**UNIVERSIDAD POLITÉCNICA DE MADRID**

FACULTAD DE CIENCIAS DE LA ACTIVIDAD FÍSICA Y DEL DEPORTE (INEF)

# Influence of sedentary behavior and physical condition on health related quality of life in older adults: a 4 year observational study of changes in fitness levels, health related quality of life and sedentary time

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**International PhD Thesis**

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Calificación .................................................

EL PRESIDENTE LOS VOCALES

1

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5 **EL SECRETARIO**

**This is my fight song,**
**Take back my life song,**
**Prove I´m alright song**
**And I don´t really care**
**if nobody else believes,**
**´cause I´ve still got**
**a lot of fight left in me**

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**List of Abbreviations and Symbols**

| | |
|---|---|
| AC | Aerobic capacity |
| ACSM | American College of Sport Medicine |
| AHA | American Heart Association |
| AGR | Age groups |
| ANOVA | Analysis of variance |
| ANCOVA | Analysis of covariance |
| BF | Body fat |
| BMI | Body Mass Index |
| CI | Confidence intervals |
| cm | Centimeter(s) |
| $cm^2$ | Square centimeter(s) |
| CSIC | Consejo Superior de Investigaciones Científicas |
| CV | Coefficient of variation |
| CVD | Cardiovascular disease |
| EQ-5D-3L | EuroQol dimensions 5 and 3 levels |
| EQ-VAS | EuroQol visual analogue scale |
| et al. | *et alii* (= and others) |
| g | Gram(s) |
| h | Hour(s) |
| h/d | Hour(s) per day/s |
| HP | Hip circunference |
| HRQoL | Health-related quality of life |
| INE | Instituto Nacional de Estadística |
| kg | Kilogram(s) |
| Kgf | Kilogram(s) force |
| lb | Pounds |
| LHSD | Left hand in standing position |
| LHST | Left hand in sitting position |
| m | Meter (s) |
| mg | Milligram(s) |
| min | Minute(s) |
| ml | Mililiter (s) |
| MVPA | Moderate to vigorous physical activity |
| MxSD | Maximal score in standing position |
| MxST | Maximal score in sitting position |
| n | Number of |
| NCDs | Non-contigious diseases |
| OR | Odds ratios |
| PA | Physical activity |
| QoL | Quality of life |
| r | Correlation coefficient |
| RHSD | Right hand in standing position |
| RHST | Right habd in sitting position |
| sec | Seconds |
| SB | Sedentary behaviour |

| | |
|---|---|
| SB0 | No change in sedentary behaviour |
| SB1 | Reducing sedentary behaviour |
| SB2 | Increasing sedentary behaviour |
| SD | Standard deviation |
| SFT | Senior Fitness Test |
| SPSS | Statistical Package for Social Sciences |
| ST | Sitting time |
| ST1 | Sitting time <2h/day |
| ST2 | Sitting time from 2 till 4 h/d |
| ST3 | Sitting time >4h/d |
| Tstr | Total strength |
| TTO | Time trade-off |
| TTO-B | Time trade-off in phase B |
| UK | United Kingdom |
| UNIANOVA | Analysis of variance unifactor |
| USA | United States of America |
| VAS | Visual analogue scale |
| WC | Waist circunference |
| WHO | World Health Organization |
| yr | Years |
| % | Percentage |
| -P75 | Under percentile 75 |
| +P75 | Over percentile 75 |
| ∑STD | Sum of scores in standing position |
| ∑SIT | Sum of the scores in sitting position |

**List of publications from the thesis**

- Maroto-Sánchez, B., Lopez-Torres, O., Palacios, G., & González-Gross, M. (2016). What do we know about homocysteine and exercise? A review from the literature. *Clinical Chemistry and Laboratory Medicine (CCLM)*, *54*(10), 1561-1577.

- López-Torres, O; Maroto-Sánchez, B, Pedrero-Chamizo, R; Vila-Maldonado S; Ara, I; González-Gross, M. Comparison of handgrip strength performance according to different initial body positions in elderly. Submmited to Reseach Quarterly for Exircise and Sport. In review

