Sitting time increases the overweight and obesity risk independently of walking time in elderly people from Spain

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Abstract

Introduction: obesity, defined as an excess of total body fat, is a matter of concern all over the world, and its prevalence is still increasing among elderly people. **Objectives:** to examine whether sedentary behaviour (hours sitting per day) is associated with higher risk of central obesity, overweight-obesity and overfat in a representative sample of non-institutionalized Spanish elderly population and if so, whether hours walking per day modified this association. **Study design:** a cross-sectional study in a sample of 3136 people ≥65 years of age. **Main outcomes measures:** anthropometric measurements were obtained using standardized techniques and equipment. Active and sedentary behaviors were recorded by questionnaire. **Results:** for both men and women, the higher prevalence of overweight-obesity, central obesity and overfat was found in those who spent sitting more than 4 hours per day and walk less than 1 hour, compared with those who spent sitting less than 4 hours per day and walk more than 1 hour (all $p<0.001$, except for central obesity in women). In men, more than 4 hours sitting per day was associated with 1.7-fold higher odds of having central obesity compared with those sitting less than 4 hours per day ($p<0.01$). In women, this sedentary behaviour increased the risk of overweight-obesity and overfat by 1.5 and 1.4, respectively ($p<0.01$). Age or time spent walking did not significantly change these results. **Conclusion:** sitting time increases the risk of overweight-obesity and overfat in women and the risk of central obesity in men, independently of walking time.

Key words: lifestyle, sedentary, physical activity, adiposity, seniors.

Abbreviations: body mass index (BMI), television (TV), body fat (BF), waist circumference (WC), confidence intervals (CI).

1 INTRODUCTION

Obesity, defined as an excess of total body fat, is a matter of concern all over the world, and its prevalence is still increasing both in old and young populations. Specifically, the prevalence of overweight and obesity among elderly people in Spain has raised from 81% in 2004 [1] to 84% in 2010 [2]. Moreover, the ageing process is known to be accompanied by an increase and redistribution of body fat [3]. Recent data showed that 67% of the Spanish elderly population has an increased fat mass, and moreover that 56% suffer from central obesity [2].

Taking into account that overweight, obesity and central obesity are associated with an increased risk of certain pathologies among older adults, including hypertension, cardiovascular disease, diabetes, dyslipidemia, arthritis, some cancers [4] and also with an earlier morbidity and functional limitation [5], this has become a major public health problem in all western countries.

Although the characteristic changes of body composition occur during the ageing process even in healthy individuals, there is evidence that lifestyle plays an important role on fat mass and its redistribution. In fact, the American College of Sports Medicine defends physical activity as relevant factor on body composition among elderly [6].

It is widely known that physical activity has a large impact on body composition in this specific population. In elderly men, leisure-time physical activity is inversely associated with body fat and body mass index (BMI) [7]. And also for a given BMI category, participants with lower levels of physical activity are characterized by an increased waist circumference compared with active individuals.

Despite the large attempt to study the relationship of physical activity patterns with obesity among elderly, much less is known about the link of sedentary behaviors and adiposity in this population. To our knowledge, there are only two studies that showed a

positive association between a sedentary behavior (television viewing) and markers of obesity in older adults [8,9]. In these researches, television (TV) viewing was associated with obesity [8] and time spent watching TV also contributed to the development of overweight [9]. This data has also been confirmed in younger populations like younger adults [10] and adolescents [11,12].

However, although television viewing is one of the most common sedentary behaviors in current societies, there are other sedentary behaviors that may be related with the risk of suffering obesity among elderly. Considering that most of the sedentary activities happen in a sitting position, measuring the time spent sitting may be more useful in order to identify the real relationship between sedentary behavior and body composition.

In this study, we examined whether an overall sedentary behaviour (hours sitting per day) is associated with high risk of central obesity, overweight-obesity and overfat in a representative sample of the non-institutionalized Spanish elderly population and if so, whether physical activity (hours walking per day) modified this association.

