

**OBESITY AS A PREDICTOR OF FALLS AMONG OLDER  
WOMEN**

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## ABSTRACT

In older people's falls often lead to hospitalisation and lengthy recovery in health care institutions and this may be conducive to financial strain on health care systems. The propensity or risk of falling rises as the individual gets older and frailer. Fear of falling, previous history of falling, poor mobility, limitations in Activities of Daily Living (ADL), side effects of medications, hazardous environment, poor vision and hearing, poor postural balance and gait impairment are among the frequent factors that give rise to falls amongst older people. However, studies focused on obesity as a risk factor for falls are rarer.

The aim of this study was to find out whether obesity increases the risk of falls among older women. The association between indoor and outdoor falls and obesity among older women was examined. The data for this study were obtained from the Finnish Twin Study on Ageing (FITSA). A total of 434 women aged 63 to 76 years old took part in the studies. The women were twins but their data were analyzed as individuals. Information on falls was recorded for 12 months of follow-up using a fall calendar. The study design was prospective.

129 women had BMI  $\geq 30$  kg/m<sup>2</sup> at baseline and were categorised as obese. Altogether 199 participants reported 434 falls. Fifty-seven participants experienced 81 indoor falls and 132 participants experienced 213 outdoor falls. Obesity increased the incidence of falls among older women. Among the obese group, half of them had reported at least one fall and one quarter reported recurrent falls. The obese group had more indoor falls than the non-obese group (24% vs. 9%). Women with indoor falls were over three times more likely to be obese as compared to women who did not fall indoors. Outdoor falls did not correlate with obesity.

This study showed that obesity is a forecaster for falls among older women. Women with indoor falls were over three times more likely to be obese as compared to women who did not fall indoors. The results of this study enhance the etiology and relative importance of risk factors for falls, obesity, indoor and outdoor falls.

Keywords: risk factors, body mass index, falls, ageing

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## 1. INTRODUCTION

According to a research carried by Pajala et al (2006) almost half of women aged 63-76 experienced at least one fall during a one year period. Falls may result in disability, hospitalisation and also to lengthy recovery in other institutions. Approximately 5-10 percent of falls result in an injury (Pajala et al 2006). In the year 2005 a study by Kannus et al. (2005) showed alarming results too. The study concluded that from the year 1970 till the year 2002 falls among older Finnish women have increased by more than 10 fold. Clearly, it can be stated that such a number of falls would become a problem in Finland in the near future as the health care system would struggle not only financially but also in terms of labour power as the Finnish nation continues to age.

The Kellogg International Work Group on Prevention of Falls by the Elderly describes a fall as a situation whereby a person accidentally comes on the ground from a higher level to a lower level without any of the two contributing factors interfering: acute illness and unexpected external pressure (Kellogg 1987). Plethoras of risks for falls among the older people have been identified. For instance the fear of falling, previous history of falling, poor mobility, limitations in Activities of Daily Living (ADL), combination side effects of medications, hazardous environment, poor sensory function - for example, visual or auditory impairment-, poor postural balance and gait impairment, cognitive impairment, anxiety and depression, incontinency, weak muscles and less physical exercises are among the most common factors that lead to falls, sometimes acting solely while at times applying a combination effect (American Geriatrics Society, 2001). Consequently, as Bruce et al (2002) have averred, obese people may be less exposed to external fall risk factors, such as slippery or uneven surfaces because they tend to be more inside their house than outside.

However, one should also take into account that researchers in the field of obesity and falls have, after having done research, come forward with the argument that obese people who have fat accumulation around the abdominal area are more prone to falling than non-obese people (Corbeil et al. 2001; Fjeldstad et al. 2008). One possible and pragmatic explanation for this phenomenon is that obese people's balance is worse than

that among non-obese individuals (Maffioletti et al. 2005). This study focuses on establishing and examining the relationship between obesity and indoor and outdoor falls among Finnish older women.

