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Prevalence of Obesity After Spinal Cord Injury

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Abstract

The prevalence of obesity has been continuously increasing in the United States. Obesity has crossed the borders of the able-bodied populations and extended to populations with disabilities, including spinal cord injury (SCI). The magnitude and the prevalence of obesity after SCI are not clearly defined. The purpose of the current review is to discuss the body of literature on the prevalence of obesity among individuals with SCI. The review will show that the prevalence of obesity after SCI is an issue that needs to be further addressed and specifically correlated to mortality rates in SCI. Body mass index (BMI) criteria need to be adjusted to meet the changes in body composition after SCI, specifically increasing fat mass and percent body fat. Prevalence of overweight and obesity in SCI by sex, age, and ethnic group needs further investigation to determine the actual magnitude of the problem, which appears to exceed epidemic proportions. Moreover, SCI-specific factors such as level of injury, American Spinal Injury Association (ASIA) impairment classification, and time since injury need to be further correlated to the prevalence of obesity after SCI.

Keywords

body composition; body mass index; epidemiology; obesity; spinal cord injury

Obesity is a major public health concern in the United States and across the world. The prevalence of obesity, as defined by body mass index (BMI) >30, among US adults has escalated from 22.9% in 1994 to 30.5% during 2002. Similarly, the prevalence of overweight (BMI >25) has increased during the same period from 55.9% to 64.5%.[1] Studies have shown that the mortality rate increases among populations with increasing BMI. The relative risk of death was 2.6 and 2 times higher in men and women, respectively, with BMI >40 compared to persons with BMI <25 kg/m^2. An estimated 300,000 deaths per year in the United States are directly attributable to obesity.[2,3] Medical expenses of obesity accounted for 9.1% of total US medical expenditures in 1998, and the economic burden of obesity may have reached as high as $78.5 billion ($92.6 billion in 2002 dollars).[4]

Obesity can be defined as a progressive disease of excess fat accumulation that has multiple, organ-specific, pathological consequences.[1,3] The epidemic of obesity has been strongly linked to an increased rate of cardiovascular diseases, metabolic diseases such as type 2 diabetes, cancer, and musculoskeletal disorders. These risks arise from the increased mass of fat tissue as well as the products generated by the increased number and size of fat cells in obese individuals. Different indices and assessment tools have been proposed to account for the escalated risk of obesity. In recent population studies, overweight and obesity are defined using BMI. BMI has been defined according to the World Health Organization (WHO) guidelines as weight/height squared (kg/m^2).[5] Failure to account for height may influence the outcome of weight measurements, because people stratified for sex and age vary in stature (Table 1).

The National Health and Nutrition Examination Survey (NHANES) has used the BMI at different cycles (I–III) to determine the prevalence of obesity among US citizens.[3] Data from NHANES III (1999–2002) have shown that the trend of obesity has drastically increased, and the prevalence of obesity among US adults has doubled compared to 1961–1980.[3,6] Modernized life, decrease in physical activities, and overfeeding are the primary reasons for this fatal trend. Consequently, the US government has set a plan to oppose the current trend and labeled this effort Healthy 2010. In the Healthy 2010 plan, dietary and exercise guidelines are proposed for Americans. For example, one should exercise at least 30 minutes per day at moderate intensity to limit obesity-associated risks, at least 60 minutes at moderate to vigorous intensity to maintain current body weight, and from 60 to 90 minutes at moderate to vigorous intensity to lose weight.[7]

Most recently, studies have shown that the prevalence of obesity has started to increase in different populations with disabilities. The prevalence of obesity among individuals with disabilities is 2 to 4 times higher than in the general population,[8] whereas the odds ratio for obesity in adults with lower extremity paralysis is 2.5 times higher than in others with nondisabled conditions.[8,9] Individuals with spinal cord injury (SCI) who use wheelchairs are commonly at risk of developing obesity. However, obesity prevalence may be underestimated or unclearly defined following SCI. Part of the problem is the lack of a valid differential tool to determine the rate of the current problem. The purpose of the current review is to summarize evidence from the literature on the prevalence and the magnitude of obesity after SCI.

