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ORIGINAL REPORT

PREVALENCE OF RISK FACTORS FOR CARDIOVASCULAR DISEASE STRATIFIED BY BODY MASS INDEX CATEGORIES IN PATIENTS WITH WHEELCHAIR-DEPENDENT PARAPLEGIA AFTER SPINAL CORD INJURY

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Objective: **To assess risk factors for cardiovascular disease at different body mass index values in persons with wheelchair-dependent paraplegia after spinal cord injuries.**
Design: **Cross-sectional study.**
Subjects: **A total of 135 individuals, age range 18–79 years, with chronic (≥1 year) post-traumatic paraplegia.**
Methods: **Body mass index was stratified into 6 categorical groups. Cardiovascular disease risk factors for hypertension, diabetes mellitus and a serum lipid profile were analysed and reported by body mass index category.**
Results: **More than 80% of the examined participants had at least one cardiovascular disease risk factor irrespective of body mass index level. Hypertension was highly prevalent, especially in men. Dyslipidaemia was common at all body mass index categories in both men and women.**
Conclusion: **Higher body mass index values tended to associate with more hypertension and diabetes mellitus, whereas dyslipidaemia was prevalent across all body mass index categories. Studies that intervene to reduce weight and or percentage body fat should be performed to determine the effect on reducing modifiable cardiovascular disease risk factors.**

Key words: prevention; dyslipidaemia; hypertension; diabetes mellitus.

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INTRODUCTION

Through the mid-20th century, traumatic spinal cord injury (SCI) carried a dismal prognosis, where many patients died within a few years post-injury, due mainly to extensive infections emanating from pressure ulcers and/or the urinary and respiratory tracts (1, 2). This situation has subsequently, improved dramatically. However, increased long-time survival has allowed other secondary conditions to emerge, such as cardiovascular disease (CVD) and diabetes mellitus (DM) (3).

There is evidence for premature morbidity and mortality in persons with SCI, including an increased prevalence of CVD (2–4). Among modifiable CVD risk factors, hypertension (HTN) (5), dyslipidaemia (DL) (6), DM (7, 8) and overweight/obesity (9) have been found to be prevalent in persons with SCI. Prevention of secondary health conditions requires a high degree of motivation on behalf of the person with SCI. On a daily basis, persons with SCI have to perform multiple procedures and impose several lifestyle restrictions. In order to minimize the risk for several SCI-specific complications and secondary conditions, such as pressure ulcers and bowel and bladder dysfunction, patients have to follow strict daily routines. Before adding further restrictions in lifestyle, in this case related to prevention of CVD, it is important to assess the relevance and validity of such measures. Thereby, it is essential to define SCI-specific "cut scores" to identify when prevention is indeed indicated. Obesity is one such secondary health condition to be considered.

Obesity is both prevalent and well-characterized as a CVD risk factor in the general population, as well as in persons with SCI (9). In order to identify obesity in the general population, a body mass index (BMI) cut-off score of 25 and above is recommended by the World Health Organization (WHO) (10). These recommendations are based on a significant increase in morbidity at and above this level.

However, in persons with SCI, an increase in body fat mass may occur without a simultaneous increase in body weight and/or BMI. This is due to the loss of lean body mass (i.e. muscle and bone tissue), which inevitably accompanies paralysis (11, 12). Thus, it is likely that a standard BMI cut-off score of 25 and above will underestimate the degree of obesity in persons with SCI (13). Consequently, several studies have suggested that BMI cut-off scores in persons with SCI should be lower than those for the general population (14–16). However, persons with SCI do not comprise a homogenous group, as lesions are complete or incomplete and occur on different neurological injury levels, something which may significantly influence body composition and BMI (12). Therefore, there is a need for studying how risk factors are distributed according to BMI scores in sub-groups of persons with SCI.

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Table I. *Characteristics of the study group (104 men, 31 women)*

Characteristics	
Age, years, mean (SD)	47.8 (13.7)
Injury duration, years, mean (SD)	18.4 (12.3)
Injury level, *n*	
Th1–Th6 (AIS A/B/C)	45 (39/4/2)
Th7–Th12 (AIS A/B/C)	66 (56/5/5)
L1–L4 (AIS A/B/C)	24 (14/4/6)

SD: standard deviation; AIS A/B/C: ASIA (American Spinal Injury Association) Impairment Scale grade A, B or C.

In an effort to define a relevant BMI cut-off score as regards CVD risk, the aim of this study was to assess CVD risk factors at different BMI scores in persons with wheelchair-dependent paraplegia after SCI.

METHODS

The study group comprised 135 wheelchair-dependent individuals (≥18 years old) with post-traumatic paraplegia (i.e. with a neurological level of lesion below Th1 and ASIA Impairment Scale (AIS) grade A, B or C) for at least 1 year. Subjects were living in the greater Stockholm area and were registered at the regional SCI outpatient centre, which oversees follow-up for approximately 95% of the regional SCI population. A total of 153 persons fulfilling these criteria were asked to participate in the study, as they consecutively attended annual check-up at the centre. From this group, 135 persons (104 men, 31 women) consented to participate in the study, thus comprising 88% of the total regional population with such injury characteristics. There were no differences in age or injury duration between men and women. Basic patient characteristics are shown in Table I.