## **2. OBESITY AND AGEING**

### **2.1 Definition of Obesity**

According to World Health Organisation (WHO 2011) obesity is defined as abnormal or excessive fat accumulation that presents a risk to health. A person is considered obese when the Body Mass Index (BMI) equal to or more than 30. Body mass index (BMI) is a simple tool to measure and categorise overweight and obesity in adult populations and individuals. It is defined as the weight in kilograms divided by the square of the height in meters ( $\text{kg}/\text{m}^2$ ) (WHO 2011). The most popular tool is Quetelet's index which is commonly known as BMI. While there are other laboratory techniques to assess body mass like skin fold technique, underwater body density measurement, magnetic resonance imaging (MRI) and computed tomography (CT) these laboratory techniques are very expensive and require specific equipment. Furthermore, they are difficult to implement in epidemiological studies (Jebb & Elia 1993). As for BMI, it is a common tool which is easy to measure without any specific equipment.

The main cause of obesity is an energy imbalance between the intake of calories and amount of calories spent. Therefore, Obesity can be the consequence of either an increase in energy-rich food or a decrease in physical activity (WHO 2011). According to the World Health Organisation (WHO 2011) nearly 300 million women were obese in 2008. Furthermore, WHO predicts that, by the year 2015, nearly 700 million adults will be obese worldwide. As ageing occurs, body fat is redistributed within the body with a preferential deposition to central and visceral, rather than subcutaneous, fat depots. Around three decades ago, Borkan et al (1982) found out by using computer tomography among 21 middle aged individuals and 20 older ones, that the older adults had significantly higher amounts of visceral abdominal fat even though they weighed 8.2 kg less than the middle-aged people. Moreover, Goodpaster et al (2001) used computer tomography around mid-thigh level found that among people aged 70 years or more, aging increase the amount of fat inside and around muscles. Body weight

increases throughout middle age and this change is followed by a period of weight stabilization which culminates in a decline in older age (Najjar & Rowland 1987).

## **2.2 Body mass index as an indicator of obesity among older people**

With aging, a certain loss in the height is evident. A longitudinal study conducted by Sorkin et al. (1999) illustrated height loss happening at the age of 30 and increasing with aging. The study shows an average loss of 3 and 5 cm for men and women by the time they reach 70 years of age. By the age of 80, an average loss of 5 cm to 8 cm was observed. It highlights an influence of height loss with BMI with an approximate of 0.7 kg/m<sup>2</sup> and 1.6 kg/m<sup>2</sup> for men and women by the age of 70 years that increases to 1.4 and 2.6 kg/m<sup>2</sup>, respectively, by age 80 years (Sorkin et al. 1999). Kyphosis is a condition whereby there is a curvature of the upper back. There are different categories of kyphosis among which postural kyphosis is the most common, especially among older people. Postural kyphosis is a medical term also having a specific code (M.40.0) in the international classification of Diseases (ICD 10 2010). Among the older people it is often referred to as hyper-kyphosis.

A study done by Nishiwaki et al. (2011) concluded that among Japanese's community-dwelling adults aged 65 years and older there was a miscalculation of BMI among the older adults with kyphotic posture. In this study, 842 residents aged 65 years or above participated. BMI was first measured using the classical formula (kg/m<sup>2</sup>), and then the predicted BMI was measured again from height as determined by demi-span, which is unaffected by kyphosis. The study found out that 10% of the participants were incorrectly classified as overweight using the classical formula (kg/m<sup>2</sup>). This study therefore shows that hyper-kyphosis among older individuals should be taken into account when computing BMI and that the demi-span technique can be used to verify data before analysing or coming to conclusions. Also, improper measurement of height can lead to a miscalculation of BMI among older people suffering from hyper-kyphosis. Despite this limitation, BMI can be considered as an acceptable indicator in measuring the obesity in older people. The World Health Organisation (WHO 2004) has put into place a table representing the international classification of adults being overweight and

obese according to their BMI (Table 1). According to this table, obese can be divided into three different main categories.

Classification	BMI(kg/m <sup>2</sup> )	
	Principal points	cut-off
<b>Underweight</b>	<b>&lt;18.50</b>	<b>&lt;18.50</b>
Severe thinness	<16.00	<16.00
Moderate thinness	16.00 - 16.99	16.00 - 16.99
Mild thinness	17.00 - 18.49	17.00 - 18.49
<b>Normal range</b>	<b>18.50 - 24.99</b>	<b>18.50 - 22.99</b>
		<b>23.00 - 24.99</b>
<b>Overweight</b>	<b>≥25.00</b>	<b>≥25.00</b>
Pre-obese	25.00 - 29.99	25.00 - 27.49
		27.50 - 29.99
<b>Obese</b>	<b>≥30.00</b>	<b>≥30.00</b>
Obese class I	30.00 - 34.99	30.00 - 32.49
		32.50 - 34.99
Obese class II	35.00 - 39.99	35.00 - 37.49
		37.50 - 39.99
Obese class III	≥40.00	≥40.00

Table 1. The International Classification of adult overweight and obesity according to BMI Source: Adapted from WHO, 1995, WHO, 2000 and WHO 2004.

