J Nutr Health Aging. 2019;23(5):401-407

IS SITTING TIME RELATED WITH PHYSICAL FITNESS IN SPANISH ELDERLY POPULATION? THE EXERNET MULTICENTER STUDY

L. SAGARRA-ROMERO[1,2], G. VICENTE-RODRÍGUEZ[3,4,5,6], R. PEDRERO-CHAMIZO[7], S. VILA-MALDONADO[2,8], N. GUSI[8,9], J.G. VILLA-VICENTE[10], L. ESPINO[11], M. GONZÁLEZ-GROSS[7], J.A. CASAJÚS[3,4,5,12], I. ARA[2,8], A. GÓMEZ-CABELLO[3,4,5,8,13]

1. Faculty of Health Sciences. University of San Jorge, Zaragoza, Spain; 2. GENUD Toledo Research Group, University of Castilla-La Mancha, Toledo, Spain; 3. GENUD Research Group, University of Zaragoza, Zaragoza, Spain; 4. Centro de Investigación Biomédica en Red de Fisiopatología de la Obesidad y Nutrición (CIBERObn), Spain; 5. Instituto Agroalimentario de Aragón (IA2); 6. Faculty of Health and Sport Sciences (FCSD), Department of Physiatry and Nursing, University of Zaragoza, Zaragoza, Spain; 7. ImFINE Research Group, Departament of Health and Human Performance, Universidad Politécnica de Madrid, Madrid, Spain; 8. CIBER de Fragilidad y Envejecimiento Saludable (CIBERFES), Spain; 9. Faculty of Sport Sciences, University of Extremadura, Cáceres, Spain; 10. Institute of Biomedicine (IBIOMED), University of León, León, Spain; 11. Unit of Sport Medicine, Cabildo of Gran Canaria, Gran Canaria, Spain; 12. Faculty of Health Sciences. Department of Physiatry and Nursing, University of Zaragoza, Zaragoza, Spain; 13. Centro Universitario de la Defensa, Zaragoza, Spain. Corresponding author: Dr. Alba Gómez-Cabello, Centro Universitario de la Defensa de Zaragoza, Carretera de Huesca s/n 50090. Zaragoza, Teléfono: 976739794, Email: agomez@unizar.es

Abstract: *Background:* Older adults spend most of their waking hours performing sedentary activities. The influence of these lifestyle patterns on the physical fitness (PF) levels of this population has not yet been sufficiently investigated. *Objective:* The aim of the study was to examine whether sedentary behavior (SB) (h•d^{-1}sitting) is associated with PF, and specifically to analyze whether sitting >4 h•d^{-1} is associated with higher risk of having lower levels of fitness in seniors. Design: EXERNET multi-center study. *Participants and Settings:* A representative sample of 3136 non-institutionalized elderly (aged 72.2±5.3 years), from 6 Regions of Spain were included in the study. *Measurements:* PF was assessed using 8 different tests from the EXERNET battery. Lifestyle patterns were collected using a validated questionnaire. ANOVA was used to compare the groups according to the hours of sitting. Binary logistic regression was used to calculate the association between the SB and low levels of fitness. *Results:* For both genders, those who spent sitting >4 h•d^{-1} had lower levels of balance, agility, walking speed and aerobic endurance ($p<0.001$). Sedentary men also had less strength of lower extremities ($p<0.05$), whereas, sedentary women were less flexible in the lower extremities ($p<0.001$). More than 4 h•d^{-1} sitting was associated, in men, to higher odds for having low strength (lower extremities), agility, flexibility (lower extremities) and aerobic endurance ($p<0.05$); and in women, to higher risk of low balance, strength (lower and upper extremities), flexibility (lower extremities), agility, walking speed and aerobic endurance ($p<0.05$). *Conclusions:* Seniors that sit >4 h•d^{-1} have lower levels of fitness and this behavior is related with an increased risk of having low levels of PF in this population.

Key words: Lifestyle, physical activity, functional capacity, health, aging.

Introduction

The global average life expectancy has increased by 5 years between 2000 and 2015, resulting in a significant growth of the elderly population worldwide (1).

In Spain, like most developed countries, according to data registered in 2016, the population over the age of 65 years has increased notably around 18,8% and it is expected to increase up to 35% in 2065 (2). Moreover, 6% of the Spanish population is octogenarian and it is also estimated to increase up to 18% in 2065 (2).

The multidimensional process of aging is inherent in humans and leads to a progressive physical and psychological decline and also to many social changes (3). Specifically, above the age of 60 years, aging has been associated with a substantial decline in global physical performance (4), less functional efficiency and worse mental functions, all of which affect the degree of dependence in elderly people (5). Apart from that, nowadays it is well known that many chronic illnesses and disabilities increase with age and are associated with low levels of several components of physical fitness (PF), such as aerobic endurance, strength or balance (6).

Although the aging process leads to many changes as reported above, it is widely proven that lifestyle plays an important role in ameliorating the age-related conditions. In this regards, increased levels of physical activity (PA) have been proposed as one of the key strategies to guarantee a successful aging (7).

It is known that moderate and regular physical exercise in older adults are associated with benefits on cardiovascular fitness (reduction in the decline of peak oxygen consumption (VO_2 peak)), prevention of falls, higher bone mineral density or strength and muscular function (8-10). Moreover, it has benefit on the primary prevention of stroke, is also associated with a reduction in cardiovascular diseases (optimization of blood pressure, lipid profile and type 2 diabetes) and it can produce changes in body composition (reduction of body fat and age-related sarcopenia) (11, 12).

