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Association between Obesity and Unintentional Injury in Older Adults

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Summary
Objective: To test the association between obesity and specific types and anatomical sites of unintentional injuries in older adults. **Methods:** Participants consisted of 52,857 men and women aged ≥65 years from the 2003 and 2005 Canadian Community Health Survey. Weight, height, and details on injuries occurring in the past year were obtained by survey. **Results:** Obese individuals had a higher risk for sprains/strains occurring at any anatomical site (odds ratio, 95% confidence interval: men 1.48, 1.48–1.62; women 1.14, 1.10–1.27). Conversely, obese individuals were less likely to have a fracture at any anatomical location (men 0.56, 0.50–0.63; women 0.66, 0.51–0.92) or at the hip (men 0.31, 0.12–0.53; women 0.42, 0.29–0.92). Finally, obese older adults did not experience more superficial injuries than normal-weight individuals. **Conclusion:** Among this large sample of older adults, obesity provided some protection against fractures but was associated with higher odds for sprains/strains.

Introduction

The average age of Canadians is increasing [1] as is the proportion of older adults who are overweight or obese [2]. Obesity is a well established risk factor for several chronic disorders [3] and physical disability [4] in older adults. There is also emerging evidence that obesity is associated with unintentional injury [5–8], defined as injuries that do not involve violence or neglect. Unintentional injuries are a potentially important outcome of obesity to study in the elderly given that they account for 34% of deaths in this age group [9].

The majority of research examining the relationship between obesity and unintentional injuries within older adults has examined fracture and sprain/strain injury subtypes that have occurred at varying anatomical sites [5, 7, 8, 10]. Studies that have considered a specific anatomical site have focused primarily on hip fractures [11–14], an injury that is associated with a loss of independence and premature mortality [15, 16]. Interestingly, obese older adults have a reduced risk of hip fracture [17, 18], potentially due to their higher bone mineral density [19] and increased fat mass [20] the latter of which would act as a cushion upon impact during a fall. Although hip fractures are clearly an important injury to consider, other types and anatomical sites are also worthy of study. For instance, sprains/strains are the most frequent injuries in older adults [21], are extremely costly [22], and are associated with muscle pain and a decrease in flexibility [23], which in turn may influence ambulation and independent living [24].

In addition to the scarcity of studies outside of hip fracture, existing studies evaluating the association between obesity and injury have seldom been based on any underlying theoretical framework. A theoretical framework helps guide the research questions and determines what variables and statistical relationships would be important to study. Development of such a framework could help guide injury control research and prognostic studies in obesity research.

Therefore, the objectives of this study were to i) develop a theoretical framework linking obesity to specific types of injury occurring in different anatomical sites within older adults and ii) test the newly developed framework within a nationally representative sample of older adults.

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Material and Methods

Objective 1: Development of Framework on Obesity and Injury Risk
We used the risk and protective factor theory approach to develop our framework [25]. This approach is based on the identification and balancing of risk and protective factors for a specific outcome [26] and has been used extensively in the field of psychology to determine strategies to decrease negative behaviors [27]. In our study we conducted literature reviews to identify biological and biomechanical factors that may increase or decrease the risk for the most common types and locations of injuries in obese and overweight older persons. After completing the literature reviews, discussions were held amongst the authors to refine the list of potential protective and risk factors identified, and to consider the magnitude of protection or risk caused by these factors.

Objective 2: Testing of Framework on Obesity and Injury Risk

Study Sample
The study sample used to test the framework consisted of men and women aged 65 and older who participated in the 2003 and 2005 cycles of the Canadian Community Health Survey (CCHS) [28]. For this study data from 52,857 adults were analyzed. CCHS is a nationally representative cross-sectional survey conducted every 2 years across Canada. Briefly, it consists of a detailed home or telephone interview and requests information on disability, diseases, health services performance, injuries, mental health and well-being. Extensive details about the questionnaire items, methodology, data accuracy and documentation are available on the Statistics Canada website [28].

Overweight and Obesity
BMI (= weight/height^2) was calculated based on self-reported weight (kg) and height (m). Standard BMI thresholds [29] were used to create normal-weight (18.5–24.9 kg/m^2), overweight (25–29.9 kg/m^2), and obese (≥30 kg/m^2) categories. Underweight individuals (≤18.49 kg/m^2), who represented 1.2% of the study sample, were excluded because the mechanisms linking a low weight to injury risk are different from the mechanisms that link excessive weight and injury risk.