Furthermore, the idea of a BMI cut-off point is to recognize, within each population, the percentage of people with a high risk of an undesirable health state that needs an intervention. The WHO expert consultation concluded that BMI cut-off points must be based on reliable measurements that should be sensitive to important health-related changes and is useful for comparisons across populations in different countries as well as makes sense to policy makers and the public to understand (Nishida et al. 2004).

### **3. FALLS AND AGEING**

#### **3.1 Fall definition**

While old individuals describe a fall as a loss of balance, health care professionals normally refer to falls as incidents leading to injuries and poor health (Zecevic et al. 2006). According to the Oxford Online Dictionary a fall is the movement from a higher level to a lower level which normally occurs rapidly and without control (Oxford Online Dictionary 2011). The World Health Organisation (WHO) defines a fall “as an event which results in a person coming to rest inadvertently on the ground or floor or other lower level” (WHO Media Centre, 2010:1.). On the other hand, as is has been mentioned above, the Kellogg International Work Group on Prevention of Falls by the Elderly describes a fall as a situation whereby a person accidentally comes on the ground from a higher level to a lower level without any of these two contributing factors interference: acute illness and unexpected external pressure (Kellogg 1987). The International Classification of Diseases (ICD) 2007 version has at least 19 different categories of falls and places them under the accident and injuries section.

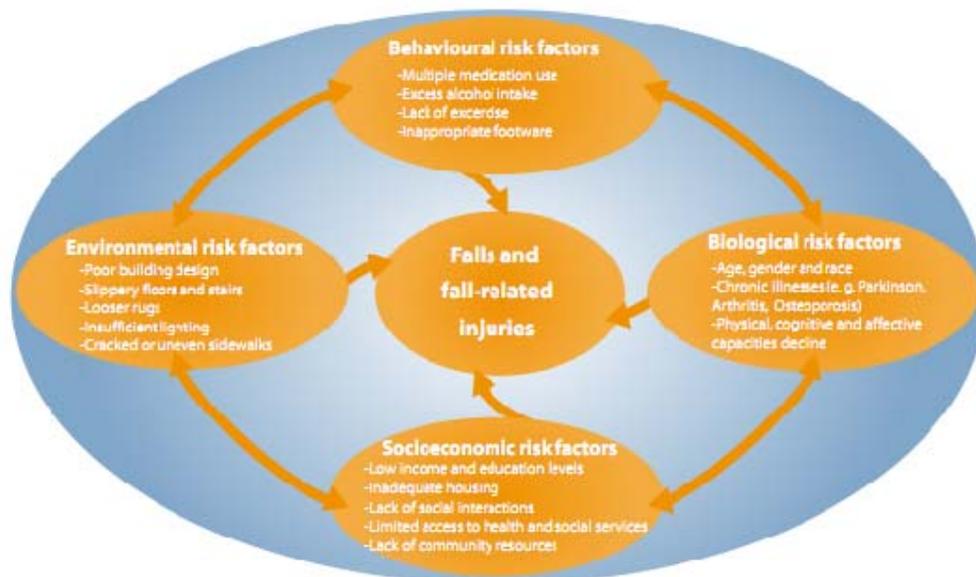
#### **3.2. Fall incidence**

Falls are a main health problem and occur commonly among older people. A recent study conducted in community settings found out that about 35% of people aged 65 and over fell at least once a year (Rubenstein, 2006). The incidence of falls seems to vary across populations in different countries. For example, in China nearly one out of three older people aged 65 years and over experience a fall least once a year (Wannian et al. 2004) while one out of five Japanese older adults falls each year respectively (Yoshida et al. 2006). In Finland, a study by Luukinen et al. (1996) found that among 1159 people over 70 years and over, 30% had experience at least one fall in a year. The participants were living at home and in institutions. Their falls were followed by phone for 12 months prospectively. The authors also found that fall incidence increased with advancing age. Another recent study by Pajala et al (2006) concluded that almost half of 434 community-dwelling women aged 63-76 experienced at least one fall during a one

year period. A study of 311 community-dwelling people aged 70 years and over followed over a 36-week period found that 17% of the participants had at least one fall and 16% of the participants experienced more than one fall (Stalenhoeft et al. 2002).