2 METHODS

The complete methodology of the elderly EXERNET multi-center study has been described elsewhere [2,13]. In brief, this study was performed on a representative sample of Spanish elderly aged 65-92 years. The population was selected by means of a multiple step, simple random sampling, taking into account first the location (six different regions from Spain: Aragón, Madrid, Castilla-La Mancha, Castilla León, Extremadura and Canarias), then 3 different cities of each region and, finally, by random assignment of the civic and sports centers. The total number of subjects was uniformly distributed in the regions and in their corresponding cities. The exclusion criteria were: people under 65 years; those who were living in nursing homes and/or were not independent or able to take care of themselves and those suffering from dementia and/or cancer. The information was collected through personal interviews using a structured questionnaire, followed by an examination to measure anthropometrics. After concluding the field study, the participants who did not fulfil the inclusion criteria were excluded. Finally, a total of 3136 subjects participated, and baseline data were collected between June 2008 and November 2009. Written informed consent was obtained from all the participants. The ethical guidelines for human research studies as stated in the Helsinki Declaration were followed throughout the study. The protocol was approved by the Clinical Research Ethics Committee of Aragón (18/2008).

2.1 Anthropometric and body composition measurements

Training workshops were organized to harmonize the assessment of anthropometrics before starting the study. These anthropometric measurements were validated by the investigators in a random sample of 100 persons. Height was measured using a portable stadiometer (SECA, Hamburg, Germany) with 2.10 m maximum capacity and a 0.001 m error margin. Subjects stood with their scapula, buttocks and heels resting against a wall; the neck was held in a natural non-stretched position, the heels were touching each other with the toe tips spread to form a 45° angle; and the head was held straight with the inferior orbital border in the same horizontal plane as the external auditory tube (Frankfort's plane) [14].

A portable bioelectrical impedance analyzer TANITA BC 418-MA (Tanita Corp., Tokyo, Japan) with a 200 kg maximum capacity and a +/- 100 g error margin was used to measure the weight and estimate the % body fat (%BF). Individuals removed shoes, socks, and heavy clothes prior to weighing.

BMI was calculated as weight (kg) divided by height^2 (m^2). The prevalence (%) of overweight and obesity was calculated according to the WHO guidelines, considering the thresholds of overweight as a BMI of 25 kg/m^2 and the thresholds of obesity as a BMI of 30 kg/m^2 [15]. Waist circumference (WC) was measured using a flexible non-elastic measuring tape. Individuals stood with feet together and arms resting by their sides. According to the International Society for the Advancement of Kinanthropometry (ISAK), the WC was taken as the narrowest point between the inferior rib border and the iliac crest [16]. The WC was used to identify individuals with central obesity above threshold values of ≥ 88 cm for women and ≥ 102 cm for men [17,18]. The prevalence of high %BF was estimated considering the cut-off points published by Gallagher et al

(2000) [19]. Values of ≥25% and ≥38%, men and women respectively, were considered as excessive fat mass, thereafter, overfat.

The anthropometric and body composition variables were measured in 97.8% (height, weight and WC) and 91.7% (fat mass) of the study participants.

2.2 Active and sedentary behavior variables

The structured validated questionnaire included information on different aspects of health, physical activity, medication and socio-demographic status [20]. The variables considered in the present study were sex, age, walking (active behavior) and sitting time (sedentary behavior) for which information was obtained in 100%, 100%, 86.8% and 83.7% of those interviewed, respectively.

Sitting time was recorded through the following question: "How many hours do you usually spend sitting per day?". The question covered any activity in which the person had to be sitting (ie. Watching television, reading, sewing, etc) and it referred to the present time. Similarly, walking time was recorded through the following question: "How many hours do you usually spend walking per day?". For both questions, each participant had to choose one of the following answers: <1 hour/ day, 1-2 hours/ day, 2-3 hours/ day, 3-4 hours/ day, 4-5 hours/ day or ≥5 hours/ day.

Hours sitting per day were used to classify subjects into: non-sedentary (<4hours/day) and sedentary (>4 hours/day). On the other hand, time spent walking was used to define an active behavior as follows: non-walking (<1 hour/day) and walking (>1 hours/day). Additionally, these variables were re-combined into four categories: non-sedentary - walking, non-sedentary - non- walking, sedentary - walking and sedentary - non-walking.

2.3 Statistical analysis

Differences between men and women were analysed by ANOVA and are presented as means and standard deviations (means ± SD). ROC curves were used to identify the cut-off points of sitting time which were related with an increased risk of suffering central obesity, overweight-obesity or overfat. Due to the fact that no sex-interaction between sitting time and adiposity variables was found, these analyses were carried out with men and women pooled together.