Unintentional Injury
Unintentional injury includes injuries that are mostly preventable and do not involve violence or neglect [30]. In this study, injured individuals were characterized as such if they provided a positive response to the question 'Not counting repetitive strain injuries, in the past 12 months, were you injured?' Injured participants then completed a series of questions aimed at obtaining information on the nature, anatomical site, need for hospital admission, external cause and activity limitations of their most serious injury. The natures of injuries listed were: multiple injuries, fractured bones, burn/scalds, dislocations, sprains/strains, cuts, scrapes/bruises/blisters, brain injuries or other. The locations of injuries listed were: hip multiple, eye(s), head, neck, shoulder, elbow, wrist, hand, hip, thigh, knee, ankle, upper back, lower back, chest and abdomen. Fractured bones and dislocation were combined together for analyses and are presented as fractures in the article. Scrapes/bruises/blisters are identified in the present article as superficial injuries.

Confounding Variables
Based on past research and theoretical considerations, an array of potential confounders was included in the analyses: age, sex, ethnicity, physical activity level, smoking status, alcohol intake and current medical condition. Age was considered as a continuous variable. Ethnicity was categorized in two groups (Caucasian and other). Moderate-to-vigorous intensity physical activity was self-reported for 16 common activities. Typical frequencies and duration of these activities were used to calculate a weekly mean time devoted to physical activity, and participants were categorized as 'sedentary' (<15 min/week), 'slightly active' (15–149 min/week), or 'active' (≥150 min/week). The lower cut-point of activity in the 'active' group corresponds to the public health guidelines for physical activity [31]. Alcohol intake was calculated based on the frequency of consumption (never, monthly, weekly or daily). Participants were considered 'current smokers' if they smoked cigarettes at the time of the survey, 'former smokers' if they were not currently smoking but had smoked more than 100 cigarettes in their life, and 'non-smokers' if they smoked less than 100 cigarettes in their lifetime. Chronic medical conditions were self-reported and regrouped in six different categories: diabetes, cardiovascular disease (hypertension, stroke, and/or heart disease), arthritis, lung disease (asthma, chronic obstructive pulmonary disease, and/or bronchitis), chronic fatigue

Table 1. Injury prevalence of the study characteristics[a]

	Total, N	Injured		χ^2 test p value
		N	%	
All participants	52,857	4,425	8.4	
Age, years				
65–74	29,043	2,307	7.9	<0.001
75–84	24,652	1,641	6.7	
≥85	11,860	477	4.0	
Sex				
Men	31,001	1,527	4.9	<0.001
Women	21,856	2898	13.3	
BMI category				
Normal	23,080	2,027	8.8	<0.01
Overweight	21,018	1,656	7.9	
Obese	8,759	742	8.5	
Ethnicity				
White	39,192	3,297	8.4	0.841
Other or not reported	13,665	1,128	8.3	
Physical activity				
Sedentary	19,289	1,689	8.8	0.049
Slightly active	30,378	2,500	8.2	
Active	2,845	233	8.2	
Alcohol intake				
Non-drinker	17,934	1,492	8.3	0.045
Monthly drinker	17,408	1,437	8.2	
Weekly drinker	10,295	872	8.5	
Daily drinker	6,510	573	8.8	
Smoking status				
Never smoke	23,702	2,009	8.5	0.082
Former smoker	22,973	1,921	8.4	
Current smoker	6,059	486	8.0	
Medical conditions				
Diabetes	7,696	708	9.2	0.01
Cardiovascular disease	22,092	1,976	8.9	<0.01
Arthritis	26,199	2,544	9.7	<0.01
Lungs disease	6,811	657	9.6	<0.01
Chronic fatigue or pain	14,977	1,726	11.6	<0.01
Visual impairment	13,532	1,318	9.7	<0.01

[a]Data presented as unweighted N.