Traditionally, a large body of evidence has focused on the relationship between PA level and health; however, the new emerging concept of sedentary behavior (SB, defined as sitting, reclining or lying down posture, during prolonged periods) has

Received September 13, 2018
Accepted for publication October 5, 2018

Published online April 22, 2019, http://dx.doi.org/10.1007/s12603-019-1193-y

been demonstrated to be a new risk factor, independently of the PA level (13-16). There is substantial evidence that shows the relationship between high volumes of sedentary time and many detrimental health outcomes, such as the increased risk of cardiovascular disease or even death (17, 18). In fact, a recent investigation developed by Rezende et al. (18) reported that sitting time (>3h•d^{-1}) is responsible for 3.8% of all-cause mortality among countries from all over the world, being this conduct higher in the Western Pacific region (5.7%), followed by European (4.4%), Eastern Mediterranean (3.3%), American (3.2%), and Southeast Asian (2.0%).

Other researchers also found an association between sitting time and cardio-metabolic disorders, negative changes in body composition such as adiposity and muscle quality or frailty (15,19-21). Among older adults, long sitting periods have been also related to geriatric outcomes including physical status, cognitive function and mental health (22, 23). Although physical function is of great relevance in seniors, only few studies have examined the relationship between the amount of SB per day and PF in this population (24-26).

Some evidence has reported that elderly people are generally less physically active than younger adults and have more mobility limitations that increase the amount of time spent on SB (8). In fact, the results of a recent study shows that over 70% of older adults spend around 8.5 h•d^{-1} sitting (27).

In this alarming scenario, it is necessary to keep in mind the importance of maintaining high levels of PF throughout aging, as well as establishing the relationship between SB and the different components of PF in the elderly.

Therefore, the aims of this study were to examine whether sedentarism has influence on fitness performance in elderly men and women and to analyze if sitting time is associated with higher risk of having low levels of PF in a representative sample of non-institutionalized Spanish elderly people.

Methods

Participants and design

The present study was performed on a representative sample of non-institutionalized elderly residing in six different regions from Spain: Aragón, Madrid, Castilla León, Castilla-La Mancha, Extremadura and Canarias. The complete methodology of the elderly EXERNET multi-center study has been described in detail elsewhere (28).

The exclusion criteria of this cross-sectional study were refusals, age under 65 years, people living in nursing homes or not able to care for themselves and those having severe advanced illnesses (i.e. dementia or cancer). A total of 3136 seniors (724 men and 2412 women; 72.2±5.3 years) were included in the study. All participants were informed of the aims, benefits and possible risks derived from participation in the tests. Afterwards, written informed consent was obtained from all participants prior to participate in the study.

The ethical guidelines for human research studies as stated in the Helsinki Declaration were followed throughout the study and the protocol was approved by the Clinical Research Ethics Committee of Aragon (18/2008).

Data were collected between June 2008 and November 2009. Information was collected through personal interviews using a structured questionnaire followed by an examination to measure anthropometrics and PF. After the fieldwork participants who did not fulfill the inclusion criteria were excluded.

Anthropometric measurements

Training workshops were organized to harmonize the assessment of anthropometrics before starting the study. The standardization process and reliability of the anthropometric measurements carried out in the pilot study and during the final workshop guaranteed the quality of the anthropometrics in the EXERNET multi-centre study (29). Height was measured to the nearest millimeter using a portable stadiometer (SECA, Hamburg, Germany) with 2.10 m maximum capacity and a 0.001m 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 45º 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) (30).

Weight was measured using a TANITA BC 418-MA (Tanita Corp. Tokyo, Japan) with a 200 kg maximum capacity and a ±100g error margin. Individuals removed shoes, socks, and heavy clothes prior to weighing. Body Mass Index (BMI) was calculated as weight (kg) divided by squared height (m2).

Active and sedentary behavior variables

The information about active and SB was collected using a validated self-administrated questionnaire (31), which also included information about their demographic characteristics, medication, quality of life and socioeconomic status. The variables considered in the present study were gender, age, sitting time (SB) and walking time (active behavior), and this information was obtained in 100%, 100%, 83.7% and 86.8% of those interviewed, respectively. Specifically, 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 (i.e. watching television, reading, sewing, etc.) and it referred to the present time. Walking time was recorded through the following question: How many hours do you usually spend walking per day? For these questions, each participant had to choose one of the following answers: <1 h/day, 1–2 h/day, 2–3 h/day, 3–4 h/day, 4–5 h/day or >5 h/day.

Hours sitting per day were used to classify subjects into: non-sedentary (<4 h/day) and sedentary (≥4 h/day). The cut-off points to define this SB are based on ROC curves carried out with the same sample and reported in a previous study (15).

Physical fitness evaluation

Researchers responsible for the PF measurements were trained to work according to a standard protocol. The inter-observer reliability of each assessment was studied in a sample of 10 elderly from the city of Toledo (32).

PF was assessed using the following eight tests (from the batteries "Senior Fitness Test" and Eurofit: EXERNET battery) (33, 34).