### 3.3 Risk Factors for falling

The World Health Organisation Global Report on Falls Prevention reported that there are actually four main categories under which factors of falls fall (WHO Global Reports on Falls Prevention 2007). They are as follows: Behavioural risk factors, Biological risk factors, Environmental risk factors and Socio-economic risk factors (WHO Global Reports on Falls Prevention 2007) (Figure 1). It has also been suggested that, often more than one category is implicated when a fall happens and, taking that fact into account, a risk factor model for falls in older age has been presented below (WHO Global Reports on Falls Prevention 2007.)



(Figure 1: WHO Global Reports on Falls Prevention 2007 - Risk factor model for falls in older age)

Risk factors for falls are interrelated. While a specific risk factor of falls, for e.g. Biological risk factor such as Parkinsonism can cause a fall, sometimes a combination of factors can lead to a fall (WHO Global Reports on Falls Prevention 2007) (Figure 1).

### **3.4 Postural balance and falls**

Body systems such as muscle and joints and the nervous system work in collaboration with the neuromuscular system to keep balance (Pollock et al. 2000). Most cross-sectional studies have clearly shown that, as opposed to younger adults, older adults' body swaying increases while standing. (Era & Heikkinen 1985; Prieto, et al. 1996). Other cross-sectional studies have found that throughout ageing there is a decrease in sway, gait patterns tend to have a wider base and double leg support phase of walking time pace increases while there is a decrease in stride length and trunk rotation (Patla 1994). Furthermore, movement become limited if there is an increase in pain and physical discomfort (Patla 1994). Furthermore, fallers who have had a sedentary life style tend to incur more injuries. For e.g. atrophy of a muscle around an unstable joint (Skelton et al 1994). Moreover, Sihvonen et al (2004) investigated the effects of balance training on postural balance and falls among frail older women aged 50-68 years living in institutions. The author concluded that among frail older women balance training programmes showed improvement in postural balance. Thus, balance training programmes can be an important intervention in fall prevention and improvement of postural balance among older women who have health limitations.

### **3.5 Assessment of falls**

Some earlier published studies on falls have been retrospective in design. In this type of studies participants were asked whether and how many times they fell in a past period – usually 12 months. This design's main limitation is that participants might not remember all their falls in the past 12 months thus giving inaccurate data to the researcher (Cummings et al. 1988). However, recent studies have made use of a prospective design approach. In this type of approach, participants are followed up prospectively over a period- usually 12 months to be able to record the incidence of falls more accurately. In prospective studies the use of fall calendars are used. They are normally sent to the participants monthly or even weekly and monthly telephone interviews are conducted to further ascertain a reported fall. The advantage of calendars is that participant is able to record their falls on a daily basis (Tinetti et al.1988; Nevitt et al. 1989 and O'Loughlin et al. 1993). More recently, Pajala et al. (2006) also argued

that in order to obtain accurate information on the factors affecting falls, a prospective study is more appropriate. Another prospective study used one year “fall calendar” among 1285 community-dwelling older people aged 65 years and identified the physical, cognitive, emotional and social functioning as potential predictors of fall (Tromp et al 2001).

However, specific details to make sure how the fall happened cannot be made until the monthly or weekly fall calendar has reached the researcher. Also, there is still a risk that many falls are not reported. It might be that circumstances that cause the fall might be inaccurate or incomplete. After a fall, old people might be distressed and forget the exact circumstances that led to the fall. Older people with cognitive impairments are even more prone to under-report falls (Stephen et al. 2001). At the same time, the first fall might negatively affect consequent falls among particular older people. Therefore, the researcher should be able to identify beforehand the target group characteristics and location they are present in, so as to be able to apply a suitable and optimal method to carry out the research or prevention programmes. (Perell et al. 2001).