Body weight was measured 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) (10).

Blood pressure, measured in the left arm, was recorded with a calibrated manometer after a 30-min rest. HTN was defined as an elevated blood pressure of ≥140 mmHg systolic and/or ≥90 mmHg diastolic according to guidelines (17) and/or ongoing drug treatment for HTN. When a patient presented multiple risk factors, the criterion score for HTN was set at a systolic and/or diastolic pressure of ≥130 mmHg and ≥85 mmHg, respectively, according to the same guidelines.

Blood glucose and a lipid panel (total cholesterol (TC), high-density lipoprotein cholesterol (HDL), low-density lipoprotein cholesterol (LDL) and triglycerides (TG)) were quantified in whole blood drawn from a superficial arm vein following an overnight (midnight) fast, according to guidelines (18).

The criteria for DM was an increased fasting blood glucose level (≥6.1 mmol/l), according to WHO guidelines (19) and/or ongoing drug treatment for DM.

Table III. *Distribution of risk factors for cardiovascular disease at different body mass index categories in the study group*

BMI level	HTN (*n*=73) %	DM (*n*=13) %	DL (*n*=109) %
<22 (*n*=33)	25	0	21
22<23 (*n*=14)	10	8	11
23<24 (*n*=18)	8	0	16
24<25 (*n*=13)	10	8	9
25<30 (*n*=44)	31	54	33
≥30 (*n*=13)	16	30	10
Total (*n*=135)	100	100	100

BMI: body mass index; HTN: hypertension; DM: diabetes mellitus; DL: dyslipidaemia.

DL was defined as at least one pathological lipid level according to guidelines of the National Cholesterol Education Project – Adult Treatment Panel III (18) and/or ongoing drug treatment for DL. Cut-off levels were: TC ≥5.0 mmol/l, HDL ≤1.0 mmol/l (men) and ≤1.3 mmol/l (women), LDL ≥3.0 mmol/l, TC/HDL ratio ≥4.5 and triglycerides >1.7 mmol/l.

Data were analysed using PASW Statistics 18 (IBM Corporation, Armonk, NY, USA). Values are described as mean (standard deviation (SD)). Differences in numerical values were calculated using Mann-Whitney *U* test, categorical differences were calculated using a χ^2 test. A p-value <0.05 was considered significant.

The study was approved by the human ethics committee at the Karolinska Institutet, Stockholm, Sweden.

RESULTS

Subjects with HTN had a significantly higher mean BMI than non-hypertensive subjects (25.4 (SD 4.2) vs 23.7 (SD 3.7), $p=0.023$). Subjects with DM likewise had a significantly higher BMI than participants without DM (27.8 (SD 3.5) vs 24.1 (SD 3.8), $p=0.001$). This difference, however, was seen only in men. No such BMI-related differences were found when comparing participants with and without DL.

HTN was significantly more prevalent in men than in women (44.2% vs 22.6%, $p=0.030$). No gender differences were found concerning DM and DL. The results are shown in Table II.

More than 80% of the study group displayed ≥1 CVD risk factor irrespective of BMI level and gender. Table III shows the distribution of HTN, DM and DL at various BMI levels. The prevalence of CVD risk factors at various BMI levels is shown in Table IV.

Table II. *Description of risk factors for cardiovascular disease in the study population*

Variable	Whole group (*n*=135) Mean (SD)	Men (*n*=104) Mean (SD)	Women (*n*=31) Mean (SD)	*p*
BMI	24.4 (4.0)	24.6 (3.9)	23.7 (4.4)	0.332
Systolic blood pressure (mmHg)	129.5 (2.9)	131.7 (24.1)	122.4 (16.7)	0.022
Diastolic blood pressure (mmHg)	78.0 (11.9)	79.3 (11.8)	73.7 (11.3)	0.018
Blood glucose (mmol/l)	5.2 (1.4)	5.2 (1.3)	5.3 (1.6)	0.736
Total cholesterol	4.8 (1.0)	4.8 (0.9)	4.6 (1.1)	0.287
HDL	1.2 (0.4)	1.1 (0.3)	1.4 (0.4)	0.002
LDL	3.0 (0.9)	3.1 (0.9)	2.9 (0.9)	0.149
TC/HDL ratio	24.4 (4.0)	24.6 (3.9)	23.7 (4.4)	0.003
TG	1.4 (0.8)	1.5 (0.8)	0.9 (0.6)	0.000

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

Table IV. *Prevalence of risk factors for cardiovascular disease at different body mass index categories in the study group*

BMI level	HTN ($n=73$) %	DM ($n=13$) %	DL ($n=109$) %
<22 ($n=33$)	33	0	72
<23 ($n=47$)	30	2	76
<24 ($n=65$)	29	2	81
<25 ($n=78$)	32	3	68
25 <30 ($n=44$)	43	16	82
≥30 ($n=13$)	70	31	85

BMI: body mass index; HTN: hypertension; DM: diabetes mellitus; DL: dyslipidaemia.