1. Balance: Flamingo Balance Test. Number of seconds keeping balance with one foot on the floor and the other resting on the opposite ankle (maximum 60 s). The test was performed twice with right and left feet alternatively. The best result obtained among the four attempts was recorded. This test measures ability to balance successfully on a single leg, which is important to walk safely and fall prevention.

2. Strength of lower extremities: Chair Stand Test. Number of full stands from a seated position that can be completed in 30 s with arms folded across chest. This test, which was performed once, assesses lower-body strength needed for numerous tasks such as climbing stairs, walking, and getting out of a chair, tube or car.

3. Strength of upper extremities: Arm Curl Test. Number of biceps curls that can be completed in 30 s holding a hand weight; 2.5 kg for women, 4 kg for men. The test was performed twice, one with each hand. The average of both results was recorded. This test evaluates upper-body strength needed for performing household and other activities involving lifting and carrying things such as groceries, suitcases and grandchildren.

4. Flexibility of lower extremities: Chair Sit-and-Reach Test. From a sitting position at the front of a chair, with leg extended and hands reaching towards toes, the number of centimeters (plus or minus) between the extended fingers and the tip of the toe. The test was performed twice, one with each leg, and the average of both results was recorded. This test measures lower-body flexibility, which is important for good posture, normal gait patterns, and various mobility tasks such as getting in and out of a bathtub or car.

5. Flexibility of upper extremities: Back Scratch Test. With one hand reaching over the shoulder and one up the middle of the back, the number of centimeters between the extended middle fingers (plus or minus) is measured. The test was performed twice, one with each hand. The average of both results was recorded. This test assesses upper-body (shoulder) flexibility, which is important in tasks such as combing one´s hair, putting and overhead garments or reaching for a seatbelt.

6. Agility: 8-Foot Up-and-Go Test. Number of seconds required to get up from a seated position, walk 2.45 m, turn and return to a seated position. The test was performed twice, with at least one minute of rest between repetitions. The best result was recorded. This test evaluates the agility/dynamic balance important in tasks that require quick maneuvering such as getting up to attend to something in the kitchen, going to the bathroom or answering the phone.

7. Walking speed: Brisk Walking Test. Number of seconds required to walk 30 m. The test was performed twice, with at least one minute of rest between repetitions. The best result was recorded. This test measures the speed of walk, important in tasks that require fast walking such as get the bus or go early to a meeting.

8. Endurance: 6-Minute Walk Test. Number of meters that can be walked in 6 min around 46 m track. This test was performed once and assesses aerobic endurance, which is very important for walking distances, climbing stairs, shopping, etc.

Gender and age-specific PF levels (percentiles) were cataloged based on the multicentre EXERNET study reference values (32), which evaluated the PF level in a representative sample of the non-institutionalized Spanish elderly population. In the present study, the 20th percentile of each test was established in order to classify people with low levels of PF.

Statistical analysis

Data of descriptive statistics and differences between men and women were analyzed and are presented as means and standard deviation (means ± SD).

The differences in PF depending on sitting time (<4 h/day or ≥4 h/day) were analyzed by 2-way ANOVA.

The associations between sit ≥ $4h^{\bullet}d^{-1}$ and the PF level (categorized by age) were calculated by binary logistic regression. Odds ratios (OR) with 95% confidence intervals (CI) obtained from logistic regression are reported for the studying models. First, we built a model I, which included the independent sedentary related variable and secondly, we created a model II, which incorporated walking time (number of hours per day) as possible confounder. These analyses were carried out separately by gender.

All analyses were carried out with the Statistical Package for the Social Sciences (SPSS, Inc. Chicago, USA) Windows software, version 21.0. Statistical significance was set at $p<0.05$.

Results

Descriptive characteristics

Descriptive characteristics and PF parameters (mean ± SD) of the study sample by gender are displayed in Table 1. Height and weight were higher in men than in women (all $p<0.001$). Women had higher BMI than men ($p<0.001$). No differences were found in age between genders. There were statistical differences between genders ($p<0.001$) for all fitness tests. Men were better in balance, strength of lower and upper extremities, agility, walking speed and aerobic endurance, while women performed better in flexibility of lower and upper extremities.

Table 1
Descriptive characteristics (anthropometrics and physical fitness values) by gender

	Men		Women		
	N	Mean ± SD	N	Mean ± SD	P
Age (years)	724	72.4 ± 5.4	2412	72.2 ± 5.3	0.260
Height (cm)	710	165.2 ± 6.7	2357	152.8 ± 5.9	<0.001
Weight (kg)	702	77.0 ± 11.0	2335	68.2 ± 11.0	<0.001
BMI (kg/m2)	702	28.1 ± 3.5	2335	29.2 ± 4.4	<0.001
Balance (s)	690	32.0 ± 23.0	2297	24.7 ± 20.3	<0.001
Strength of lower extremities (reps)	693	15.3 ± 4.0	2299	14.3 ± 3.5	<0.001
Strength of upper extremities (right arm) (reps)	690	17.1 ± 4.0	2267	16.2 ± 4.0	<0.001
Strength of upper extremities (left arm) (reps)	686	17.2 ± 4.1	2273	16.4 ± 4.1	<0.001
Lower body flexibility (right leg) (cm)	695	-8.4 ± 12.0	2314	-2.5 ± 10.0	<0.001
Lower body flexibility (left leg) (cm)	689	-8.4 ± 12.1	2312	-2.1 ± 10.0	<0.001
Upper body flexibility (right arm) (cm)	695	-16.0 ± 13.7	2306	-8.3 ± 11.0	<0.001
Upper body flexibility (left arm) (cm)	694	-19.0 ± 12.7	2301	-13.0 ± 11.0	<0.001
Agility/Dynamic Balance unit of measurement (s)	697	5.5 ± 1.5	2314	6.0 ± 1.7	<0.001
Walking speed (s)	634	15.4 ± 3.7	2211	18.0 ± 4.0	<0.001
Aerobic endurance (m)	630	566.0 ± 98.0	2137	513.0 ± 91.0	<0.001