### **3.6 Indoor and outdoor falls**

Among older community-dwelling people, about half of falls happened outside and near-home surroundings (Bergland et al 2003 and Mänty et al 2009). Most indoor fallers experienced falls on a flat surface which they use commonly such as bedroom and kitchen. Among community dwelling older women, the number of falls occurring outside the house decreased with age (Lord et al. 1994). Moreover, frailer people tend to have more indoor falls. These findings therefore show that the occurrence of falls is related to places where older people are normally doing daily activities (Lord et al. 1994). Intrinsic risk factors like history of falls (Skelton et al. 2004; Pennix et al. 2005) have a clearer association with indoor fragile falls (Bath & Morgan 1999; Bergland et al. 2003). Outdoor falls are more likely related to external risk factors such as terrain (Lord et al. 1994).

Nonetheless, most studies on risk factors or interventions published tend to combine all falls in spite of the location. If indoor and outdoor falls are not separated, it can be

difficult to assess the magnitude of associations between various risk factors and falls. Even more, associations may be completely neglected when indoor and outdoor falls are combined. Therefore, it is important to describe falls scenes and conduct post-fall interviews (Hill et al. 1999; Bergland et al. 2003). Recently, Jennifer et al (2010) argued that the risk factors for indoor and outdoor falls are different. Thus, identifying the location of falls would better be able to target specific recommendation, prevention and intervention programmes for indoor frailer fallers and outdoor active fallers respectively.

### **3.7 Obesity as a fall risk factor**

A study conducted in the USA found out that obese older adults had a higher incidence of fall risks than non-obese ones (27% vs. 15%) (Fjeldstad et al 2008). This study included both males and females around the age of 50. The study had a well defined assessment guide to obtain previous falls records from the participants as well as an acceptable definition of a fall. The study identified that obese people were significantly older than non-obese ones ( $p = 0.015$ ) and that among the obese group, history of falls were related to shorter times to maintain balance which resulted to a higher incidence of falls (Fjeldstad et al. 2008.) Another experimental study suggested that obese persons, particularly those with an abnormal distribution of body fat in the abdominal area, may be at higher risk of falling than lightweight individuals (Corbeil, 2001). This is so because obese individuals have more postural stresses and perturbations of body balance as compared to lightweight individuals.

Overweight has a close relationship with other chronic diseases even though it stands as an independent risk factor for fall. There exist other mechanisms through which obesity affect falls among older people. An increase in BMI has a negative association to the levels of physical activity and is also linked to an increase in physical impairment. This may lead to poor postural balance and an increase in incidence of falls (Freidmann et al. 2001). Recently, Christine et al (2012) conducted a study to examine the effect of obesity on falls among older people and whether older people who experienced falls are more prone to disability in activities of daily living. The study reported that there exist a linear relationship between weight and the risk of falling among older people: that is;

the more obese an individual was, the greater was the risk of falling. Even though, obese older people were more prone to falls, chronic diseases and health problems to some extent explained the relationship between obesity and tendency to fall (Christine et al 2012).

#### **4. AIMS OF THE STUDY**

The main purpose of the study was to investigate whether obesity increases the incidence of falls among older women.

The specific aims of the study were to examine:

- The effect of obesity on the propensity of falls among older women
- The association between indoor and outdoor falls and obesity among older women

## **5. PARTICIPANTS AND METHODS**

### **5.1 Participants**

The analyses in this study were based on a prospective observational population-based study. The data were obtained from the Finnish Twin Study on Ageing (FITSA) conducted in Finland between September 2000 and March 2004. A total of 828 women were contacted of which 434 took part. Three persons were not able to participate in fall surveillance because of poor health and three persons refused participation. A total of 428 women took part in fall surveillance for one year after baseline measurements. The criteria for participation were that both co-twins agreed to participate, could walk 2 km and were able to travel on their own to the research center in Jyväskylä. Although the participants consisted of twins, in this study the sample was treated as a set of individuals.

### **5.2 Ethics**

All participants gave a written consent form and the ethics committee of Central Finland approved the FITSA study.

### **5.3 Measurements**

#### **5.3.1. Body Mass Index**

The participants came for one day at the research centre where a physical examination, interviews and clinical tests were done. Body weight and body height were measured using a beam-balance and a medical stadiometre. Participants were without shoes and wore light indoor clothes. Subject's weight was recorded to the nearest 0.1 kg and height to the nearest 0.5 cm. BMI was calculated by dividing weight in kilograms by the square of the height in meters ( $\text{kg/m}^2$ ). Obesity was defined as a  $\text{BMI} \geq 30$  (WHO 2011).