Table 2. Description of the most serious injury in the last 12 months[a]

	% of total population	% of injured individuals
General description of injury		
Any injury	8.4	–
Hospital admission following injury	4.1	48.8
Result of a fall	4.7	55.9
Activity limiting	7.7	91.7
External cause		
Sports or leisure	5.4	64.3
Other	3.0	35.7
Environment where injured		
Home	5.6	66.7
Other	2.8	33.3
Type and anatomical site of injury		
Fractures		
Any anatomical site	2.7	32.1
Hip	0.3	3.6
Ankle/foot	0.5	5.9
Wrist/hand	0.5	5.9
Shoulder/elbow	0.4	4.8
Other	1.1	13.1
Sprains or strains		
Any anatomical site	2.4	28.6
Knee	0.5	5.9
Ankle/foot	0.5	5.9
Lower back	0.5	5.9
Wrist/hand	0.2	2.4
Other	0.7	8.3
Superficial (scrape/bruise/blister)		
Any anatomical site	1.0	11.9
Lower limbs (hip, knee, thigh, ankle, foot)	0.4	3.4
Other injury	2.3	27.4

[a]Prevalence presented as weighted%

or pain (fibromyalgia, back problem, migraine, and/or fatigue) and visual impairment (glaucoma and/or cataracts).

Statistical Analysis

Possible protective and risk factors for unintentional injury in obese older adults were identified by creating a theoretical framework. These risk and protective factors were then tested in the statistical analyses. Because there are known sex differences in the type and mechanism of injury and body composition in older adults, all analyses were stratified by sex. Some of the analyses were also stratified by age group (≤75 vs. >75 years). Differences in the prevalence of different types and anatomical sites of injury identified by the theoretical framework according to BMI category and the different covariates were assessed by χ^2. Associations between BMI status and injury were also assessed with logistic regression models that were adjusted for age, ethnicity, physical activity, smoking, alcohol and chronic conditions. Statistics accounted for the sample weights, complex survey design, and the use of a combined sample from the 2003 and 2005 CCHS surveys [32]. Bootstrap techniques were used to estimate the 95% confidence intervals. Significance was accepted at $p \leq 0.05$. Data management and statistical analyses were performed using SAS version 9.1 (SAS Institute, Carry, NC, USA).

Table 3. Biomechanical framework linking obesity with potential risk and protective factors for different types and anatomical sites for unintentional injury in older adults.

Type and anatomical site of injury	Possible protective factors		Possible risk factors						Overall risk in obese individuals
			increased risk of falls			increased fat mass			
	greater bone density	greater fat pad cushion	more morbidities	more medications	altered gait and balance	extra force on falls	lower neural sensitivity	greater extremity friction	
Fractures									
Hip	↓↓↓	↓↓↓	↑	↑	↑	↑	–	–	↑
Wrist/hand	↓	↓	↑↑	↑↑	↑↑	↑↑↑	–	–	↑↑↑
Shoulder/elbow	↓↓	↓↓	↑	↑	↑	↑	–	–	↑
Sprains/strains									
Knee	–	–	↑↑	–	↑↑	↑	↑	↑	↑↑↑
Ankle/foot	–	–	↑↑	↑↑	↑↑	↑↑	↑	–	↑↑↑
Lower back	–	–	↑	↑	↑	↑↑	–	–	
Superficial									
Lower limbs	–	–	↑↑	–	–	–	↑↑↑	↑↑↑	↑↑↑

↓↓↓ Strong protector factor for obese versus normal weight
↓↓ Moderate protector factor for obese versus normal weight
↓ Small protector factor for obese versus normal weight
↑↑↑ Strong risk factor for obese versus normal weight
↑↑ Moderate risk factor for obese versus normal weight
↑ Small risk factor for obese versus normal weight
– Not a protective or risk factor for specific injury type and location

Results

Descriptive Characteristics of Sample

Within the 52,857 study participants, 8.4% reported being injured within the 12 months prior to the survey. As shown in table 1, the proportion of participants who reported an injury within the previous 12 months varied by age, sex, BMI level, physical activity level and alcohol intake ($p \leq 0.05$). Almost half of these injuries resulted in a hospital admission, 55.9% were the result of a fall, and 91.6% were activity limiting (table 2). Most injuries happened at home and occurred while participating in sports or other leisure activities (table 2). The most common injuries by type and anatomical site are described in table 2. The framework was developed around these most common injuries.

Objective 1: Development of Framework on Obesity and Injury Risk (table 3)

Two possible protective factors for unintentional injury in obese older adults emerged from the literature. These protective factors consisted of an increased bone mineral density, which would offer protection against fractures, and an increased fat mass, which would provide added cushioning during a fall in some anatomical sites, thereby providing protection against fractures. Six possible risk factors for unintentional injury in obese older adults emerged from the literature. Three of these risk factors were related to increasing the risk of falling and stumbling: i) more comorbidities, ii) greater medication use and iii) altered gait (walking pattern) and balance. By increasing the risk of falls, these three risk factors could influence fractures, sprains/strains and superficial injuries. The remaining three possible risk factors for unintentional injury were related to the greater fat mass in an obese person. This added fat mass would lead to a greater force on impact during a fall and could lead to diseases (e.g. type 2 diabetes, peripheral neuropathy and peripheral vascular disease) that might lower neural sensitivity and thus might increase friction in the extremities when moving. These risk factors could influence sprains/strains and superficial injuries.