Differences in PF values depending on sitting time (less or more than 4 h•d^{-1})

PF variables of the study sample by gender and sitting time (h•d^{-1}) are shown in Table 2. The group of men and women that were sedentary (≥4h•d^{-1}) had lower level of balance, agility, walking speed and aerobic endurance (all p<0.001). Sedentary men also had less strength of lower extremities (16.0±3.5 vs.14.6±4.0; p<0.05). Moreover, women who sat more than 4 h•d^{-1} were significantly less flexible in the lower extremities (right and left leg; both p<0.001).

Association between sedentary lifestyle and risk of low fitness

Table 3 presents the Odds Ratio for having low levels of physical fitness in those sitting ≥4h•d^{-1}, compared with the elderly who sat less than 4 h•d^{-1}.

In men, more than 4 h of sitting a day was related with higher risk (1.8, 2.4 and 2.0-fold higher odds) of having low strength of lower extremities, agility and aerobic endurance, respectively (all p<0.05), compared to those sitting less than 4h•d^{-1} (Model I). In women, this SB increased the risk (1.4, 1.4, 1.5 and 1.6-fold higher odds) of having low fitness in the following tests: balance, flexibility of left leg, agility and walking speed, respectively (all p<0.05) (Model I).

Table 2
Differences in Fitness Test values depending on sitting time (h•d) stratified by gender

	< 4h sitting/day		≥ 4h sitting/day		
	Men				
	N	Mean ± SD	n	Mean ± SD	P
Balance (s)	372	35.5 ± 22.9	210	27.4 ± 22.1	<0.001
Strength of lower extremities (reps)	370	16.0 ± 3.5	212	14.6 ± 4.0	0.020
Strength of upper extremities (right arm) (reps)	367	17.1 ± 4.0	212	17.0 ± 4.0	0.715
Strength of upper extremities (left arm) (reps)	366	17.2 ± 4.0	213	17.0 ± 4.0	0.867
Lower body flexibility (right leg) (cm)	371	-8.2 ± 11.6	212	-8.6 ± 12.4	0.915
Lower body flexibility (left leg) (cm)	370	-8.0 ± 11.5	210	-8.6 ± 13.1	0.911
Upper body flexibility (right arm) (cm)	371	-15.0 ± 13.7	213	-16.0 ± 13.7	0.834
Upper body flexibility (left arm) (cm)	370	-18.4 ± 12.7	213	-19.2 ± 11.1	0.885
Agility/Dynamic Balance (s)	373	5.2 ± 1.0	214	5.8 ± 1.8	<0.001
Walking speed (s)	351	15.0 ± 2.7	191	16.0 ± 4.1	<0.001
Aerobic endurance (m)	355	579.4 ± 84.5	192	538.4 ± 108.0	<0.001
	Women				
Balance (s)	1364	26.0 ± 20.5	568	22.2 ± 19.5	<0.001
Strength of lower extremities (reps)	1367	14.2 ± 3.4	570	14.0 ± 3.5	0.266
Strength of upper extremities (right arm) (reps)	1350	16.1 ± 4.0	559	16.0 ± 3.8	0.542
Strength of upper extremities (left arm) (reps)	1350	16.2 ± 4.1	561	16.2 ± 4.0	0.394
Lower body flexibility (right leg) (cm)	1373	-2.2 ± 9.8	576	-4.1 ± 10.6	<0.001
Lower body flexibility (left leg) (cm)	1373	-2.0 ± 9.8	574	-3.6 ± 10.6	<0.001
Upper body flexibility (right arm) (cm)	1368	-7.7 ± 10.7	573	-8.7 ± 10.6	0.472
Upper body flexibility (left arm) (cm)	1365	-12.5 ± 10.7	572	-13.4 ± 10.7	0.450
Agility/Dynamic Balance (s)	1374	6.0 ± 1.5	576	6.3 ± 1.9	<0.001
Walking speed (s)	1329	17.7 ± 3.6	546	18.7 ± 4.1	<0.001
Aerobic endurance (m)	1337	517.4 ± 84.7	533	495.6 ± 101.6	<0.001

Associations after adjustment for time spent walking (Model II) showed similar results. However, men increased also the risk of having low flexibility in both legs. In women, sitting time was associated with 1.5, 1.4, 1.3 and 2.0-fold higher odds of having low levels of strength of lower extremities, strength of upper extremities (left arm), flexibility of lower extremities (right leg), and aerobic endurance.

