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Original Article

Change in BMI affects the risk of falling in postmenopausal osteopenic and osteoporotic women

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Abstract

Objectives: To investigate the impact of the body mass index (BMI) change on risk of falling in postmenopausal women with osteopenia or osteoporosis. Also, we aimed to evaluate and associate the individuals' functionality, mobility and balance with the risk of falling. **Methods**: This one-year prospective observational study assessed 498 postmenopausal Greek women over the 50th year of age suffering from either osteoporosis or osteopenia. Parameters such as the height, weight and BMI were documented. Furthermore, the subjects were asked whether they experienced a fall the preceding year. Balance was evaluated using the Berg Balance Scale, the Timed-Up-And-Go test, and the 30 Seconds Sit-to-Stand test. Hand-grip strength was assessed with the Jamar Hydraulic Hand Dynamometer. **Results**: The observed one-year BMI change was associated with falls in postmenopausal osteopenic and osteoporotic women over the age of 70. Additionally, there were statistically significant changes in the BBS, TUG, 30CST and the hand-grip strength on both hands at the one-year follow-up but there were not associated with an increased fall risk. **Conclusion**: The one-year change in BMI was associated with the risk of falling in postmenopausal osteopenic and osteoporotic women over the 70th year of age. Whereas, the one-year change in balance, mobility and grip strength were not linked to an increased risk of falling.

Keywords: Body Mass Index, Falls, Osteopenia, Osteoporosis, Postmenopausal women

Introduction

The reported upsurge of life expectancy for the most part of the world has concerned health professionals. This observation implies shifting from a younger to an older population, with the extent of two billion adults being over 60 years old[1]. As reported by Andreyeva et al. (2007), a respected number of European women and men above the 50th year of age were identified as either overweight or obese[2]. According to figures mirroring an over a decade time span, the global population is becoming older and more overweight[3]. All of the above disclose a series of adverse effects for the individual at a socio-economic level. Excessive body weight could be the stepping stone for the manifestation and the aggravation of chronic health conditions such as diabetes mellitus, cardiovascular diseases, hypertension, or arthritis[4,5]. Moreover, it can cause a problem in daily activities such as walking up the stairs and getting up from a chair[5]. Subsequently, excessive body weight could be correlated with fall incidences in older adults[6].

Most of the time, falls lead to a series of adverse outcomes such as physical injuries, hospitalization, admission to long-term care, development of fear of falling, limitation of several activities, social isolation, a decrease of self-efficacy, and low quality of life[7]. Falls have been incriminated for an upsurge in morbidity, being responsible for over 17 million disability-adjusted life years lost[3]. As reported by World Health Organization, one in three adults exceeding the age of 65 could be considered a high-risk faller[3]. Amidst the numerous risk factors, the body mass index (BMI) and its

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manifestations have received large-scale attention, mainly due to the relevant adverse health problems.

It is of great interest whether BMI affects the fall risk in postmenopausal older adults suffering from decreased BMD. Middle and older adults with increased BMI are considered high-risk fallers[8,9]. Data collected from epidemiological studies showed that obesity leads to an increased fall risk[10-12]. Obese individuals were 30% more prominent to falls, whereas normal-weight individuals had a possibility of 23% experiencing a fall incident[10]. Interestingly, in a recent study carried out by S. Neri et al. (2017), the numbers mentioned above were even higher – 30% for normal-weight individuals in the preceding year and 45% for obese individuals in the same period[13]. That higher proportion could be explained by the fact that the sample was composed solely of female subjects, a factor that is strongly correlated to higher fall risk and more frequent falls. One crucial musculature-related fact is that the excessive weight, usually in younger individuals, leads to an increase in muscle mass and strength. This is observed as part of musculoskeletal adaptations due to increased overload[14]. But due to the ageing process, that adaptive mechanism faces a compromise, and there is a decrease in muscle strength that leads to an increased risk of physical disability[15]. Also, the muscle fat infiltration could mediate the associated manifestation. Because of the generally decreased physical activity levels, following the poor results in the related examinations, there was an increased fear of falling (FOF) in obese individuals[13,16]. FOF could be developed after a fall and could lead to further avoidance of physical activities to prevent more similar incidences[17,18]. This fatalistic way of perceiving things could be further mediated via reduced physical activity, which could enhance the fall risk among obese individuals. Interestingly enough, some studies reported that obese older adults have less fall risk because they move less – thus, the fall risk is decreasing. Hence overweight and obese older adults seem to adopt a more tentative gait pattern, slower pace when walking, and increased base support due to their difficulties[19]. On the other hand, low BMI values could set a fertile ground for the manifestation of other comorbidities, such as osteoporosis, leading to an increased fall risk. The underweight status is heavily affiliated with fall-risk factors such as disproportional composition of body, deterioration of mobility, and distressed stability.