Percentage of (prevalence) men and women classified in each of the four lifestyle categories; as well as the percentage of men and women having a high prevalence of central obesity, overweight-obesity and overfat depending on the lifestyle group were calculated and studied by X^2.

Binary logistic regression was used to test the association among overweight-obesity, central obesity and overfat and the sedentary independent variable (hours per day sitting) by sex. Odds ratios with 95% confidence intervals (CI) are reported for the studying models. Model I included the independent sedentary related variable. Model II incorporated age as possible confounder and Model III was built in order to determinate whether the association between central obesity, overweight-obesity or overfat and sedentary behaviour was independent of an active behaviour (walking time). To test if medication or other physical activity participation could mediate on the associations mentioned above, all the analyses were repeated adding these variables into the model.

All analyses were carried out with the Statistical Package for the Social Sciences (SPSS, Inc. Chicago, USA) Windows software, version 15.0. Statistical significance was set at $p<0.05$.

3 RESULTS

Descriptive data for anthropometrics and body composition are displayed in Table 1. In men, height, weight, and WC were higher while BMI and % BF were lower when compared with women (all $p < 0.01$). No difference was found in age between sexes.

The cut-off points of sedentary behaviour which were related with an increase in the risk of suffering central obesity, overweight-obesity and overfat were 4 hours in all cases (Table 2).

Percentages of men and women having low and high time walking and sitting per day are displayed in Figure 1, showing that men are less sedentary and more active than women ($p<0.001$). Specifically, the percentages of men and women in each of the walking and sitting categories (<1 hour/ day, 1-2 hours/ day, 2-3 hours/ day, 3-4 hours/ day, 4-5 hours/ day or ≥5 hours/ day) were: 3.0 and 3.5; 9.5 and 13.0; 25.6 and 28.5; 25.5 and 24.8; 18.0 and 15.6; 18.5 and 14.6% (for hours sitting per day; men and women respectively in each category) and 24.7 and 35.4; 52.9 and 50.2; 16.6 and 11.6; 3.7 and 1.7; 1.3 and 0.7; 1.0 and 0.6% (for hours walking per day; men and women respectively in each category).

The percentage of men in the non-sedentary – walking group was significantly higher, while the percentage of men in the sedentary – non-walking group was significantly lower compared with women (48.6 vs. 47.2% and 10.2 vs. 13.0%, respectively; $p<0.001$; Figure 2). Even within the sedentary group there were more active men than active women (26.5 vs. 17.1% $p<0.001$; Figure 2). Moreover, prevalence of men and women in the non-sedentary – walking group was significantly greater compared with the rest of the groups ($p<0.001$; Figure 2).

Figure 3 shows the differences by X^2 of the prevalence on central obesity, overweight-obesity and overfat depending of the lifestyle group in men and women. Women placed

in the non-sedentary – walking group had lower prevalence of overweight-obesity, central obesity and overfat than those in the rest of the groups ($p<0.001$). In men, those sited in the non-sedentary – walking group had lower prevalence of overweight-obesity and overfat compared with the sedentary – walking and sedentary – non-walking groups but higher prevalence than those in the non-sedentary – non-walking group ($p<0.001$). For central obesity, men in the non-sedentary – walking group had lower prevalence than those in the rest of the groups ($p<0.001$), except for the sedentary – walking group ($p=0.084$). Moreover, for men and women, the higher prevalence of overweight-obesity, central obesity and overfat was found in those placed in the sedentary – non-walking group, except for central obesity in women, where the higher prevalence was found in the non-sedentary – non-walking group.

3.1 Association between sedentary lifestyle and risk of central obesity, overweight-obesity and overfat

Due to medication and other physical activity participation did not substantially change the results (data not shown); the present data are adjusted for the following confounders: age (Model II) and time spent walking per day (Model III).

In men, more than 4 hours sitting per day was associated with 1.7-fold higher odds (1.190 to 2.401) for having central obesity compared with those sitting less than 4 hours per day (Table 3). In women, this sedentary behaviour increased the risk of overweight-obesity and overfat by 1.5 (1.093 to 1.928) and 1.4 (1.173 to 1.780), respectively (Table 3). Age (Model II) and time spent walking (Model III) did not significantly change these results.