Subjects with lower-level paraplegia (Th7 and below) had a significantly higher systolic (133.7 (SD 23.1) vs 121.1 (SD 20.3) mmHg, $p=0.003$) and diastolic (79.7 (SD 10.9) vs 74.5 (SD 13.0) mmHg, $p=0.022$) blood pressure than subjects with higher-level injuries (Th6 and above). Concordantly, significantly more subjects with lower-level injuries were hypertensive than participants with higher-level paraplegia (77% vs 23%, $p=0.034$). There were no significant differences in the other variables when comparing participants with high and low injury levels.

DISCUSSION

Over 80% of the subjects had ≥ 1 CVD risk factor, irrespective of BMI scores. However, there was a high frequency of HTN, especially in men, with a significantly higher blood pressure in subjects with lower-level injuries and higher BMI. This is in accordance with previous studies (5, 20), and also reflects that patients with injuries below Th6 have a remaining autonomically mediated vasoconstriction. The results indicate the need for prevention, detection and treatment of HTN in this patient group, especially in lower-level paraplegia.

The frequency of DM is higher in male subjects with higher BMI. This is in line with Rajan et al. (21), who showed an association between obesity and DM in military veterans with SCI.

DL was highly prevalent independent of BMI level. The results are in line with Demirel et al. (8), who reported high serum lipid levels in subjects with SCI compared with controls, without correlation with injury level and completeness of lesions. De Groot et al. (22) also found unfavourable lipid profiles in a study group of persons with complete and incomplete paraplegia, but an increase in BMI seemed to influence the lipid profile. Storch et al. (23) found dyslipidaemia in both tetraplegic and paraplegic subjects, but did not relate the results to BMI.

It is well known that the body composition in persons with SCI is altered, with a higher proportion of fat tissue compared with lean tissue mass (9, 12, 24). However, in this study, it is surprising that even participants with a relatively low BMI had such a high frequency of DL.

Based on data on body composition, it has been recommended that the cut-off score representing a "healthy" BMI should be set lower in persons with SCI (16, 25). However, the results of the present study indicate that no such lower BMI cut score exists which is of relevance as to when CVD prevention is needed. The very high prevalence of DL regardless of BMI score, together with changes in body composition, problems in making correct assessments of body height and the great heterogeneity in SCI lesions per se, seem to diminish the relevance of BMI as such in the SCI population.

In order to prevent CVD morbidity and mortality after SCI, it seems important that rehabilitation programmes and regular clinical follow-ups of this patient group should not only focus on SCI-specific medical problems, such as urinary tract dysfunction, ulcers etc, but also identify the occurrence of CVD risk factors. If BMI is used at all as a clinical indicator for obesity, it is probably of high value to also measure blood pressure and take blood tests of serum lipids. Test of fasting blood glucose could also be of value, especially in men with high BMI. Further complementary investigations to examine body composition using dual-energy x-ray absorp tiometry and/or ultrasonography of the abdomen to estimate body fat might be indicated (26). It may also be of importance to explore whether abdominal circumference is a better discriminator for obesity and other CVD risk factors in the clinical setting for long-term follow-up after SCI.

Another question is what kinds of preventive measures for CVD are relevant. Garshick et al. (3) claim that mortality in persons with SCI is related to factors that are treatable or preventable, for instance lifestyle habits. In the normal population, physical activity is generally recommended (27). However, it can be hard to find suitable physical activities for this patient group depending on injury level, cardiovascular function and severity of paralysis. Furthermore, in this study these CVD risk factors seem to occur also in persons with a low BMI. It might be the case that, besides physical activity, diet recommendations and drug treatment are more realistic for CVD prevention in this patient group. Further studies are needed to evaluate the effects of different preventative strategies.

When interpreting the results of this study, the following limitations should be considered:

- Measure of body height, a crucial component in the BMI equation, was obtained by history alone. It is well known that there may be a bias in overestimation of body height by recall. In addition, there are expected problems to define a "correct" measure for this purpose, even if actual body height were to be obtained, e.g. due to spinal deformities, joint contractures, vertebral body compressions, etc.
- The material in this study consists of patients with wheelchair-dependent paraplegia. Since the study group is relatively large, it is probably possible to generalize the results to other patients with this specific injury and functional level. However, it is not possible from this data to draw conclusions concerning patients with tetraplegia, as the body composition, muscle function and metabolic situation may be quite different in that patient group. This also supports the need for further studies in this area.

In conclusion, a large majority of participants had DL independent of BMI level. Higher BMI values tended to associate

with more HTN and DM, whereas DL was prevalent across all BMI categories. When assessing CVD risk factors in this patient group, evaluation of blood pressure and serum lipids appears to be of high importance and more significant than calculating BMI levels. This should be considered in clinical guidelines for this patient group in rehabilitation programmes and in clinical follow-ups. Studies that intervene to reduce weight and/or percentage body fat should be performed to determine the effect on reducing modifiable risk factors for CVD.

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