According to the National Spinal Cord Injury Statistical Center, there are approximately 11,000 new cases of SCI annually.[10,11] In June 2005, the prevalence of individuals with SCI was estimated to be 250,000–400,000. Motor vehicle collisions account for 47.5% of SCI reported cases, whereas falls and violence are secondary common causes of SCI, accounting for 22.9% and 13.8% of all traumatic SCI, respectively. SCI most commonly occurs among males 16–30 years old.[11] It has been estimated that the annual total cost resulting from SCI is about 7.7 billion dollars.[12]

Individuals with SCI are at risk of developing obesity because they are largely reliant on their wheelchairs for mobility. There is currently a dearth of information and data on the prevalence and the magnitude of obesity after SCI. SCI represents a clear model for the effect of reduced physical activity on body composition. Following SCI, there are abrupt changes in body composition, including reduced fat-free mass and increased fat mass.[13–15] Reduced skeletal muscle mass in the face of unchanged dietary habits results in an abnormal balance between energy intake and expenditure, subsequently causing an accumulation of fat mass and the development of obesity. Of note, an imbalance between energy intake and expenditure of about 2% could result in a weight gain of 20 to 30 kg over a 1-year period.[16] Further, obesity has recently been demonstrated to be a factor that can alter the rehabilitation and functional outcome after SCI.[17]

In a recent retrospective survey, BMI was used to determine the prevalence of obesity among 408 individuals with SCI. The results showed that 65.9% are overweight, and 30% of those individuals are obese. For this group of individuals, the prevalence of overweight and obesity was reportedly higher in paraplegia than tetraplegia regardless of American Spinal Injury Association (ASIA) classification.[18] The authors of that study failed to recognize that fat-free lean mass (bone and skeletal muscle) was probably greater in persons with paraplegia and contributed a greater proportion to total body weight, spuriously increasing the perceived percentage of persons with paraplegia who were more “obese” than those with tetraplegia. Stated another way, individuals with tetraplegia likely had a greater amount of total fat than those with paraplegia, but they had relatively lower BMIs because fat weighs significantly less than muscle. In another retrospective survey, 47% of US veterans with SCI had a BMI <25 kg/m^2, whereas 33% were classified as overweight and 20% had a BMI ≥30 kg/m^2, which classified them as obese.[19] Studies utilizing BMI to classify obesity in SCI, however, grossly underestimate the number of individuals with excess body fat.

BMI is widely used as a method of classification among normal weight, overweight, and obese individuals.[5] Unfortunately, BMI does not take into consideration the composition of an individual’s body mass. As noted in Table 2, numerous studies involving individuals with SCI have demonstrated a significant discrepancy between percent body fat (%BF) and the BMI criteria for overweight and obesity as established by the WHO.[14,20–30] These criteria do not correspond to the same degree of fatness in the SCI population due, in large part, to differences in body composition and specifically fat-free mass.[14,24,31] It has been shown that SCI individuals with a similar BMI to controls have higher body fatness,[24] such that BMI grossly underestimates the prevalence of obesity among individuals with SCI. Preliminary data from our lab have shown that even SCI individuals with BMI <25 are at the risk of developing metabolic syndrome characterized by excess central fat mass, low HDL, high LDL, insulin resistance, and glucose intolerance.[32]

Many studies have shown that average BMI for individuals with SCI ranges between 21.7 and 28.9 kg/m^2, independent of time since injury (Table 2). This range of BMI fails to support the higher prevalence of obesity after SCI, whereas these same studies demonstrate that percent body fat actually ranges from 23% to as high as 40%. By definition, “obese” men have >22% fat[33] and ~80% of individuals with SCI are male, therefore most individuals with SCI should be considered obese or, by conservative standards, at the borderline between overweight and obese. Most studies reporting BMI in SCI have subsequently overlooked and underreported the actual magnitude of obesity in this population when compared to the non-SCI population.

A number of factors contribute to the higher fat mass and high prevalence of obesity in SCI. The reduction in physical activity can be represented by recent studies reporting that ~45%

of persons with SCI need assistance with transfers.[17,22,34] Reduction in energy expenditure certainly plays a role in the development of obesity in this population.[35] Individuals with SCI have been shown to have lower values of total daily energy expenditure, reduced resting metabolic rate, reduced thermic effect of activity, and reduced thermic effect of food even after adjustment of fat-free mass compared to matched controls.[28] It has been found that monozygotic twins with SCI have lower energy expenditure than their able-bodied co-twins, proportional to reductions in fat-free mass.[36] This is further substantiated in cross-sectional studies in the SCI population.[14] Individuals with SCI experienced greater reduction in their sympathetic activity compared to healthy individuals, which likely contributes further to lower resting metabolism.[37] A strong link has been found between lower sympathetic activity, reduction in energy expenditure, and increase in fat mass percentage in selected populations with SCI.[38]

Individuals with SCI are at risk for developing obesity-related disorders and subsequently for premature death. The mortality rate for cardiovascular disease is 228% higher in SCI than in non-SCI populations.[15] In one study, 62% of veterans with SCI were glucose intolerant, and 22% of those were frankly diabetic.[39] Increased body weight in SCI has been associated with increased risk of developing median nerve injury and subsequent carpal tunnel syndrome; ulnar nerve entrapment has also been reported.[40] Moreover, obese persons with SCI will likely encounter problems during their rehabilitation that could limit their functional outcomes. Nursing precautions such as two-person assist for transfers and bed turning should be considered to reduce back injuries associated with bariatric care. It has also been shown that obese persons with SCI have difficulty in gaining independence in bowel and bladder training compared to nonobese persons with the same level of injury.[17,40]