We considered the potential magnitude of each of these potential protective and risk factors for each of the most prevalent types and anatomical sites of injury that were identified in the study sample. Based on the combined effect of these various protective and risk factors, we predicted the direction and magnitude of association between obesity and each of the primary types and anatomical sites of injury. The developed framework, which we have labeled the biomechanical framework given the types of protective and risk factors identified, is summarized in table 3.

Objective 2: Testing of Framework on Obesity and Injury Risk

The associations between BMI, both as a continuous and categorical (normal weight, overweight, obese) variable, and different types and anatomical sites of injury are shown in table 4. Based on the biomechanical framework, we expected the likelihood of hip fracture to be lower in obese individuals

Table 4. Associations between BMI category and different types and anatomical sites of injury[a]

	Men (N = 21,856)			Women (N = 31,001)		
	BMI	overweight (N = 9,775)	obese (N = 3,472)	BMI	overweight (N = 11,243)	obese (N = 5,287)
Fractures						
Any anatomical site	0.94 (0.93–0.95)	0.57 (0.51–0.62)	0.56 (0.50–0.63)	0.96 (0.94–0.98)	0.73 (0.71–0.82)	0.66 (0.51–0.92)
Hip	0.89 (0.86–0.91)	0.20 (0.02–0.57)	0.31 (0.12–0.53)	0.83 (0.77–0.91)	0.52 (0.31–0.92)	0.42 (0.29–0.92)
Wrist/hand	1.00 (0.99–1.03)	1.19 (0.62–2.55)	0.83 (0.28–0.95)	0.95 (0.94–0.96)	0.76 (0.58–1.36)	0.98 (0.68–1.44)
Shoulder/elbow	0.95 (0.92–1.02)	0.74 (0.32–1.73)	0.38 (0.15–2.73)	0.97 (0.93–1.03)	0.77 (0.47–1.43)	1.05 (0.52–2.38)
Other	0.92 (0.89–0.94)	0.34 (0.32–0.93)	0.47 (0.34–0.93)	0.96 (0.95–0.97)	1.12 (0.87–1.72)	0.71 (0.48–1.96)
Sprains/strains						
Any anatomical site	1.03 (1.01–1.05)	1.05 (0.98–1.23)	1.48 (1.41–1.62)	1.01 (1.00–1.02)	1.02 (0.78–1.43)	1.14 (1.10–1.27)
Knee	1.04 (1.02–1.08)	1.32 (0.92–1.28)	1.84 (0.63–5.98)	1.01 (1.00–1.02)	1.11 (0.65–1.98)	1.23 (0.76–2.46)
Ankle/foot	1.05 (0.97–1.14)	1.53 (0.77–3.87)	2.33 (0.95–1.14)	1.01 (1.00–1.02)	1.02 (0.68–1.63)	1.12 (0.62–1.92)
Lower back	0.99 (0.93–1.07)	1.08 (0.87–1.37)	1.18 (0.62–2.98)	1.01 (1.00–1.03)	1.02 (0.68–1.42)	1.59 (0.85–2.99)
Other	1.04 (1.01–1.06)	1.32 (0.93–2.27)	1.81 (0.82–4.33)	1.01 (0.99–1.02)	2.10 (1.23–3.25)	1.67 (0.92–2.05)
Superficial						
Any anatomical site	1.00 (0.99–1.03)	1.21 (0.75–2.09)	1.35 (0.86–2.69)	0.98 (0.95–1.01)	0.97 (0.78–1.57)	1.01 (0.52–1.93)
Lower limbs	0.98 (0.97–1.03)	0.53 (0.38–1.10)	0.65 (0.27–1.07)	0.98 (0.96–1.01)	0.92 (0.41–2.05)	1.18 (0.51–2.73)
Other injury	1.00 (0.97–1.04)	0.90 (0.72–1.18)	0.95 (0.77–1.32)	0.98 (0.97–0.99)	0.92 (0.91–1.07)	0.83 (0.88–0.96)