BMI bears an influence on numerous necessary physical functions throughout one's daily living, e.g. a slower gait speed, a shorter stride length, diminished muscle strength of the lower extremities, weakened endurance etc. Hergenroeder et al. examined the influence of BMI on the individual's functionality. Their study assessed the self-reported and performance-based functionality in obese older women and highlighted that the significant deteriorations were independent of the severity of obesity[20].

Material and methods

In this prospective observational study, we aimed to evaluate the impact of annual BMI change on the fall risk in 498 postmenopausal Greek women. Participants were recruited from an outpatient osteoporosis clinic. Inclusion criteria included postmenopausal women between 50 and 90 years of age with recent BMD values consistent with osteopenia or osteoporosis (BMD T-score <-1 SD at any skeletal site). Women suffered a recent fracture in the lower extremities (≥6 months), renal or hepatic failure, neoplasms (when the individual's general health was directly affected), dementia in a progressed stage and use of medication favoring the fall risk were excluded from the study.

The study was carried out in agreement with the World Medical Association Declaration of Helsinki-Ethical Principles for Medical Research Involving Human Subjects and the ethical approval for the study was granted by the Scientific Committee of Konstantopouleio Hospital in Greece.

Age, height, weight, BMI and self-reported falls were recorded for each of the participants. Additionally, their balance, mobility, functionality and handgrip strength on both hands were evaluated via the Berg Balance Scale (BBS), the Timed-Up-and-Go (TUG) test, the 30 Seconds Sit-to-Stand (30CST) and the Jamar Hydraulic Hand Dynamometer, respectively. The aforementioned evaluation procedures took place at the baseline visit as well as at the 1-year follow-up visit. The only exception of the above procedure was that falls documentation was performed solely at the follow-up visit.

By evaluating the participants' BMI at the baseline visit as well as in the 1-year follow-up visit, we were able to document the difference between the results and have the exact annual BMI change. Likewise, we documented the annual change for the BBS, the 30CST, the TUG scores and the Jamar Hydraulic Hand Dynamometer scores.

One thing that needs to be clarified is the procedure of getting information regarding the fall. In order to avoid any misconception, before asking the individuals if they experienced any fall, we explained in detail what we consider as a fall in our study. In this study, any unintentional change from the standing position resulting in coming to rest at a lower level was defined as a fall.

The subjects were stratified according to their age into three age groups (50-69, 70-79, and 80+). Regarding their BMD T-score values during the baseline visit, the subjects were defined as osteopenic or osteoporotic. According to their BMI values at the follow-up visit, the subjects were categorized as underweight (BMI<18.5), normal weight (BMI: 18.5-24.9), pre-obesity state (BMI: 25-29.9) and obesity (BMI >30). All measurements were conducted by the same person so as to ensure that all measurements were made in the same manner.