### **5.3.2. Prospective Fall surveillance**

A fall was described as a person accidentally coming on the ground from a higher level to a lower level without any of these two contributing factors interference: acute illness and unexpected external pressure (Kellogg 1987). The follow-up data on falls were gathered during one year from 428 participants.

The participants marked their fall using a calendar. Whenever they fell they put a cross on the date they fell on the calendar. At the end of each month they mailed the calendar back to the research centre. If participants forgot to mail in their monthly calendar, they were reminded to do so. When a participant had a fall, more details were obtained concerning the fall. The researcher would phone and ask about more details, for e.g. how the fall happened, causes, nature and consequences of the fall. 89% of falls had a complete description of the scene (Pajala et al. 2006).

### **5.3.3. Self reported health, physical activity and Balance tests.**

Education (years) and self-reported health (ranging from: very poor, poor, average, good and very good) were recorded using a structured questionnaire. Due to a small number of answers in the extreme categories, the answers were categorized (recomputed) again for analysis as poor, average and good. Balance characteristics such as difficulty when walking on flat surface, difficulty when getting dressed while standing, difficulty standing while eyes closed, difficulty descending stairs, dizziness when standing (ranging from: Never, sometimes, often and always) were recorded using a structured questionnaire. Due to a small number of answers in the extreme categories, the answers were categorized (recomputed) again for analysis as never and sometimes/often.

Self reported physical activity was measure using the seven-point scale by Grimby (Grimby scale 2000). The scale is shown below:

0 = "mainly sitting in one place"

- 1 = "light physical activity 1-2 times/week"
- 2 = "light physical activity several times/week"
- 3 = "1-2 times/week sweating physical activity."
- 4 = "several times/week sweating physical activity."
- 5 = "active sports"
- 6 = "competitive sports"

Due to a small number of answers in the extreme categories, the answers were categorized (recomputed) again for analysis as Sedentary/light and moderate/heavy. Balance was measured using the Good Balance force platform (Metitur Ltd, www.Metitur.com). Semi-tandem (the first metatarsal joint of one foot besides the calcaneus of the other foot) standing for 20 s with eyes open, semi-tandem standing 20 s with eyes closed, tandem standing (feet positioned heel-to-toe along the midline of the platform) for 20 s with eyes open, and tandem standing for 20 s with eyes closed (Sihvonen et al. 2004). A 2-category variable based on lab test results on semi-tandem and tandem stance was also created: tried but unable and able.

## **5.4 Statistical Methods**

Statistical software was used for data analysis (SPSS version 19). Independent t-test and Chi-Square test were used during data analyses. The data are presented as mean  $\pm$  SD. Cross tabulations were used to describe the baseline characteristics of falls among obese and non-obese group. P value  $<0.05$  was considered to be statistically significant. The association between obesity and indoor and outdoor falls among older women was investigated with logistic regression analysis. The model was adjusted for age and the base model was adjusted one at a time for known and suspected fall risk factors.

## 6. RESULTS

Baseline characteristics are presented in table 1. The mean age of the participants was 68.6 years (standard deviation [SD] 3.4). The mean of education years among the non-obese group was 8.9 years (standard deviation [SD] 3.3) and 8.0 years (standard deviation [SD] 2.2) among the obese group.

Table 1. Subject Characteristics in non-obese and obese women aged between 63 -76 years.

<b>Characteristic</b>	<b>Non-obese (n=305)</b>	<b>Obese (n=129)</b>	<b>P Value</b>
Age in years, mean $\pm$ SD	68.7 $\pm$ 3.5	68.4 $\pm$ 3.3	0.208
Weight in kg, mean $\pm$ SD	64.7 $\pm$ 7.9	83.0 $\pm$ 10.0	0.040
Height in cm, mean $\pm$ SD	159.1 $\pm$ 6.4	157.4 $\pm$ 5.3	0.035
BMI, kg/m <sup>2</sup> mean, $\pm$ SD	25.6 $\pm$ 2.7	33.7 $\pm$ 3.6	0.001
Education in years, mean $\pm$ SD	8.9 $\pm$ 3.3	8.0 $\pm$ 2.2	< 0.001

Obese  $\geq$  30 kg/m<sup>2</sup>

Non-obese < 30kg/m<sup>2</sup>

Table 2 presents the characteristics and the types of falls among the non-obese and obese group.

Table 2. Incidence and scenes of falls followed over a year period for non-obese and obese women aged between 63 -76 years.