Table 3
Odds Ratio for having low levels of physical fitness in sedentary men and women

	Men		Women	
	OR	**95% CI**	**OR**	**95% CI**
Model I				
Balance (s)	1.350	0.884 - 2.062	1.470	1.155 - 1.856*
Strength of lower extremities (reps)	1.870	1.199 - 2.903*	1.078	0.832 - 1.398
Strength of upper extremities (right arm)	0.675	0.412 - 1.103	0.771	0.588 - 1.011
Strength of upper extremities (left arm)	0.839	0.511 - 1.378	0.801	0.608 - 1.056
Flexibility of lower extremities (right leg)	1.036	0.672 - 1.598	1.262	0.997 - 1.596
Flexibility of lower extremities (left leg)	1.040	0.677 - 1.597	1.441	1.142 - 1.818*
Flexibility of upper extremities (right arm)	1.043	0.679 - 1.603	1.047	0.814 - 1.347
Flexibility of upper extremities (left arm)	1.000	0.644 - 1.553	0.949	0.739 - 1.218
Agility (s)	2.470	1.308 - 4.666*	1.560	1.122 - 2.169*
Walking speed (s)	1.687	0.912 - 3.120	1.646	1.192 - 2.272*
Aerobic endurance (m)	2.034	1.324 - 3.124*	1.204	0.937 - 1.547
Model II				
Balance (s)	1.468	0.931 - 2.314	1.494	1.183 - 1.882*
Strength of lower extremities (reps)	1.689	1.050 - 2.716*	1.477	1.155 - 1.888*
Strength of upper extremities (right arm)	0.971	0.575 - 1.640	1.264	0.989 - 1.615
Strength of upper extremities (left arm)	1.125	0.662 - 1.914	1.393	1.086 - 1.788*
Flexibility of lower extremities (right leg)	1.715	1.092 - 2.695*	1.292	1.029 - 1.622*
Flexibility of lower extremities (left leg)	1.725	1.102 - 2.700*	1.234	0.982 - 1.550
Flexibility of upper extremities (right arm)	1.097	0.683 - 1.762	1.040	0.817 - 1.325
Flexibility of upper extremities (left arm)	1.260	0.784 - 2.023	1.211	0.957 - 1.532
Agility (s)	2.300	1.203 - 4.396*	1.488	1.073 - 2.064*
Walking speed (s)	1.249	0.633 - 2.465	1.928	1.401 - 2.653**
Aerobic Endurance (m)	2.205	1.396 - 3.484**	2.028	1.600 - 2.570**

Odds Ratio (OR); 95% Confidence Interval (CI). Sedentary men and women (those who spent sitting ≥4h•d^{-1}); Model I: included the independent sedentary related variable; Model II: incorporated walking time as possible confounder; *p<0.05; **p<0.01

Discussion

In this study, we investigated the influence of SB on PF in seniors. The main results of the present study are that 1) Self-reported sitting time has a negative influence on PF, both in men and women. Specifically, seniors who sit less than 4h•d^{-1} have higher levels of PF in most of the studied tests. 2) The least affected variables are those that involve the upper extremities. 3) Men (36%) and women (30%) who sit more than 4h•d^{-1} is related with an increased risk of having low levels of PF independently of walking time and this negative influence is different between the genders.

Large body of evidence has reported across the years the beneficial health benefits of PA among older adults, such as increases in cardio-respiratory performance, benefits on strength and muscular function, prevention of falls and possible cognitive benefits with reduction in incidence of dementia (8, 11, 35-37). On the contrary, the absence of regular activity in seniors has been related to some diseases and disabilities such as heart disease, stroke, type 2 diabetes, high blood pressure, metabolic syndrome, some types of cancer or decreases in cardiorespiratory and muscular fitness (38-40).

It is well known that PA is important for independent living in older adults; nevertheless, a new concept is emerging, suggesting that SB has to be considered as a new risk factor for health independently of the PA level (14, 41). In fact, prolonged periods in a sitting, reclining or lying posture, have been related to some health problems such as the risk of developing cardiovascular disease, metabolic syndrome, cardio-metabolic biomarkers, increased risk of obesity and in the worst case, mortality (15, 42, 43). In view of this negative association, many studies have centered their efforts in trying to understand whether the adverse consequences to patients health are caused by SB only, or rather they can also be attributed to too little PA (44). For instance, in this study we verified that, in Spanish elderly population, sitting time was negatively associated with the level of fitness.

Although there is strong evidence about the influence of PA on fitness performance among older subjects, as reported above, there is a lack of studies focusing on the influence of SB and PF in this group of population.

It has been previously reported that the amount of time that people spend in SB increases with age. Specifically, a recent systematic review (45) shows that elderly people (≥60 years old) spend an average of 9.4 h a day in SB, that equating to 65-80% of their waking day. Therefore, this characteristic lifestyle of the elderly population may lead to the development of certain pathologies and health issues.

As fitness level in older adults has a strong influence on the capability for maintaining functional independence and being self-confident (46, 47), and considering that decreases in muscle strength or walking speed may affect negatively the ability of older people to perform functional tasks such as raise and sit in a chair, walk a certain distance (48, 49) or increase the risk of frailty during the aging process (50) ,among older adults the highest priority should be to find strategies for maintaining the functional ability and independence.