4 DISCUSSION

The main findings of the present study are: 1) that 4 hours of sitting per day was associated with a higher risk of developing overweight-obesity, central obesity and/or overfat among elderly people; 2) that sedentary – non-walking men and women had higher prevalence of overweight-obesity, central obesity and overfat than those non-sedentary – walking; 3) that more than 4 hours sitting per day was associated with higher risk of having central obesity in men and higher risk of overweight-obesity and overfat in women compared with those sitting less than 4 hours per day; and 4) that nor age or time spent walking change the associations between sitting time and overweight-obesity, central obesity and overfat.

A novelty aspect of our research is that we describe the cut-off points for self-reported sitting time that are related with an increase in the risk of developing adiposity-related diseases. Specifically, for central obesity, overweight-obesity and overfat, sitting more than 4 hours per day increases the risk of developing these body composition problems.

In addition, these results indicate that sedentary levels have a negative effect on body composition among elderly people and that 1 hour of walking per day is not enough to counteract such association. In regard to the relationship between lifestyle and adiposity, scientific literature has focused more on the study of physical activity than in the study of sedentary behaviours. Among seniors, a negative relationship between obesity and weekly walking has been shown. In fact, walking less than 30 minutes per day was associated with 2.7 greater probability of being obese and high-intensity exercise, such as brisk walking or gardening, was inversely correlated with body fat [7]. Moreover, previous findings of the elderly EXERNET multi-center study displayed an inverse relationship between active lifestyle (walking-hours per day) and BMI and WC in both elderly men and women [2]. In addition, within each BMI category, people with

higher levels of leisure-time and work-related physical activity are characterized by a lower WC, compared with inactive individuals [21]. Finally, the American College of Sports Medicine (ACSM) position stand summarizes that compared to their sedentary, age-matched peers, older athletes exhibit a more favorable body composition profile, including less total and abdominal body fat [6]. On the other hand, it has been shown that specific training programs are able to reduce fat mass and lead to a favourable redistribution of the latter in older adults and elderly people. In studies involving overweight-obese sedentary people, an aerobic exercise program without dietary modification has shown to be effective in reducing total body fat [22,23], body weight, and intra-abdominal and subcutaneous abdominal fat [24,25]. Regarding strength training, several studies have found that moderate- or high-intensity resistance exercises lead to decreases in total body fat mass [26,27].

As it has been exposed above, physical activity, as well as specific training programmes, is able to reduce or attenuate the changes that occur in body composition during the ageing process. However, the role of sedentary behavior and its relation with adiposity indicators has generally been less studied, especially among seniors. To our knowledge, there are only two studies that describe the association between a sedentary behavior (television viewing) with obesity markers [8,9] in adults and young-seniors. In the first one, Jakes et al. [8] showed in men and women aged between 45 and 74 years that self-reported television viewing was positively associated with markers of obesity. In fact, men and women who watched less than 2 h of television each day and participated in more than 1 h per week of vigorous activity had significantly lower BMI values than those who reported watching more than 4 h of television each day and no participation in vigorous activity. Ching et al. [9] examined the relationship between non-sedentary and sedentary activity levels and risk of overweight in a cohort of men

aged 40 to 75 years. In this research, increased time spent watching television was associated with increased prevalence and odds ratio for overweight. Men who watched 41 or more hours TV per week had 4 times higher risk of being overweight than men watching TV 1 hour or less per week and even men watching only 2 to 5 hours per week had increased odds of being overweight when compared with men watching the least amount. Moreover, adjustment for physical activity had little impact on the odds ratio for the overweight associated with increasing time spent watching TV. These results seem to be similar to those found in younger populations: adults, adolescents and children [10-12], and to those found in our study with elderly people. In fact, our findings showed that sitting time, the most widespread sedentary behavior, has a strong relation with obesity markers in both, elderly men and women. Specifically, sitting more than 4 hours per day seems to have a deleterious effect on body composition during the ageing process, and walking time appears to be insufficient to mediate between sedentary and obesity relationship. Furthermore, those people who spent sitting more than 4 hours per day and walk less than 1 hour have higher prevalence of overweight-obesity, overfat and central obesity than those who spent sitting less than 4 hours per day and walk more than 1 hour. A possible explanation for these results may be that sedentary behaviours lead to a reduction of the energy expenditure without reducing energy intake. Moreover, as it has been previously shown, sedentary behaviour may favor concurrent consumption of energy-dense snacks and beverages [28] which finally lead to increased energy reserves. Additionally, another explanation for these results may be that the intensity of the self-reported walking time is extremely low and therefore, it is not enough to counteract the adverse effect of a sedentary lifestyle.

