing surveys developed for English-speaking persons with disabilities (14, 15). The questionnaire was developed stepwise and tested for content validity by multiple interviews of patients with SCI. Thirty subjects with SCI (14 with paraplegia and 16 with tetraplegia) and 6 experts (sports instructors and physiotherapists at the SCI centre) were included in the pre-study validation process. The following characteristics were targeted: type(s) of physical activity; frequency, duration, and intensity of activity; layout of questionnaire; and adequacy of written instructions. Validation interviews included questions about: comprehensibility, representativeness, lack of queries, redundancy of queries, and additional comments. The content validity was found to be satisfactory for the purpose of this study.

A test-retest reliability of the questions was performed on 24 persons with 7–14 days between tests. According to the standard categorization: "poor (<0.20), fair (0.21–0.40), moderate (0.41–0.60), good (0.61–0.80) and very good (0.81–1.00)", the overall reliability of the survey was deemed good (16).

Our cut-off comprised a volume of physical activity corresponding to a minimum of 30 min each day of the week.

Participants were dichotomized into 2 groups based on their self-report, either performing physical activity on a moderate and/or vigorous level ≥ 30 min per day, or not.

Blood pressure was measured after 30 min of rest, recorded on the left arm with a calibrated manometer.

Blood glucose concentrations and a lipid panel (total cholesterol (TC), low-density lipoprotein cholesterol (LDL), high-density lipoprotein cholesterol (HDL) and triglycerides (TG)) were quantified in whole blood drawn from a superficial vein following an overnight (midnight) fast and then assayed under standards of Swedish governmental oversight for clinical laboratories.

Body weight was measured in kilograms on a calibrated scale. Body height was obtained by participant report. BMI was computed as body weight (kg) divided by the square of body height (m) (17).

Data were analysed using PASW Statistics 18. In a first stage, analysing group variables, results were described by mean and standard deviation (SD). Differences between groups in numerical values were calculated using Mann-Whitney *U* test accounting for non-normality. In a second stage of analysis, simple and multiple linear and logistic regression models were set up to produce crude and adjusted estimates of the relationship between physical activity (≥ 30 min/day) and the CVD risk markers, accounting for potential confounding from factors summarized in Table I (e.g. age, sex and education). All continuous CVD risk markers were studied using linear regression.

The maximum likelihood ratio test was employed to test the inclusions of new explanatory variables using a significance threshold of 0.1. Thus, for confounders to be considered, they needed to be associated with both the explanatory variable and the outcome variable estimating a significant difference of a *p*-value of less than 0.1 using the maximum likelihood ratio test. In all other interpretations of coefficients, a p-value <0.05 was considered significant, and corresponding 95% confidence intervals (CI) were presented for the coefficients.

Table I. *Basic characteristics of 134 wheelchair-dependent individuals with post-traumatic spinal cord injury, paraplegia American Spinal Injury Association Impairment Scale (AIS) grades A, B or C for at least one year*

Variable	Whole group ($n=134$)	Men ($n=103$)	Women ($n=31$)	*p*-value
Age, years, mean (SD)	47.8 (13.8)	47.9 (13.0)	47.3 (16.4)	0.778
Injury duration, years, mean (SD)	18.5 (12.3)	18.2 (12.4)	19.6 (12.2)	0.416
Level of injury, %				0.798
Th1–Th6	34	33	36	
Th7–L4	66	67	64	
Education level, %				0.199
Nine years of school/senior high school	55	58	45	
Further education/university	45	42	55	
Civil status, %				0.172
Single/living with parents	40	43	29	
Partner/married	60	57	71	
Smokers (%)	16	15	19	0.793
Physical activity before injury, %				0.836
Never/seldom	30	31	29	
1–2 times/week	21	20	25	
3 or more times/week	49	49	46	

SD: standard deviation.