In terms of fitness, results from this study showed that long sitting periods (>4 h•d^{-1}) have a negative influence on PF level in seniors, affecting their muscle strength, balance, flexibility, agility, walking speed and endurance. Thus, our results are in line with the study carried out by Santos et al. (26) with 312

older adults over 65 years. They showed that long periods of time in SB (measured with accelerometers) were related with worse upper and lower body strength, agility, dynamic balance and lower flexibility. Moreover, they found a positive relationship between time spent in moderate-to-vigorous PA and functional fitness, independently of SB. However, while Santos et al. found associations between SB and the strength of upper extremities, in our study we found that this sedentary pattern was not associated with lower performance in this test. Our hypothesis is that seniors perform activities with their arms while they are sitting, and therefore, SB may not affect this PF component. The discordance between studies could be partially explained by the number of hours spent in the SB. It is possible that 4h•d^{-1} may not be enough to negatively affect upper body strength; however, longer time in this sedentary activity could lead to a lower performance in this test.

Other fitness parameters such as balance and agility performance progressively decline with age and could be related with falls, postural control and loss of confidence. To our knowledge balance, stride length and walking speed are reduced in older adults indicates a more pronounced postural sway in this population (51). Cooper et al. (52) observed in a cohort study with older adults (range 60.3-64.9 years) that SB was strongly associated with worst standing balance time. In this regard, we also found a negative association between SB and agility, in both genders. In fact, sitting more than 4 h•d^{-1} was related with the risk of being less agile (OR 2.3; 95% 1.20-4.36; OR 1.4; 95% 1.07-2.06, men and women, respectively), independent of walking time a day (Model II). Moreover, sitting more than 4h•d^{-1} is strongly associated with an increased risk of walking slowly (OR 1.6; 95% 1.19-2.27) and less balance capacity (OR 1.4; 95% 1.15-1.85) in women. Hence, future interventions may decrease SB in this population, especially in women, in order to prevent the risk of having a bad postural fitness and also to prevent falls.

Accumulating evidence indicates that there is a progressive decline in the cardiovascular system across the aging process. Moreover, sedentary lifestyle in elderly produces an accelerated decline in VO_2max (53, 54). In fact, in a recent study carried with adults and seniors (18-91 years) (55), found an inverse association between total daily sitting time (≥10 h•d^{-1}) and cardiorespiratory fitness. Similarly, we found worst values in aerobic capacity in men and women who were sitting more than 4 h•d^{-1} ($p< 0.05$). In addition, having an active lifestyle was associated with a decreased risk of having less aerobic capacity in seniors (men and women). According to this evidence, long sedentary periods should be avoided with the goal of maintain functional independence and quality of life in senior.

In global terms, our findings confirmed that older adults with prolonged SB (such as sitting down) have a negative influence in terms of PF level.

Some limitations should be acknowledged. Firstly, the results could be partially based by the fact that only independent non-institutionalized elderly were included in the present study. Results from an institutionalized elderly population might not be identical. Among the strengths, we included the multi-centric study design and a large sample size with a large variety of tests used to measure the PF; however, there is a limitation related with the large difference between men and women in sample size.

In conclusion, sitting time is a risk factor for having low levels of PF in the Spanish seniors, and this association is independent of the walking time. Overall, we observed that men and women who spend more than 4 h•d^{-1} in sitting posture, have less PF than those who were sitting less than 4 hours, especially in lower extremities. Moreover this sedentary lifestyle was associated in men, to higher risk of having low strength, agility, flexibility and aerobic endurance; and in women to higher risk of low balance, strength, flexibility, agility, walking speed and aerobic endurance.

Taking into account the findings of the present study, it is necessary to recommend less time sitting and maybe to create new policies of health behavior for elderly, focusing on new strategies of interventions. It is also necessary to incorporate new programs and activities for implementing changes in lifestyle, such as interventions aimed to reduce the total volume of sitting per day and breaking up prolonged periods of sitting time among this group of population.

Acknowledgments: The Elderly EXERNET Multi-center Study was supported by the Ministerio de Trabajo y Asuntos Sociales (104/07), Ministerio de Sanidad, Politica Social e Igualdad (147/2011), University of Zaragoza (UZ 2008-BIO-01), Centro Universitario de la Defensa de Zaragoza (UZCUD2016-BIO-01), Ministerio de Economía, Industria y Competitividad (DEP2016-78309-R), the Biomedical Research Networking Center on Frailty and Healthy Aging (CIBERFES) and FEDER funds from the European Union (CB16/10/00477). The authors are also grateful to all the volunteers and collaborators whose cooperation and dedication made this study possible.

Disclosure statement: The authors declare they have no competing interest.

Ethical Standards: 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). Written informed consent was obtained from all the participants.

References

1. (WHO) WHO. Global health and aging. NIH Publication. 2011;11-7737.
2. IMSERSO. Informe 2016. Las personas mayores en España. Datos estadísticos estatales por comunidades autónomas. 2017.
3. Dziechciaz M, Filip R. Biological psychological and social determinants of old age: bio-psycho-social aspects of human aging. Annals of agricultural and environmental medicine : AAEM. 2014;21(4):835-838.
4. Mendonca GV, Pezarat-Correia P, Vaz JR, Silva L, Heffernan KS. Impact of Aging on Endurance and Neuromuscular Physical Performance: The Role of Vascular Senescence. Sports medicine. 2016.
5. Dijkstra A, Hakverdioglu G, Muszalik M, Andela R, Korhan EA, Kedziora-Kornatowska K. Health related quality of life and care dependency among elderly hospital patients: an international comparison. The Tohoku journal of experimental medicine. 2015;235(3):193-200.
6. McPhee JS, French DP, Jackson D, Nazroo J, Pendleton N, Degens H. Physical activity in older age: perspectives for healthy ageing and frailty. Biogerontology. 2016;17(3):567-580.
7. Gopinath B, Kifley A, Flood VM, Mitchell P. Physical Activity as a Determinant of Successful Aging over Ten Years. Sci Rep. 2018;8(1):10522.
8. Taylor D. Physical activity is medicine for older adults. Postgrad Med J. 2014;90(1059):26-32.
9. Suominen H. Muscle training for bone strength. Aging clinical and experimental research. 2006;18(2):85-93.
10. Chin APMJ, van Uffelen JG, Riphagen I, van Mechelen W. The functional effects of physical exercise training in frail older people : a systematic review. Sports Med.