Given the findings of the current study, and taking into account the important health implications of body composition on the ageing process, public health measures should

encourage the reduction of sedentary behaviors among the elderly and participation in supervised-physical activity sessions or training programmes with appropriate intensity and execution.

Some limitations should be acknowledged. The results could be partially biased by the fact that only independent non-institutionalized elderly were included in the present study. Results from institutionalized elderly population might not be identical. On the other hand, the absence of objective measures of active and sedentary behaviours (walking and sitting time) and the lack of information regarding the intensity of the walking activity could mask a possible interaction between an active behaviour and the relationship of sedentary behaviour with adiposity indexes. Finally, the lack of dietary habits is also a limitation in the present study. The latter should be taken into account in the future in order to see if the energy intake or other dietary patterns could modify the associations found in this study. The strong points of this research are the sample size, which allows the data to be extrapolated to other seniors, the description of the cut-off point for self-reported sitting time and the large variety of methods used to identify the body composition status of the elderly people.

5 CONCLUSION

In conclusion, sitting 4 or more hours per day increases the risk of overweight-obesity and overfat in women and the risk of central obesity in men. Moreover, although physical activity alone is related with a healthier body composition among elderly, in this specific population, one hour of walking is not enough to counteract the negative effect of a sedentary lifestyle on adiposity markers. Therefore, a reduction of sedentary behaviors among elderly should be encouraged in order to guarantee a healthier body composition during the ageing process.

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All authors have read and approved the manuscript, and have contributed significantly to the research of the present manuscript.

Specifically, the author´s contributions are:

AGC: I declare that I participated in the data collection, data analysis, data interpretation, drafting manuscript, revising manuscript content and that I have seen and approved the final version data collection.

RPC: I declare that I participated in the data collection, data analysis, revising manuscript content and that I have seen and approved the final version.

PRO: I declare that I participated in the data collection, data analysis, revising manuscript content and that I have seen and approved the final version.

RHP: I declare that I participated in the data collection, data analysis, revising manuscript content and that I have seen and approved the final version.

JARM: I declare that I participated in the data collection, data analysis, revising manuscript content and that I have seen and approved the final version.

EM: I declare that I participated in the data collection, data analysis, revising manuscript content and that I have seen and approved the final version.

SA: I declare that I participated in the study design, data interpretation, revising manuscript content and that I have seen and approved the final version.

JGV: I declare that I participated in the study design, data interpretation, revising manuscript content and that I have seen and approved the final version.

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MGG: I declare that I participated in the study design, data interpretation, revising manuscript content and that I have seen and approved the final version.

JAC: I declare that I participated in the study design, data interpretation, revising manuscript content and that I have seen and approved the final version.

IA: I declare that I participated in the study design, data interpretation, revising manuscript content and that I have seen and approved the final version.

GVR: I declare that I participated in the study design, data interpretation, drafting manuscript, revising manuscript content and that I have seen and approved the final version.

The authors declare no conflict of interest.

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Table 1. Age, Height, Weight, Body Mass Index (BMI), Waist Circumference and Fat Mass Stratified by Sex.

Table 2. Sitting Time Cutoff Points Related with an Increase of Central Obesity, Overweight-Obesity and Overfat Risk.

Table 3. Odds Ratio for Having Central Obesity, Overweight-Obesity and Overfat in Sedentary Men and Women.

Figure 1. Prevalence of men and women spend sitting >4 or <4 h per day and walking >1 or <1 h per day.

Figure 2. Prevalence of men and women classified in each of the four lifestyle categories by X^2.

[*] p<0.001between men and women within each group

[a] p<0.001between non-sedentary – walking elderly men compared with the rest of the groups

[b] p<0.001between non-sedentary – walking elderly women compared with the rest of the groups

Figure 3. Prevalence (%) of men and women having central obesity, overweight-obesity and overfat depending of the lifestyle group by X^2.

[a] p<0.001between non-sedentary – walking elderly men compared with the rest of the groups

[b] p<0.001between non-sedentary – walking elderly women compared with the rest of the groups

[c] p<0.001between non-sedentary – walking elderly men compared with the non-sedentary – non-walking and sedentary – non-walking groups