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## ABSTRACT

The present thesis analyzes the effect of sedentary behavior (SB) and fitness level on the Health-Related Quality of Life (HRQoL) in older adults. The work is framed within the EXERNET project. This doctoral thesis examines the influences of SB and fitness on HRQoL with 2 different perspectives: cross-sectional and longitudinal. The EXERNET study began in 2008 as a cross-sectional research to study physical condition and body composition in older adults. In 2012, the project was prolonged and a longitudinal study was carried out. Therefore, 3 different studies are included in this thesis. The first study is a descriptive analysis of the fitness changes occurred between the two phases of the study in those subjects who could be recuperated. A total sample of 1,064 was included in this study. The second study consisted in a cross-sectional research with the initial sample at phase one about the effects of SB and fitness on HRQoL. A total of 3,136 individuals from different regions of Spain were included in this study. The third study analyzes the effects of variations in SB in the period between both phases, by different fitness levels, on the HRQoL. This study includes 1,064 subjects. The main findings of this thesis are: 1) Physical capacities involute differently over time. To remain active could contribute in maintaining or reducing the decline in fitness level during a 4-year period of time in older adults. 2) Higher sitting time seems to be related to poorer scores in HRQoL tests in older adults. High levels of fitness may help attenuating the negative effects of sitting time in the subjective perception of HRQoL. Thus, sitting time is negative related to quality of life in general but more specifically in subjects with low a fitness levels. 3) Independently from fitness, a reduction of the total sitting in a 4-year period could lead to greater HRQoL in older adults. High fitness levels were also related to greater HRQoL. More longitudinal studies that help clarifying the interaction between SB and fitness are needed, especially in older adults due to the tendency of this sector of the population to high levels of sedentary time and low fitness.


**Key words:** Sedentary behaviours, fitness, older adults, health related quality of life, involution.

| WHAT IS KNOWN ABOUT QUALITY OF LIFE, SEDENTARY BEHAVIOUR AND FITNESS | WHAT DOES THIS THESIS ADD? |
|---|---|
| There is not agreement in the scientific community about the influence of SB and PA on QoL. | Commonly, studies have focused on comparing SB vs PA, using accelerometers or activity questionnaires. This thesis quantifies fitness using a battery of physical tests, what could be of major interest so that PA is relevant in what it concerns to fitness level. |
| Some studies found that both, SB and PA are independently associated to QoL. | This thesis examined the relation of SB and fitness, but not PA, on QoL. Although both concepts seem to be related, it is possible to practice regular PA and not having a good fitness level but also practicing reduced PA time per day could lead to good fitness levels if the PA is of high intensity and is well designed. |
| Some studies found that PA but not SB is associated to QoL. | High levels of fitness, related or not to PA could help counteracting the negative effects of too much ST. |
| Some studies found that SB, independently from the time spent in MVPA is related to poorer QoL. | SB is related to poorer QoL. This thesis concluded that in subjects with high fitness, the negative effects of high ST tend to soften. |
| Any study reviewed focused on the effect of fitness in retaliation to SB on HRQoL. | This thesis emphasizes the important of considering fitness levels and not only PA as the variable to relate to SB and QoL. |
| Any study reviewed combining SB and fitness had a longitudinal design with changes in SB over time as a variable. | This thesis studied how the changes in SB over time affect QoL. It is crucial to measure variations in SB and fitness over time, especially in the older adults, so that this group tends to reduce PA and increase SB with age. |

**RESUMEN**

La presente tesis analiza el efecto del comportamiento sedentario (SB) y el nivel de condición física en la Calidad de Vida relacionada con la Salud en adultos mayores. El trabajo se enmarca dentro del proyecto EXERNET. Esta tesis doctoral examina la influencia del SB y el fitness en la calidad de vida bajo 2 perspectivas diferentes: una transversal y otra longitudinal. El estudio EXERNET comenzó en 2008 como una investigación transversal para estudiar la condición física y la composición corporal en adultos mayores. En 2012 el proyecto fue prolongado, realizándose un estudio longitudinal. Por lo tanto, en esta tesisse incluyen 3 estudios diferentes. El primer estudio es un análisis descriptivo de los cambios en la condición física producidos entre las dos fases del estudio en los sujetos que continuaron en la segunda fase. Se incluyó una muestra total de 1.064 en este estudio. El segundo estudio consistió en una investigación transversal con la muestra inicial en la fase uno sobre los efectos de SB y fitness en la calidad de vida. Un total de 3.010 individuos de diferentes regiones de España fueron incluidos en este estudio. El tercer estudio analiza los efectos de las variaciones en el SB en el período entre ambas fases, según los diferentes niveles de condición física, y su relación con la calidad de vida. Este estudio incluyó 1.064 sujetos. Los principales hallazgos de esta tesis son: 1) Permanecer activo podría ayudar a mantener o reducir la disminución en el nivel de condición física durante un período de 4 años en adultos mayores. 2) Un sedentarismo más alto parece estar relacionado con puntuaciones más pobres en las pruebas de calidad de vida (TTO y las 5 dimensiones) en adultos mayores. Los altos niveles de condición física podrían ayudar a atenuar los efectos negativos del tiempo sentado en la percepción subjetiva de la calidad de vida. Por lo tanto, el tiempo sentado es negativo en relación con la calidad de vida en general, pero más específicamente en sujetos con niveles de condición física bajos. 3) Independientemente de la condición física, una reducción del tiempo sentado total en un período de 4 años podría conducir a una mayor calidad de vida en los adultos mayores. Los altos niveles de condición física también se relacionaron con una mayor calidad de vida. Se necesitan más estudios longitudinales que ayuden a aclarar la interacción entre el comportamiento sedentario y la condición física, especialmente en adultos mayores debido a la tendencia de este sector de la población a altos niveles de sedentarismo y baja actividad física.