2008;38(9):781-793.
11. Vogel T, Brechat PH, Lepretre PM, Kaltenbach G, Berthel M, Lonsdorfer J. Health benefits of physical activity in older patients: a review. International journal of clinical practice. 2009;63(2):303-320.
12. Allen J, Morelli V. Aging and exercise. Clinics in geriatric medicine. 2011;27(4):661-671.
13. Thorp AA, Owen N, Neuhaus M, Dunstan DW. Sedentary behaviors and subsequent health outcomes in adults a systematic review of longitudinal studies, 1996-2011. American journal of preventive medicine. 2011;41(2):207-215.
14. van der Ploeg HP, Hillsdon M. Is sedentary behaviour just physical inactivity by another name? The international journal of behavioral nutrition and physical activity. 2017;14(1):142.
15. Gomez-Cabello A, Pedrero-Chamizo R, Olivares PR, et al. Sitting time increases the overweight and obesity risk independently of walking time in elderly people from Spain. Maturitas. 2012;73(4):337-343.
16. Davis MG, Fox KR, Stathi A, Trayers T, Thompson JL, Cooper AR. Objectively measured sedentary time and its association with physical function in older adults. J Aging Phys Act. 2014;22(4):474-481.
17. Endorsed by The Obesity S, Young DR, Hivert MF, et al. Sedentary Behavior and Cardiovascular Morbidity and Mortality: A Science Advisory From the American Heart Association. Circulation. 2016;134(13):e262-279.
18. Rezende LF, Sa TH, Mielke GI, Viscondi JY, Rey-Lopez JP, Garcia LM. All-Cause Mortality Attributable to Sitting Time: Analysis of 54 Countries Worldwide. American journal of preventive medicine. 2016;51(2):253-263.
19. Bankoski A, Harris TB, McClain JJ, et al. Sedentary activity associated with metabolic syndrome independent of physical activity. Diabetes care. 2011;34(2):497-503.
20. Chastin SF, Ferriolli E, Stephens NA, Fearon KC, Greig C. Relationship between sedentary behaviour, physical activity, muscle quality and body composition in healthy older adults. Age and ageing. 2012;41(1):111-114.
21. Del Pozo-Cruz B, Manas A, Martin-Garcia M, et al. Frailty is associated with objectively assessed sedentary behaviour patterns in older adults: Evidence from the Toledo Study for Healthy Aging (TSHA). PloS one. 2017;12(9):e0183911.
22. Copeland JL, Ashe MC, Biddle SJ, et al. Sedentary time in older adults: a critical review of measurement, associations with health, and interventions. British journal of sports medicine. 2017;51(21):1539.
23. Rosenberg DE, Bellettiere J, Gardiner PA, Villarreal VN, Crist K, Kerr J. Independent Associations Between Sedentary Behaviors and Mental, Cognitive, Physical, and Functional Health Among Older Adults in Retirement Communities. J Gerontol A Biol Sci Med Sci. 2016;71(1):78-83.
24. Sardinha LB, Santos DA, Silva AM, Baptista F, Owen N. Breaking-up sedentary time is associated with physical function in older adults. The journals of gerontology Series A, Biological sciences and medical sciences. 2015;70(1):119-124.
25. Gennuso KP, Gangnon RE, Matthews CE, Thraen-Borowski KM, Colbert LH. Sedentary behavior, physical activity, and markers of health in older adults. Medicine and science in sports and exercise. 2013;45(8):1493-1500.
26. Santos DA, Silva AM, Baptista F, et al. Sedentary behavior and physical activity are independently related to functional fitness in older adults. Experimental gerontology. 2012;47(12):908-912.
27. Harvey JA, Chastin SF, Skelton DA. Prevalence of sedentary behavior in older adults: a systematic review. Int J Environ Res Public Health. 2013;10(12):6645-6661.
28. Gomez-Cabello A, Pedrero-Chamizo R, Olivares PR, et al. Prevalence of overweight and obesity in non-institutionalized people aged 65 or over from Spain: the elderly EXERNET multi-centre study. Obesity reviews : an official journal of the International Association for the Study of Obesity. 2011;12(8):583-592.
29. Gomez-Cabello A, Vicente-Rodriguez G, Albers U, et al. Harmonization process and reliability assessment of anthropometric measurements in the elderly EXERNET multi-centre study. PloS one. 2012;7(7):e41752.
30. Sanchez-Garcia S, Garcia-Pena C, Duque-Lopez MX, Juarez-Cedillo T, Cortes-Nunez AR, Reyes-Beaman S. Anthropometric measures and nutritional status in a healthy elderly population. BMC public health. 2007;7:2.
31. Ravens-Sieberer U, Wille N, Badia X, et al. Feasibility, reliability, and validity of the EQ-5D-Y: results from a multinational study. Quality of life research : an international journal of quality of life aspects of treatment, care and rehabilitation. 2010;19(6):887-897.