<b>Characteristic</b>	<b>Non-obese</b>	<b>Obese</b>	<b><math>\chi^2</math> Test</b>
	(n=305) f (%)	(n=129) f (%)	<b>P -value</b>
≥ 1 Indoor falls	27 (9)	30 (24)	< 0.001
≥ 1 outdoor falls	111 (38)	49 (40)	0.906
≥ 1 injurious falls	78 (26)	44 (34)	0.092
Recurrent falls	61 (20)	32 (25)	0.311

Obese  $\geq 30$  kg/m<sup>2</sup>

Non-obese < 30kg/m<sup>2</sup>

Altogether 199 participants reported 434 falls. Fifty-seven participants experienced 81 indoor falls. Nearly one third of the participants were obese (30%); half of them had reported at least one fall (50%) and 25% had reported more than one fall. In addition obese group had more indoor falls than the non-obese group (24% vs. 9%).

Moreover, obese people had more difficulty in descending stairs as compared to non-obese people (23% vs. 15%) (Table 3).

Table 3. Balance characteristics, Tandem and semi-tandem tests in non-obese and obese women aged between 63 -76 years.

<b>Characteristic</b>	<b>Non-obese</b> (n=305) f (%)	<b>Obese</b> (n=129) f (%)	<b><math>\chi^2</math> Test</b> <b>P -value</b>
Difficulty when walking on flat surface			
Never	273(90)	114(88)	
Sometimes/often	32(10)	15(12)	0.728
Difficulty when getting dressed while standing			
Never	224(73)	86(67)	
Sometimes/often	81(27)	43(33)	0.153
Difficulty standing while eyes closed			
Never	260(85)	110(85)	
Sometimes/often	45(15)	19(15)	0.995
Difficulty descending stairs			
Never	259(85)	99(77)	
Sometimes/often	46(15)	30(23)	0.041
Dizziness when standing			
Never	191(63)	82(64)	
Sometimes/often	114(37)	47(36)	0.853
Unable to do tandem test	61 (20)	29 (23)	0.560
Unable to do Semi-tandem test	7 (2)	2 (2)	0.619

Obese  $\geq$  30 kg/m<sup>2</sup>

Non-obese < 30kg/m<sup>2</sup>

Table 4. Self rated health; self reported physical activity in non-obese and obese women aged between 63 -76 years.

<b>Characteristic</b>	<b>Non-obese</b> (n=305) f (%)	<b>Obese</b> (n=129) f (%)	<b><math>\chi^2</math> Test</b> <b>P -value</b>
Self rated health			
Poor	13 (4)	9 (7)	
Average	194 (64)	97 (75)	
Good	98 (32)	23 (18)	0.008
Self reported physical activity level			
Sedentary/ light	238 (78)	105 (81)	
Moderate/heavy	67 (22)	24 (19)	0.432

Obese  $\geq$  30 kg/m<sup>2</sup>  
Non-obese < 30kg/m<sup>2</sup>

Compared to the obese group, the non-obese group reported their health as good (18% vs. 32%) (Table 4).

Indoor falls correlated with obesity. Women with indoor falls were over three times more likely to be obese as compared to women who did not fall indoors. Outdoor falls did not correlate with obesity. The base model was adjusted one at a time for known and suspected fall risk factors. The increased risk of indoor falls among people who were obese was not explained by their higher prevalence of balance problems for example difficulty descending stairs or poorer self reported health.

Table 5. Association between indoor and outdoor falls and obesity among 63– 76 year old women

**Adjusted for age**

	<b>Indoor fallers OR (95% CI)</b>	<b>Outdoor fallers OR (95% CI)</b>
Base model <sup>a</sup>	3.12 (1.76 - 5.55)	1.02 (0.92 - 1.04)
Base model adjusted for <sup>b</sup>		
Education (years)	3.10 (1.69 - 5.70)	1.03 (0.65 - 1.63)
Difficulty when walking on flat surface	3.18 (1.79 - 5.65)	1.03 (0.67 - 1.59)
Difficulty when getting dressed while standing	3.00 (1.68 - 5.34)	0.99 (0.64 - 1.53)
Difficulty standing while eyes closed	3.14 (1.77 - 5.59)	1.03 (0.67 - 1.58)
Difficulty descending stairs	2.93 (1.64 - 5.24)	1.01 (0.65 - 1.55)
Dizziness when standing	3.14 (1.77 - 5.58)	1.02 (0.66 - 1.57)
Self rated health	2.90 (1.62 - 5.19)	1.05 (0.68 - 1.63)

Logistic regression model for obesity among those with indoor or outdoor falls as compared to women with no falls.