[a]Data presented as odd ratio (95% confidence interval). Odds ratios were adjusted for age, ethnicity, physical activity, smoking, alcohol, and chronic conditions. Reference group for BMI groups analyses: normal-weight men (N = 8,609) and normal-weight women (N = 14,471); OR = 1.

than in normal-weight individuals, and this was supported by our findings in both men (OR 0.31, 95% CI 0.12–0.53) and women (OR 0.42, 95% CI 0.29–0.92). A similar pattern was observed in overweight men and women. Furthermore, for every increase of one BMI unit, men would have 11% and women 17% lower rates of hip fracture. Based on the biomechanical framework, we expected obese individuals to have an increased likelihood of fractures in the wrist/hand and shoulder/arm (table 3). However, this was not the case (table 4). In fact, obese men had significantly lower odds of wrist/hand fractures (OR 0.83, 95% CI 0.28–0.95), and in women every increase of one BMI unit increase was associated with a 5% lower odds of wrist/hand fractures. Finally, there was a noticeably albeit not significantly lower odds of should/elbow fractures in obese men (OR 0.38, 95% CI 0.15–2.73) relative to normal-weight men.

A greater relative odds of sprains/strains in the ankle/foot, knee, and lower back was expected in obese persons (table 3). These expectations were observed to some extent (table 4). The odds ratio for sprains/strains at each anatomical site were higher for obese (range 1.12–2.33) and overweight (range 1.02–2.10) men and women when compared with their normal-weight counterparts; however, these odds ratios did not reach statistical significance. When based on continuous BMI measures, there was a significant increase in the odds for sprains/strains in the knee in men and in the knee, ankle/foot and lower back in women. Furthermore, the odds ratios for sprains/strains occurring at any anatomical site were statistically higher in obese men (OR 1.48, 95% CI 1.41–1.62) and women (OR 1.14, 95% CI 1.10–1.27) in comparison to men and women with normal weight.

As for superficial injuries (scrapes/bruises/blisters), a greater relative odds for superficial injuries in the lower limbs was expected in obese persons (table 4). These expectations were not observed, regardless of whether BMI was considered as a continuous or categorical variable.

Additional analyses stratified by age group (≤75 years vs. >75 years) demonstrated that there was no distinguishable moderating impact of age on the observed relationships (data not shown).

Discussion

The aim of this study was to develop and test a biomechanical framework that explains the relationship between obesity and different types of injury occurring at different anatomical locations within older adults. Despite the promise that theoretical frameworks offer for informed study of the etiology of injury and despite the role of obesity as a determinant of health, the evidence discovered in the current study was only partially supportive of our biomechanical framework. Within the large and representative sample of older adults, obese men and women reported lower rates of fractures (occurring at any anatomical site or specifically in the hip. Conversely, higher BMI values were associated with higher rates of sprains/strains occurring at any anatomical site, and within men, with higher rates of sprains/strains in the knee.

Comparison to Previous Literature

Although not theory driven, several previous studies, which included adults of all ages, have examined the association between obesity and fractures occurring at any anatomical location [5–8]. The results from these studies indicate that obese adults have a greater fracture risk than their normal-weight counterparts. Studies limited to post-menopausal women report a lower prevalence or no association between obesity and fractures [33–35]. Consistent with these observations and our newly developed biomechanical framework in older adults, we observed lower relative odds for fractures occurring at any anatomical location within both overweight and obese older adults. Therefore, irrespective of the fact that overweight and obese older adults experience a higher number of falls [36], possibly because of greater morbidity [37] and medication use [38] and an altered walking pattern [39] as identified by the biomechanical framework, they do not have a greater overall risk of fractures.

As with overall fracture risk, an extensive body of literature has demonstrated that obese individuals have a reduced risk of hip fracture [11, 12, 18, 20, 40, 41]. Our results were consistent with this finding. In the biomechanical framework, we hypothesized that the excessive fat in the hip region would offer considerable protection for obese individuals when falling, mostly because of a greater cushioning. We did not expect the same to occur in many other regions of the body, such as the wrist and elbow, as the amount of subcutaneous fat in these regions is limited. However, to our surprise, obese men had lower relative odds of fractures in the wrist/hand and shoulder/elbow. Thus, while obesity may increase the fall force, it may not increase the fall force reaching the bone. Other studies have reported that there is no association between obesity status and wrist fracture [34, 42]. We are unaware of previous studies that have examined this association for specific regions outside of the hip and wrist. One of the reasons why we did not find the expected associations between obesity and some specific injuries in our study may be due to the fact that we were not able to fully account for the activities and circumstances (other exposures) that lead to these injuries. For example, we were not able to control for the propensity for obese versus non-obese people to stay homebound [43] and the risks that come with such an exposure.