Table II. *Comparison of risk markers for cardiovascular disease between the groups of subjects with different physical activity levels*

Variable	Whole group (n=134) Mean (SD)	>30 min/day (n=27) Mean (SD)	<30 min/day (n=107) Mean (SD)	p-value
BMI	24.2 (4.5)	23.1 (3.4)	24.5 (4.7)	0.053
Systolic BP, mmHg	129.7 (23.0)	121.6 (11.8)	131.7 (24.6)	0.023
Diastolic BP, mmHg	77.9 (11.8)	71.9 (9.2)	79.3 (12.0)	0.007
Blood glucose, mmol/L	5.2 (1.4)	5.0 (1.0)	5.2 (1.5)	0.649
TC	4.8 (1.0)	4.9 (0.7)	4.8 (1.0)	0.423
HDL	1.2 (0.4)	1.1 (0.3)	1.2 (0.4)	0.332
LDL	3.0 (0.9)	3.2 (0.6)	3.0 (1.0)	0.276
LDL/HDL quota	2.8 (1.5)	3.1 (1.0)	2.7 (1.6)	0.072
TG	1.3 (0.8)	1.4 (0.8)	1.3 (0.8)	0.875

SD: standard deviation; BMI: body mass index; BP: blood pressure; TC: total cholesterol; HDL: high-density lipoprotein cholesterol; LDL: low-density lipoprotein cholesterol; TG: triglycerides.

Table III. *Crude and adjusted linear regression coefficients of physical activity (> 30 min per day) on CVD risk markers*

Variable	Crude Mean (95% confidence interval)	Adjusted Mean (95% confidence interval)
BMI,	–1.364 (–3.264 to 0.536)	–0.664 (–2.587 to 1.259)
Systolic BP, mmHg	–10.155 (–19.824 to –0.486)*	–3.819 (–12.980 to 5.341)
Diastolic BP, mmHg	–7.420 (–12.316 to –2.524)*	–5.062 (–9.916 to –0.208)*
Blood glucose, mmol/l	–0.230 (–0.819 to 0.359)	0.067 (–0.515 to 0.648)
TC	0.165 (–0.246 to 0.575)	0.321 (–0.093 to 0.736)
HDL	–0.07 (–0.223 to 0.083)	–0.027 (–0.183 to 0.129)
LDL	0.216 (–0.169 to 0.600)	0.292 (–0.106 to 0.689)
LDL/HDL quota	0.310 (–0.321 to 0.942)	0.291 (–0.366 to 0.949)
TG	0.031 (–0.299 to 0.361)	0.107 (–0.233 to 0.447)

*p<0.05.
SD: standard deviation; BMI: body mass index; BP: blood pressure; TC: total cholesterol; HDL: high-density lipoprotein cholesterol; LDL: low-density lipoprotein cholesterol; TG: triglycerides.

RESULTS

One out of 5 persons (20.1%) reported undertaking physical activity ≥30 min per day. Examples of moderate physical activity were wheeling and strength training, and examples of vigorous physical activity were basketball and hand-cycling. A group comparison of risk markers between persons with the different physical activity levels is shown in Table II.

A comparison of CVD risk markers between the groups of persons fulfilling criteria or not, showed significant differences regarding blood pressure, and a tendency to significant differences regarding BMI and LDL/HDL ratio.

The mean amount of weekly physical activity was 53 min (standard deviation (SD) 134 min), and the mean amount of weekly moderate/vigorous training and physical activity was 107 ± 182 min. Older age correlated with a lower level of self-reported physical activity, with the amount of daily physical activity (p=0.047), and with the amount of moderate/vigorous physical training and physical activity level (p=0.005). Persons who were physically active >30 min per day were significantly younger than those who were inactive (40.6 (SD 9.2) vs 49.6 (SD 14.2), p=0.001). When adjusting for age in a multiple linear regression model, significant association between systolic blood pressure and the physical activity variable disappeared and the estimated coefficient decreased by approximately threefold, while the risk marker of diastolic blood pressure still revealed a significant effect from physical activity with a smaller decrease in coefficient. Physical activity above the minimum recommended level correlated with a mean decrease in diastolic blood pressure of approximately 5 mmHg. The adjusted estimate from the multiple linear regression models are shown in Table III.

Men had significantly higher systolic and diastolic blood pressures than women, lower HDL, higher LDL/HDL ratio, and higher TG. No other significant differences were found between men and women.

There were no significant differences between the physically active and non-active group concerning the socioeconomic factors in the study.