	Baseline Mean Value (SD)	1-Year Follow-up Mean Value (SD)	Mean Difference (95% CI)	p-value
BMI	25.75 (3.86)	25.79 (3.86)	0.05(-0.05 / 0.15)	0.372
Timed Up and Go test (TUG) [sec]	8.24 (4.22)	8.77 (4.55)	0.53 (0.25/0.81)	**<0.001**
Grip strength right hand (kPA)	0.45 (0,13)	0.42 (0,11)	-0.03 (-0.04/-0.02)	**<0.001**
Grip strength left hand (kPA)	0.43 (0.13)	0.39 (0.11)	-0.04 (-0.05/-0.03)	**<0.001**
Berg Balance Scale (BBS)	55.47 (1.17)	55.58 (1.05)	0.11 (0.04/0.18)	**0.003**
30 Second Sit to Stand test (30CST)	12.52 (3.29)	13.09 (3.88)	0.57 (0.33/0.82)	**<0.001**

Table 1. Comparison of variables during the 1-year follow-up period (kPA: kilopascal).

Overall	Falls Mean Value (SD)		Mean Difference (95%CI)	p-value
	No	Yes		
Change in BMI	0.009 (1.153)	0.210 (1.089)	0.20 (-0.05/0.45)	0.118
Change in Timed Up and Go test (TUG) [sec]	0.583 (3.042)	0.333 (3.614)	-0.25 (-0.95/0.45)	0.482
Change in Grip strength right hand change (kPA)	-0.035 (0.120)	-0.025 (0.130)	0.01 (-0.02/0.04)	0.489
Change in Grip strength left hand (kPA)	-0.037 (0.129)	-0.041 (0.154)	0.00 (-0.03 / 0.03)	0.806
Change in Berg Balance Scale (BBS)	0.080 (0.735)	0.204 (1.015)	0.12 (-0.09/0.34)	0.257
30 Second Sit to Stand test change (30CST)	0.688 (2.568)	0.112 (3.549)	-0.58 (-1.33/0.18)	0.133

Table 2. Unifactorial analysis of the change in variables regarding falls (kPA: kilopascal).

Statistical Analysis

Data were expressed as means ± standard deviations for continuous variables and as numbers and percentages for categorical data. The normality of continuous variables was analyzed using a Kolmogorov-Smirnov test. The one-way analysis of variance model was held using the x^2 test, the Fisher exac test, t-test. All tests were two-sided, with a p value <0.05 denoting statistical significance. All analyses were carried out using the SPSS vr. 2100 statistical package (IBM Corporation, Somers, NY, USA).

Results

The subjects had a mean age of 68.99 years (9.46 SD), while the mean BMI value was 25.75±3.86 at the baseline and 25.79±3.86 at the 1-year follow-up visit (Table 1). The 50-69 age group comprised of 246 women, the 70-79 age group: 171, and the 80+ age group: 81.

An increase in the TUG scores was observed during the 1-year follow-up visit (8.24±4.22 vs 8.77±4.55) (N=295, 59.2%), as well as in the 30CST test (12.52±3.29 vs 13.09±3.88) (N=246, 49.4%) and BBS scores (55.47±1.17 vs 55.58±1.05) (N=65, 13%). Whereas the grip strength in both hands faced a decrease (0.45±0.13 vs 0.42±0.11; 0.43±0.13 vs 0.39±0.11). The total score of assessed variables presented a statistically significant change. Whereas BMI stood as the only exception (p=0.372) (Table 1).

At the 1-year follow-up evaluation, Participants were classified according to body mass index (BMI) as normal weight (N=232, 46.6%), overweight pre-obese (N=199, 39.9%), or obese (N=67, 13.5%).

We examine the association of the variables change with the documented fall incidents in the overall population as well as in each of the three age groups. Of the overall population, none of the variables' 1-year change was correlated to falls (Table 2). That observation was also met in the age group 50-69 (Table 3).

In the 70-79 age group, the observed BMI change in the 1 year had a statistically significant correlation to falls (p=0.041) (Table 4). That particular observation was met for the BMI change (p=0.045) also in the 80+ age group (Table 5). The other variables' change did not present any strong correlation to falls in the above-mentioned age groups.