Our results for sprains/strains are in line with others who, regardless of the age group studied, report an increased risk for overall sprains and strains in obese individuals [5–7]. This finding is also consistent with our framework which suggests that the excessive weight in obese persons may increase the odds for sprains and strains possibly by increasing the stress on the musculoskeletal system [44]. To our knowledge, no previous studies have examined the association between obesity and sprains/strains occurring at specific anatomical sites. Thus, our study provides new information in this area. Specifically, although not significantly elevated, the trend in results suggests that older adults have higher injury rates in several regions such as the knee, foot and back. These results are in line with others who have already noted a positive association between BMI and pain in the knee, hip and lower back, especially in older women [45].

Although obese individuals are more likely to have an impaired neural sensitivity [46] and encounter a greater friction between their legs when walking [47], they did not have more superficial injuries (overall or in specific regions) in the present study or in two previous reports [6, 7]. Again, this might be explained by the fact that older adults are more homebound and sedentary than their lean counterparts [43, 48], and hence less exposed to having these types of injury.

Strengths and Limitations

Foundations for the framework that we developed included existing risk and protective factor approaches [25] and biomechanical principles such as the difficulty in mobility for obese older individuals because of an increased risk of falling [36], more comorbidities, greater medication use and an altered walking pattern and balance. We view this as a novel contribution to the obesity and injury control literatures. Through the use of a national and robust database, we also had the opportunity to examine very specific types and anatomical sites of injury suggested by our background research. Most studies in this field focus on a limited number of injury outcomes, especially in older adults where the focus is on hip injury [11, 12, 14, 49]. Limitations of this study also warrant comment. First, the CCHS relied upon self-reported assessments of height and weight to calculate BMI status. Although strong correlations have been observed between self-reported and measured weights [50], such measures are subject to misclassification errors that would make the BMI exposure groups more alike. This is likely to bias true estimates of effect towards the null. Second, as only 6.3% of the obese individuals and 1.0% of the whole sample reported a BMI over 35 kg/m^2 (class II or III obesity), we were unable to examine differences in injury risk at different levels of obesity. Third, injuries are also subject to misclassification errors. Many of the reported injuries may have been of a less serious nature and. hence. more likely to have etiological origins that are based upon random causes. Furthermore, as the CCHS only collected detailed information on the one most serious injury experienced during the past 12 months, this practice would contribute to non-differential errors in outcome classification and bias the results towards no effect. Finally, the cross-sectional design did not allow us to ascertain the temporal sequence of the variables studied.

Conclusions

In order to address an identified gap in the biomedical literature, this study proposed and tested a theoretical framework for the etiological study of relations between obesity and injury among older people. It was hoped that development of such a framework could be used in the future to help guide injury control research and prognostic studies in obesity research. Unfortunately, a number of the relationships that we examined in a robust sample of older adults were not fully supportive of the framework. Nonetheless, the results of this study could be used to further refine and develop a more complete and valid framework.

Disclosure

The authors declared no conflict of interest.

References

1 Statistics Canada: Canada's Aging Population; product # h39–608. 2002. Available from *http://dsp-psd.pwgsc.gc.ca/Collection/H39–608–2002E.pdf* (accessed June 24, 2010).

2 Tjepkema M, Shields M: Adult Obesity in Canada: Measured Height and Weight in Canada.2005. Available from *www.statcan.gc.ca/pub/82–620-m/2005001/article/ adults-adultes/8060-eng.htm* (accessed July 4, 2010).

3 Lawrence VJ, Kopelman PG: Medical consequences of obesity. Clin Dermatol 2004;22:296–302.

4 Davison KK, Ford ES, Cogswell ME, Dietz WH: Percentage of body fat and body mass index are associated with mobility limitations in people aged 70 and older from Nhanes III. J Am Geriatr Soc 2002;50:1802–1809.

5 Finkelstein EA, Chen H, Prabhu M, Trogdon JG, Corso PS: The relationship between obesity and injuries among U.S. adults. Am J Health Promot 2007;21:460–468.

6 Hu HY, Chou YJ, Chou P, Chen LK, Huang N: Association between obesity and injury among taiwanese adults. Int J Obes (Lond) 2009;33:878–884.