<sup>a</sup> adjusted for age

<sup>b</sup> The base model was adjusted one at a time for known and suspected fall risk factors

## 7. DISCUSSION

The primary findings were that obesity increased the risk of falls among older women. Additionally, obese individuals had poorer self-reported health. These findings showing that obese people have a greater risk of falling are in line with other studies (Corbeil et al. 2001; Bruce et al. 2002; Mänty et al. 2009). In this study among the obese group, half of them reported at least one fall and one-quarter of them reported recurrent falls. Another study conducted by Christine et al (2012) examining the effect of obesity on falls among older people and whether older people who experienced falls are more prone to disability in activities of daily living reported that there exist a linear relationship between weight and the risk of falling among older people: that is; the more obese an individual was, the greater was the risk of falling.

In this study, the obese group reported more difficulty in descending stairs as compared to non-obese people. This finding supports a previous study that showed that obese people have worse postural balance compared to non-obese people (Maffioletti et al. 2005). Furthermore, Bruce et al. 2002 argued that among obese individuals there is an inverse relationship between Body Mass Index (BMI) and levels of activity; an increase in Body Mass Index among obese people would increase the risk of future functional impairment (Freidmann et al. 2001) which could possibly lead to postural imbalance and thus lead to a greater risk of falling. As such, obese people may have fear of falling and would further restrict their level of activity and would prefer to stay more indoors than outdoors, thus reporting higher indoor falls than outdoor falls. Another experimental study suggested that obese persons, particularly those with an abnormal distribution of body fat in the abdominal area, may be at higher risk of falling than lightweight individuals (Corbeil, 2001).

The most likely explanation of this study reporting that obese women fell more indoors would be that indoor fallers may have been more vulnerable to the negative effects of falls and they may have had common risk factors for both falls and functional limitation. Outdoor fallers may possibly have a higher level of activity, lower level of

postural instability compared to indoor fallers. It is possible that indoor obese fallers would be frailer than outdoor fallers thus reporting more injurious falls than the latter.

Secondary findings showed that women with indoor falls were three times more likely to be obese as compared to women who did not fall indoors, which is in line with another study. Mänty et al. 2009 who examined outdoor and indoor falls as predictors of mobility limitation among older women reported that compared to outdoor fallers and non-fallers, a higher percentage of indoor fallers were obese (24% vs. 26% vs. 51%, respectively) as well as compared to outdoor fallers and non-fallers, indoor fallers had ~20% poorer standing balance. However, this study also reports that the increased risk of indoor falls among people who are obese was not explained by their higher prevalence of balance problems and poorer self-rated health.

The strengths of this study are the relative large data set of older high-functioning community dwelling women. The detailed follow-up of falls in the FITSA study was a good possibility to study obesity as a predictor of falls. The participation in the study was high. Of the baseline, over 95% finished the 12-month fall surveillance. The criteria for recruitment was that the participants had to be female, able to walk 2 km and travel on their own to the research centre in Jyväskylä. Therefore, the results can be generalised to older high-functioning community dwelling women.

One limitation of this study could be the methods used to analyse the data. In this study, binomial regression model was used to find the association between indoor and outdoor falls and obesity. A more suitable method would be negative binomial regression model. This method takes into account that falls are non-independent observations. Moreover negative binomial regression assumes that falls tend to be recurrent events and one fall can make future falls more likely. Another limitation of this study was that the data did not allow the study of frailer population and samples including men. Further studies need to be done to assess whether weight loss intervention programmes would reduce the risk of falling among older obese adults.

## **8. CONCLUSION**

This study supports the observation that obesity increases the risk of falling among community dwelling older women. Women with indoor falls were over three times more likely to be obese as compared to women who did not fall indoors. The results of this study enhance the etiology and relative importance of risk factors for falls, obesity, indoor and outdoor falls.

In addition, obese women have poorer self-reported health as compared to non-obese women. Obese women had more difficulty in descending stairs as compared to non-obese women. Further studies need to be conducted to see whether weight loss interventions can reduce the risk of falling among older women and whether a frailer population including men would produce the same results.

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