Although cardiorespiratory problems represent 36% of deaths beyond the first year of injury,[41] there is no clear evidence linking these deaths to obesity, largely because it has not been examined. Most studies reporting morbidity and mortality in SCI have failed to evaluate even the grossest measure of obesity (BMI), because measures of height and weight have not been included in the largest datasets over the past 30 years and only recently have data been evaluated from the Veterans Health Administration (VHA) database.[19] Although Weaver et al.[19] suggest the higher prevalence of obesity in SCI could explain a shorter life span compared to the able-bodied population, the true mortality rate resulting from obesity remains to be determined. Additionally, racial and ethnic influence on the prevalence of obesity in SCI is considered a major research question that needs to be addressed. For example, it remains unclear whether African Americans with SCI have a higher prevalence of obesity than matched Caucasians, as is the case in the non-SCI population. Answering these questions may help to increase the life expectancy of persons with SCI, providing essential information to medical personnel, insurance providers, and epidemiologists.

Several factors need to be considered when referring to the prevalence of obesity after SCI. Level of injury (tetraplegia vs. paraplegia), ASIA Impairment Scale classification, time since injury, and level of physical activity may be modifying factors. Each could contribute to the prevalence of obesity in SCI. There is paradoxical evidence to support that the prevalence of obesity is higher in persons with paraplegia compared to tetraplegia, based on reports using BMI rather than true body composition assessment.[18] Rasmann-Nuhlicek et al.[42] showed that the percent fat mass is higher in quadriplegic persons by ~5%; others have noticed no difference between both groups.[14] Moreover, completeness of SCI has no significant impact on the degree of adiposity in SCI as reported by BMI, but it is not clear if ASIA classification has an impact on the prevalence of obesity when true body fat mass is assessed. Gupta et al.[18] showed that ASIA C and D tend to have higher prevalence of obesity compared to ASIA A and B. The data were not analyzed statistically, thus it is unknown whether a significant difference exists; notably body composition was not assessed. Furthermore, the impact of physical activity on obesity in persons with SCI remains unclear. Olle et al.[43] showed that percent fat mass was 15% in physically active persons with SCI compared to 23% in sedentary SCI individuals.

In summary, the prevalence and the magnitude of obesity after SCI have not been sufficiently assessed and need further investigation. It is clear from the current review that there is a dearth of information on the prevalence of obesity after SCI and there are a limited number of studies dealing with obesity and adiposity after SCI, other than what has been reported by BMI. The BMI criteria need to be adjusted downward to reflect true obesity in SCI, because reliance on the usual criteria set by the WHO is misleading and grossly underestimates true prevalence. Demographic variables such as age, gender, race, level of injury, completeness of SCI, ASIA classification, and years post injury need to be further correlated to the prevalence of obesity after SCI. Multicenter trials are warranted using the largest datasets available in order to capture the true prevalence of obesity in the population with SCI, because it has tremendous implications with regard to long-term care, morbidity, and mortality.

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Table 1

Classification of body weight in adults according to body mass index (BMI)

Classification	BMI (kg/m^2)	Risk of comorbidities
Underweight	<18.5	Low
Normal range	18.5–24.9	Average
Overweight /Pre-obese	25.0–29.9	Increased
Obese class I	30.0–34.9	Moderate
Obese class II	35.0–39.9	Severe
Obese class III	40.0	Very severe

Table 2

Body composition assessment in representative population with SCI

Study	*N*	Age (yrs)	BMI (kg/m^2)	%BF	SCI
Clasey and Gater, 2005[20]	13	37	24.8	27	Para
Modlesky et al., 2004[21]	8	35	24.6	33.8	Para
Spungen et al., 2003[14]	67	40	25.4	36.3	Para
	66	37	25.8	34.2	Quad
Maggioni et al., 2003[22]	12	33.8	25.7	31.1	Para
Buchholz et al., 2003[23]	27	29.1	23.5	27.2	Para
Jones et al., 2003[24]	20	16–52	23.1	27.5	Para
		7	26.7	35	Quad
Buchholz et al., 2003[25]	28	34.2	24.3	30.8	Para
Desport et al., 2000[26]	20	45.4	26.9	32.8	Para
Spungen et al., 2000[27]	8	40	22.3	33.5	Para
Monroe et al., 1998[28]	10	31.9	21.7	23	Para
George et al., 1987[29]	15	30.8	22.3	25.5	Para/quad
Bulbulian et al., 1987[30]	22	27.5	22.3	22.4	Para

Note: BMI = body mass index; %BF = percent body fat; Para = paraplegia; Quad = quadriplegia.