7 Matter KC, Sinclair SA, Hostetler SG, Xiang H: A comparison of the characteristics of injuries between obese and non-obese inpatients. Obesity (Silver Spring) 2007;15:2384–2390.

8 Xiang H, Smith GA, Wilkins JR 3rd, Chen G, Hostetler SG, Stallones L: Obesity and risk of nonfatal unintentional injuries. Am J Prev Med 2005;29:41–45.

9 Angus D, Cloutier E, Albert T, Chénard D, Shariatm Adar A: The Economic Burden of Unintentional Injury in Canada, 1998. Availble from *www.phac-aspc.gc.ca/injury-bles/ebuic-febnc/index-eng.php* (accessed June 5, 2010).

10 Hu G, Baker SP: Trends in unintentional injury deaths, U.S., 1999–2005: age, gender, and racial/ethnic differences. Am J Prev Med 2009;37:188–194.

11 Cummings SR, Nevitt MC, Browner WS, Stone K, Fox KM, Ensrud KE, Cauley J, Black D, Vogt TM: Risk Factors for hip fracture in white women. Study of Osteoporotic Fractures Research Group. N Engl J Med 1995;332:767–773.

12 De Laet CE, Van Hout BA, Burger H, Weel AE, Hofman A, Pols HA: Hip fracture prediction in elderly men and women: validation in the Rotterdam Study. J Bone Miner Res 1998;13:1587–1593.

13 Arterburn DE, Crane PK, Sullivan SD: The coming epidemic of obesity in elderly Americans. J Am Geriatr Soc 2004;52:1907–1912.

14 Kiel DP, Felson DT, Anderson JJ, Wilson PW, Moskowitz MA: Hip fracture and the use of estrogens in postmenopausal women. The Framingham Study. N Engl J Med 1987;317:1169–1174.

15 Abrahamsen B, van Staa T, Ariely R, Olson M, Cooper C: Excess mortality following hip fracture: a systematic epidemiological review. Osteoporos Int 2009;20:1633–1650.