Palabras clave: Conductas sedentarias, fitness, adultos mayores, calidad de vida relacionada con la salud, involución.

# 6 CHAPTER 1. INTRODUCTION

## 6.1 Research Background

### *6.1.1* Health related quality of life

In 1948, the World Health Organization (WHO) defined health as "the state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (1). Health-related quality of life (HRQoL) is both an individual and group perception of physical and mental health over time and narrows quality of life (QoL) to aspects relevant to health. To our knowledge, there is no available universally accepted definition for that term (2).This multi-dimensional concept includes domains related to physical, mental, emotional, and social functioning. This is a much more complex concept than direct measures of population health, life expectancy, and causes of death. The focus is on the impact that health status has on QoL.

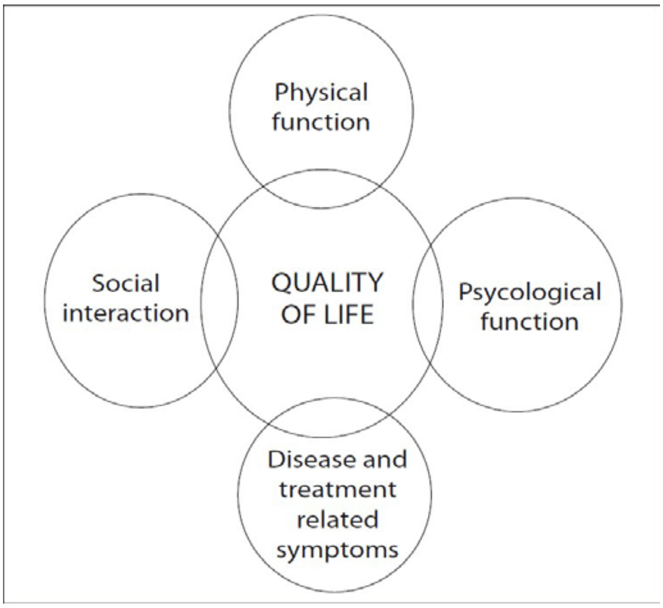



Figure 1. Multidimensional estructure of HRQoL. (Obtained from the Indian Journal of cancer. January-March 2012. Volume 49-Issue 1. Page Nos. 1-195)

HRQoL can include both objective and subjective perspectives in each domain (3). That results in the fact that individuals with the same objective health status can report very different subjective QoL. The factors that lead to a better subjective perception of a HRQoL in individuals with different objective ones are important to be identified as it could help improving the QoL in elderly. Since 2012, through the efforts of Dr. Jadad, a new reconceptualization has been propounded, proposing a new definition of QoL related to the ability of individuals or communities to adapt and self-manage physical, mental or social challenges they encounter in life (4). As population age and the pattern of illnesses changes, the definition proposed by WHO may even be counterproductive since the presence of chronic diseases in older adults is a fact. “The state of complete physical, mental and social well-being” that the WHO definition proposes would leave most of the population unhealthy most of the time, fact even more pronounce as people age. By successfully adapting to an illness, people are able to work, be physically active or to participate in social activities and feel healthy despite limitations. With this new conceptualization, to be able to stay physically active as the aging process occurs seems crucial for being healthy and manifesting a good HRQoL.