32. Pedrero-Chamizo R, Gomez-Cabello A, Delgado S, et al. Physical fitness levels among independent non-institutionalized Spanish elderly: the elderly EXERNET multi-center study. Archives of gerontology and geriatrics. 2012;55(2):406-416.
33. Jones R. Senior Fitness Test Manual. Human Kinetics ed., Champaign, IL. 2001.
34. EUROFIT. Test europeo de aptitud física. Ministerio de Educación y Ciencia, Madrid. 1992
35. Varma VR, Tan EJ, Wang T, et al. Low-intensity walking activity is associated with better health. J Appl Gerontol. 2014;33(7):870-887.
36. Kannus P, Sievanen H, Palvanen M, Jarvinen T, Parkkari J. Prevention of falls and consequent injuries in elderly people. Lancet. 2005;366(9500):1885-1893.
37. Liu CJ, Latham NK. Progressive resistance strength training for improving physical function in older adults. Cochrane Database Syst Rev. 2009(3):CD002759.
38. Elsawy B, Higgins KE. Physical activity guidelines for older adults. American family physician. 2010;81(1):55-59.
39. Thompson PD, Buchner D, Pina IL, et al. Exercise and physical activity in the prevention and treatment of atherosclerotic cardiovascular disease: a statement from the Council on Clinical Cardiology (Subcommittee on Exercise, Rehabilitation, and Prevention) and the Council on Nutrition, Physical Activity, and Metabolism (Subcommittee on Physical Activity). Circulation. 2003;107(24):3109-3116.
40. El Bilbeisi AH, Hosseini S, Djafarian K. The Association between Physical Activity and the Metabolic Syndrome among Type 2 Diabetes Patients in Gaza Strip, Palestine. Ethiop J Health Sci. 2017;27(3):273-282.
41. Owen N. Sedentary behavior: understanding and influencing adults' prolonged sitting time. Prev Med. 2012;55(6):535-539.
42. Pandey A, Salahuddin U, Garg S, et al. Continuous Dose-Response Association Between Sedentary Time and Risk for Cardiovascular Disease: A Meta-analysis. JAMA cardiology. 2016;1(5):575-583.
43. Wilmot EG, Edwardson CL, Achana FA, et al. Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. Diabetologia. 2012;55(11):2895-2905.
44. Owen N, Healy GN, Matthews CE, Dunstan DW. Too much sitting: the population health science of sedentary behavior. Exercise and sport sciences reviews. 2010;38(3):105-113.
45. Harvey JA, Chastin SF, Skelton DA. How Sedentary are Older People? A Systematic Review of the Amount of Sedentary Behavior. Journal of aging and physical activity. 2015;23(3):471-487.
46. Mullen SP, McAuley E, Satariano WA, Kealey M, Prohaska TR. Physical activity and functional limitations in older adults: the influence of self-efficacy and functional performance. The journals of gerontology Series B, Psychological sciences and social sciences. 2012;67(3):354-361.
47. McAuley E, Konopack JF, Morris KS, et al. Physical activity and functional limitations in older women: influence of self-efficacy. The journals of gerontology Series B, Psychological sciences and social sciences. 2006;61(5):P270-277.
48. Westerterp KR. Daily physical activity, aging and body composition. The journal of nutrition, health & aging. 2000;4(4):239-242.
49. Landers KA, Hunter GR, Wetzstein CJ, Bamman MM, Weinsier RL. The interrelationship among muscle mass, strength, and the ability to perform physical tasks of daily living in younger and older women. The journals of gerontology Series A, Biological sciences and medical sciences. 2001;56(10):B443-448.
50. Guyonnet S, Secher M, Vellas B. Nutrition, Frailty, Cognitive Frailty and Prevention of Disabilities with Aging. Nestle Nutrition Institute workshop series. 2015;82:143-152.
51. Ruffieux J, Keller M, Lauber B, Taube W. Changes in Standing and Walking Performance Under Dual-Task Conditions Across the Lifespan. Sports medicine. 2015;45(12):1739-1758.
52. Cooper AJ, Simmons RK, Kuh D, et al. Physical activity, sedentary time and physical capability in early old age: British birth cohort study. PloS one. 2015;10(5):e0126465.
53. Fleg JL, Strait J. Age-associated changes in cardiovascular structure and function: a fertile milieu for future disease. Heart Fail Rev. 2012;17(4-5):545-554.
54. Aparicio-Ugarriza R, Pedrero-Chamizo R, Bibiloni MDM, et al. A Novel Physical Activity and Sedentary Behavior Classification and Its Relationship With Physical Fitness in Spanish Older Adults: The PHYSMED Study. J Phys Act Health. 2017;14(10):815-822.
55. Eriksen L, Gronbaek M, Helge JM, Tolstrup JS. Cardiorespiratory fitness in 16025 adults aged 18-91 years and associations with physical activity and sitting time. Scandinavian journal of medicine & science in sports. 2016 DEC; 26 (12): 1435-43.