The 67 obese participants had a 73.1% possibility not to experience any fall in the preceding year (vs 26.9% obese fallers). The pre-obese participants had a greater possibility (78.9%) not to fall (vs 21.1% pre-obese fallers). Last but not least, the same tendency was observed in the normal weight participants having a possibility of 83.6%

Age group 50-69	Falls Mean Value (SD)		Mean Difference (95%CI)	p-value
	No	Yes		
Change in BMI	0.218 (1.052)	0.153 (1.099)	-0.065 (-0.446/0.315)	0.735
Change in Timed Up and Go test (TUG) [sec]	0.172 (3.312)	0.426 (2.736)	0.254 (-0.910/1.418)	0.668
Change in Grip strength right hand (kPA)	-0.030 (0.119)	-0.017 (0.184)	0.013 (-0.034/0.060)	0.577
Change in Grip strength left hand (kPA)	-0.029 (0.131)	-0.045 (0.218)	-0.016 (-0.093/0.061)	0.674
Change in Berg Balance Scale change (BBS)	-0.005 (0.383)	0.229 (1.003)	0.233 (-0.115/0.581)	0.182
Change in 30 Second Sit to Stand test (30CST)	0.821 (2.814)	0.286 (4.055)	-0.535 (-1.619/0.549)	0.332

Table 3. Unifactorial analysis of the change in variables regarding falls in the age group 50-69 (kPA: kilopascal).

Age group 70-79	Falls Mean Value (SD)		Mean Difference (95%CI)	p-value
	No	Yes		
Change in BMI	-0.126 (1.251)	0.316 (0.796)	0.441 (0.018/0.865)	**0.041**
Change in Timed Up and Go test (TUG) [sec]	0.635 (1.724)	0.261 (2.152)	-0.374 (-1.038/0.290)	0.267
Change in Grip strength right hand (kPA)	-0.041 (0.125)	-0.043 (0.099)	-0.002 (-0.045/0.041)	0.924
Change in Grip strength left hand (kPA)	-0.046 (0.132)	-0.043 (0.118)	0.003 (-0.045/0.050)	0.908
Change in Berg Balance Scale change (BBS)	0.152 (0.715)	0.158 (0.886)	0.006 (-0.268/0.281)	0.963
Change in 30 Second Sit to Stand test (30CST)	0.689 (1.887)	0.158 (3.141)	-0.532 (-1.610/0.547)	0.326

Table 4. Unifactorial analysis of the change in variables regarding falls in the age group 70-79 (kPA: kilopascal).

Age group 80+	Falls Mean Value (SD)		Mean Difference (95%CI)	p-value
	No	Yes		
BMI change	-0.469 (1.109)	0.128 (1.441)	0.597 (0.013/1.181)	**0.045**
Timed Up and Go test (TUG) change [sec]	2.020 (3.899)	0.312 (5.918)	-1.708 (-3.913/0.498)	0.127
Grip strength right hand change (kPA)	-0.035 (0.113)	-0.008 (0.068)	0.026 (-0.022/0.075)	0.281
Grip strength left hand change (kPA)	-0.046 (0.111)	-0.031 (0.083)	0.015 (-0.034/0.064)	0.549
Berg Balance Scale change (BBS)	0.232 (1.440)	0.240 (1.234)	0.008 (-0.653/0.669)	0.981
30 Second Sit to Stand test change (30CST)	0.179 (2.943)	-0.200 (3.500)	-0.379 (-1.874/1.116)	0.616

Table 5. Unifactorial analysis of the change in variables regarding falls in the age group 80+ (kPA: kilopascal).

not to fall (vs 16.4% normal fallers). In total, 400 of study's particpants did not experience a fall, while 98 fell during the one-year time period (Table 6). To conclude, the three BMI categories did not show a strong correlation with falls.