DISCUSSION

The main result of this study was that self-reported physical activity, according to recommendations for the general population, in persons with paraplegia due to SCI did not correlate with decreased CVD risk markers. The exception was a slightly decreased diastolic blood pressure, which has shown to be of a preventive value, especially for persons below 50 years of age. However, whether this preventive effect is applicable to this patient group with SCI is not fully known (18).

No other differences in risk markers were seen when controlled for age. This may indicate that the general recommendations are not sufficient or fully applicable as CVD prevention for persons with SCI.

The self-reported method might be inaccurate in assessing the true work intensity and amount of physically active time per week. The intensity of a physical activity may be experienced differently between different persons. However, questionnaires are well-established for this type of assessment in population-based studies. In addition, there are no standard methods for studying physical activity in daily living in the SCI population.

The currently defined "moderate intensity" physical activity level is 40–59% of VO_2 or heart rate reserve, and "vigorous-intensity" physical activity level is defined as 60–85% of VO_2 or heart rate reserve (8). These physical activity levels might not be reachable by SCI subjects, at least not in those with neurological lesion levels above Th6, due to disruption of sympathetic outflow and/or due to the small remaining muscle mass under voluntary control. It has also been shown that rating of perceived exertion (RPE) related to VO_2 and heart rate is not valid as an index of perceived exertion in persons with SCI (19). Further studies are needed in order to establish a method to evaluate perceived exertion in persons with SCI.

Some previous studies indicate that high-intensity physical activity might have beneficial effects on the blood lipid profile in persons with SCI (20, 21). However, further investigation is needed to determine whether physical activity may be effective for CVD prevention in this population. Furthermore, it remains to be established which actual frequency and intensity of physical activity, if any, may be effective and recommended for CVD prevention after SCI, as the recommendations for the general population seem to be either inappropriate or not applicable for persons with paraplegia.

Our findings show an overall low level of self-reported physical activity among wheelchair-dependent persons with paraplegia due to SCI. The recommended level of 30 min per day, at least 5 days per week, at moderate or vigorous intensity (9, 22), was reported by only 20% of the sample. By contrast, results from a survey on Swedish public health, carried out in 2009, showed that 66% of the men and 65% of the women reported being physically active 30 min or more per day (23). In our study group, approximately 50% reported being physically active 30 min or more, 3 times or more per week prior to the injury. Thus, the physical activity level apparently decreased post-injury, possibly reflecting the many hurdles posed to persons with this disability in maintaining a physically active lifestyle. Such hurdles comprise transportation problems, the time it takes for the disabled person to prepare for physical activity, lack of interest, internal barriers and/or an economic reasons for not being physically active (4, 5). Ginis et al. showed that, with increasing age and time post-injury, leisure-time physical activity decreases. They also showed no relation between pre-injury levels of physical activity and leisure-time physical activity post-injury (24, 25).

Buchholz et al. (26) reported a lower BMI and waist circumference in physically active vs physically inactive women, but no changes in other risk factors over an 18-month period. Our results showed a tendency of a decreased BMI level in the physically active group, but not after adjusting for age.

Krause et al. (27) have pointed out the importance of avoiding other CVD risk factors among persons with SCI, including smoking, alcohol overconsumption, use of prescription and illicit drugs, disordered sleep, etc. Other preventative factors should also be studied further, e.g. diets and pharmacological methods.

Aside from possible positive CVD preventive effects, it is important that clinics, responsible for SCI rehabilitation and regular follow-ups, etc., adopt the guidelines developed for physical activity, in order to improve physical activity levels, and thereby increase physical capacity and muscular strength and facilitate activities of daily living in this SCI population (10, 11).

It should be noted that this study is restricted to persons who are wheelchair-dependent due to post-traumatic paraplegia. Further studies among other SCI subgroups are needed in order to generalize these findings to persons with SCI in general.

In conclusion, only 20% of the study group reported undertaking physical activity for more than 30 min per day. Self-reported physical activity, according to recommendations, in persons with SCI, did positively influence diastolic blood pressure. However, no other reductions in CVD risk markers were seen after controlling for age. The results indicate a positive effect of physical activity, but we cannot conclude that recommendations for physical activity in CVD prevention for the general population are applicable to wheelchair-dependent persons with SCI.

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