16 de Luise C, Brimacombe M, Pedersen L, Sorensen HT: Comorbidity and mortality following hip fracture: a population-based cohort study. Aging Clin Exp Res 2008;20:412–418.
17 Hemenway D, Colditz GA, Willett WC, Stampfer MJ, Speizer FE: Fractures and lifestyle: effect of cigarette smoking, alcohol intake, and relative weight on the risk of hip and forearm fractures in middle-aged women. Am J Public Health 1988;78: 1554–1558.
18 Meyer HE, Tverdal A, Falch JA: Body height, body mass index, and fatal hip fractures: 16 years' follow-up of 674,000 Norwegian women and men. Epidemiology 1995;6:299–305.
19 Baumgartner RN, Stauber PM, Koehler KM, Romero L, Garry PJ: Associations of fat and muscle masses with bone mineral in elderly men and women. Am J Clin Nutr 1996;63:365–372.
20 Lauritzen JB, Askegaard V: Protection against hip fractures by energy absorption. Dan Med Bull 1992;39:91–93.
21 Raina P, Dukeshire S, Wong M, Scanlan A, Chambers L, Lindsay J: Patterns of self-reported health care use in injured and uninjured older adults. Age Ageing 1999;28:316–318.
22 Luo X, Pietrobon R, Sun SX, Liu GG, Hey L: Estimates and patterns of direct health care expenditures among individuals with back pain in the United States. Spine 2004;29:79–86.
23 Nevitt MC, Cummings SR, Hudes ES: Risk Factors for injurious falls: a prospective study. J Gerontol 1991;46:M164–170.
24 Mottram S, Peat G, Thomas E, Wilkie R, Croft P: Patterns of pain and mobility limitation in older people: cross-sectional findings from a population survey of 18,497 adults aged 50 years and over. Qual Life Res 2008;17:529–539.
25 Bogenschneider K: An ecological risk/protective theory for building prevention programs, policies, and community capacity to support youth. Fam Relat 1996;45:127–138.
26 Witt PA, Crompton JL: The protective factors framework: a key to programming for benefits and evaluating for results. J Park Recreat Admi 1997;15:1–18.
27 Marshall SW, Runyan CW, Yang J, Coyne-Beasley T, Waller AE, Johnson RM, Perkis D: Prevalence of selected risk and protective factors for falls in the home. Am J Prev Med 2005;28:95–101.
28 Statistics Canada: Canadian Community Health Survey (CCHS) Ottawa, 2005–2009. Available from *www.statcan.gc.ca/imdb-bmdi/3226-eng.htm* (accessed August 8, 2010).
29 World Health Organization Obesity: Preventing and Managing the Global Epidemic. Available from *www.atividadefisica.pro.br/artigos/WHO%20 obesity.pdf* (accessed June 3, 2010).
30 Davis RM, Pless B: BMJ bans 'accidents'. BMJ 2001;322:1320–1321.
31 Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, Macera CA, Heath GW, Thompson PD, Bauman A: Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. Med Sci Sports Exerc 2007;39:1423–1434.
32 Thomas S, Wannell B: Combining cycles of the Canadian Community Health Survey. Health Rep 2009;20:53–58.
33 Huopio J, Kroger H, Honkanen R, Saarikoski S, Alhava E: Risk factors for perimenopausal fractures: a prospective study. Osteoporos Int 2000;11: 219–227.
34 Kato I, Toniolo P, Zeleniuch-Jacquotte A, Shore RE, Koenig KL, Akhmedkhanov A, Riboli E: Diet, smoking and anthropometric indices and postmenopausal bone fractures: a prospective study. Int J Epidemiol 2000;29:85–92.
35 van Staa TP, Geusens P, Kanis JA, Leufkens HG, Gehlbach S, Cooper C: A simple clinical score for estimating the long-term risk of fracture in postmenopausal women. QJM 2006;99:673–682.
36 Fjeldstad C, Fjeldstad AS, Acree LS, Nickel KJ, Gardner AW: The influence of obesity on falls and quality of life. Dyn Med 2008;7:4.
37 Janssen I: Morbidity and mortality risk associated with an overweight BMI in older men and women. Obesity (Silver Spring) 2007;15:1827–1840.
38 Dzien A, Pfeiffer KP, Dzien-Bischinger C, Hoppichler F, Lechleitner M: The influence of obesity on the frequency and distribution of medication. Acta Med Austriaca 2003;30:51–54.
39 Bouchard DR, Dionne IJ, Brochu M: Sarcopenic/obesity and physical capacity in older men and women: data from the Nutrition as a Determinant of Successful Aging (NUAGE) – the Quebec Longitudinal Study. Obesity (Silver Spring) 2009;17: 2082–2088.
40 Schott AM, Cormier C, Hans D, Favier F, Hausherr E, Dargent-Molina P, Delmas PD, Ribot C, Sebert JL, Breart G, Meunier PJ: How hip and whole-body bone mineral density predict hip fracture in elderly women: the EPIDOS Prospective Study. Osteoporos Int 1998;8:247–254.
41 Slemenda C: Prevention of hip fractures: risk factor modification. Am J Med 1997;103:65S–71S; discussion 71S–73S.
42 Owusu W, Willett W, Ascherio A, Spiegelman D, Rimm E, Feskanich D, Colditz G: Body Anthropometry and the risk of hip and wrist fractures in men: results from a prospective study. Obes Res 1998;6:12–19.
43 Jensen GL, Silver HJ, Roy MA, Callahan E, Still C, Dupont W: Obesity is a risk factor for reporting homebound status among community-dwelling older persons. Obesity (Silver Spring) 2006;14:509–517.
44 Clark KN: Balance and strength training for obese individuals. ACSM Health Fitness J 2004;8:14–20.
45 Andersen RE, Crespo CJ, Bartlett SJ, Bathon JM, Fontaine KR: Relationship between body weight gain and significant knee, hip, and back pain in older Americans. Obes Res 2003;11:1159–1162.
46 Slovenkai MP: Foot problems in diabetes. Med Clin North Am 1998;82:949–971.
47 Spyropoulos P, Pisciotta JC, Pavlou KN, Cairns MA, Simon SR: Biomechanical gait analysis in obese men. Arch Phys Med Rehabil 1991;72:1065–1070.
48 Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, Buchner D, Ettinger W, Heath GW, King AC: Physical activity and public health. a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. JAMA 1995;273:402–407.
49 Hall SE, Williams JA, Senior JA, Goldswain PR, Criddle RA: Hip fracture outcomes: quality of life and functional status in older adults living in the community. Aust N Z J Med 2000;30:327–332.
50 Lawlor DA, Bedford C, Taylor M, Ebrahim S: Agreement between measured and self-reported weight in older women. Results from the British Women's Heart and Health Study. Age Ageing 2002;31:169–174.