Discussion

We evaluated the impact of annual BMI change in postmenopausal women with falls. Furthermore, we assessed the correlation between the different categories of BMI (normal weight, pre-obese and obese) and the risk of falling. In agreement with our findings, the detected BMI change was associated with an increased fall risk for participants over the age of 70. In contrast, the observation above was not met in the age group 50-69 and the overall population. To the best of our knowledge, this is the first published study that evaluated the effect of the annual BMI change and its impact on the fall risk in

			Falls during last year		Total
			No	Yes	
BMI at the follow-up visit	Normal	N	194	38	232
		% within BMI category	**83,6%**	16,4%	100,0%
	Pre-obesity	N	157	42	199
		% within BMI category	**78,9%**	21,1%	100,0%
	Obesity	N	49	18	67
		% within BMI category	**73,1%**	26,9%	100,0%
Total		N	400	98	498
		% within BMI categories	**80,3%**	19,7%	100,0%

Table 6. Correlation of BMI categories and falls at the 1-year follow-up.

postmenopausal women with low BMD values.

Throughout our study, an overall increase of the BMI variable was observed. The majority of the participants at the follow-up were at normal weight (N=232, 46.6%), 199 participants were pre-obese (39.9%), while 67 were obese (13.5%). Our study does not prove a clear-cut connection in-between the BMI categories and fall risk in postmenopausal women.

The findings of related studies which were carried out during the latter decade were delineated by inconsistency. Cohort studies reported no association between increased BMI in older adults and falls[10-14].On the contrary, studies portray middle and older-aged adults as high-risk fallers, implying that increased BMI values lead to falls[15,16]. It stands as common knowledge that obesity impacts the postural sway and subsequently balance, therefore increasing functional limitation and halted balance, which could lead to repeated falls. Sharley et al. reported that in older adults suffering from severe obesity, both static and dynamic stability was outlined by a severe disability[17]. There is an inverse relationship between BMI and physical activity levels, meaning that obese individuals tend to have a sedentary lifestyle[17]. Excessive body fat might worsen physical functionalities such as walking, getting up from a chair or kneeling, etc. Overweight and obese older adults seem to adopt a more tentative gait pattern, slower pace, slower stride, and increased base support due to their difficulties[18].

There have been studies reporting that obese older adults have low fall risk due to the fact that they move less – thus, the fall risk is diminishing. On the other hand, low BMI values could set a fertile ground for the manifestation of other comorbidities, such as osteoporosis, which could lead to increased fall risk[17]. Nevertheless, the underweight status is heavily affiliated with fall-risk factors such as the disproportional composition of the body, deterioration of mobility, and distressed stability.

The functionality, mobility, and the overall balance for each individual were assessed via the BBS, the TUG test, the 30CST test, and the Jamar Hydraulic Hand Dynamometer. The relevant outcomes were of statistical significance in the follow-up, but did not correlate to an increased risk of falling in the same period. Specifically, we observed an increase in the TUG scores at the one-year follow-up visit, which is expressed as a negative outcome for the assessed individuals since a slower walking pace is correlated to an increased risk of falling. On the other hand, the increase observed regarding the BBS and the 30CST scores is expressed as an improvement of the functional balance and the ability to get up from a chair. The grip strength of both hands showed a decrease. As an exception, of being statistically not significant, stood the BMI variable (p-value=0.372), but likewise did not correlate to an increased fall risk.

In our study, one significant limitation was the relatively short follow-up period, which enabled only two assessments for each participant. A further potential limitation was that the falls data were self-reported. Self-reported falls especially by older adults were likely to involve under-reporting falls due to older persons not recognizing the severity of a fall or not remembering a fall.

Conclusion

In accordance with our results, the annual BMI change in postmenopausal osteopenic and osteoporotic women were associated with an increased fall risk only in women over the age of 70. Additionally, the one-year observed change in their functionality, mobility, and balance were not linked to an increased risk of falling. Further studies, including also males, are needed so as to confirm our findings.

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