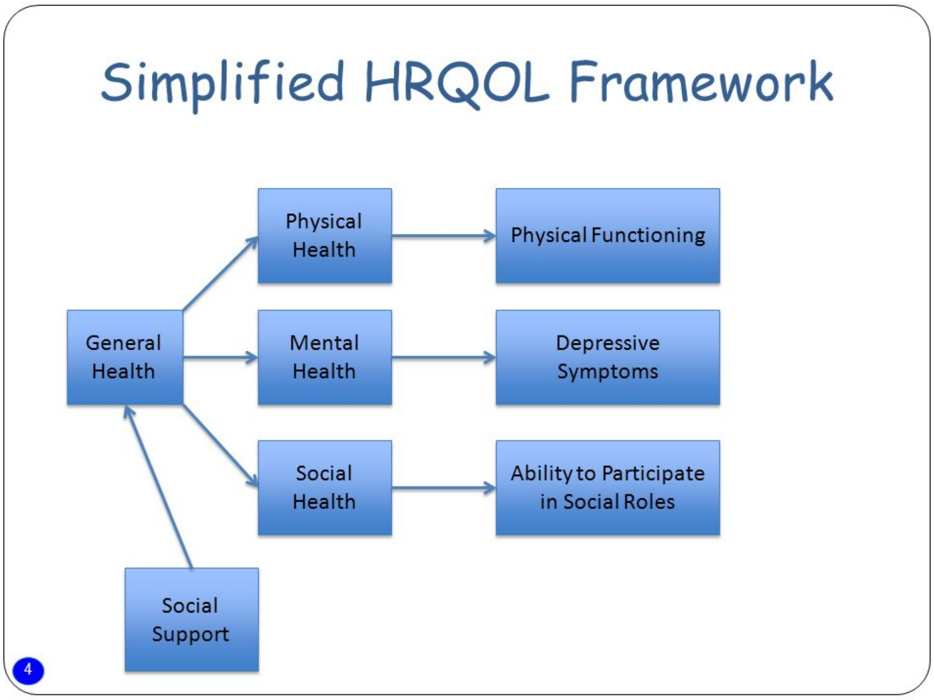



Figure 2. Resume of the factors influencing health and HRQoL. (Obtained from the Health-Related Quality of Life Measures (HLT POL 239B) Ron D. Hays, Ph.D. - UCLA Department of Medicine)

### *6.1.2* Aging process

Aging can be defined as the accumulation of damage in molecules, cells and tissues over a lifetime; this often decreases an organism's capacity to maintain homeostasis in stress conditions, and entails a greater risk for many diseases (cancer, cardiovascular and neurodegenerative disorders) and premature mortality (5-8). Aging therefor, is a natural process related to the decline in both physical and mental abilities determined by genetic and environmental factors. As individuals age, the losses in both capacities are related to lower physical fitness and cognitive levels. These limitations could lead to physical, emotional and social problems resulting in deterioration in QoL.

As the world's population is ageing (every country in the world is experiencing growth in the number and proportion of older persons in their population) demographic structures in developed societies are changing. Although the aging population represents a success of the health and social improvements on disease and death, it involves large economic, cultural and social impacts and elevated governmental costs.

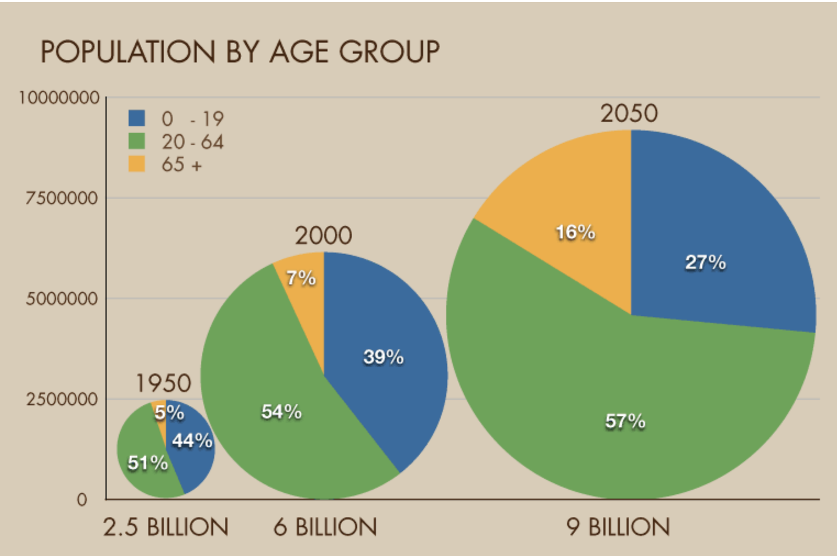



Figure 3. Population distribution by age group and expectations for 2050. (Obtained from the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2006 Revision and World Urbanization Prospects: The 2005 Revision, http://esa.un.org/unpp).

In the last 30 years, the population aged 65 and over has doubled in Spain. A decrease in fertility and birth-rate together with an increase of life expectancy has resulted in an aging population. This process is even more dynamic looking at the group of the oldest. Thus, the growth rate of over 85 years is six times larger than the whole rate of the Spanish population. The QoL for this rapidly growing segment of the population can no longer be ignored without disastrous consequences (7). One of the key challenges facing governments is to find appropriate, cost-effective and fiscally affordable ways to assist people to live independently and as healthy as possible. Older people should be encouraged to remain independent and self-reliant as long as possible.

After the WHO introduced the term active aging (understood as the process of optimizing opportunities for physical, social and mental health throughout life) in the late 90s (9) this has been an important subject of study for researches that have tried to understand the main factors influencing this process.

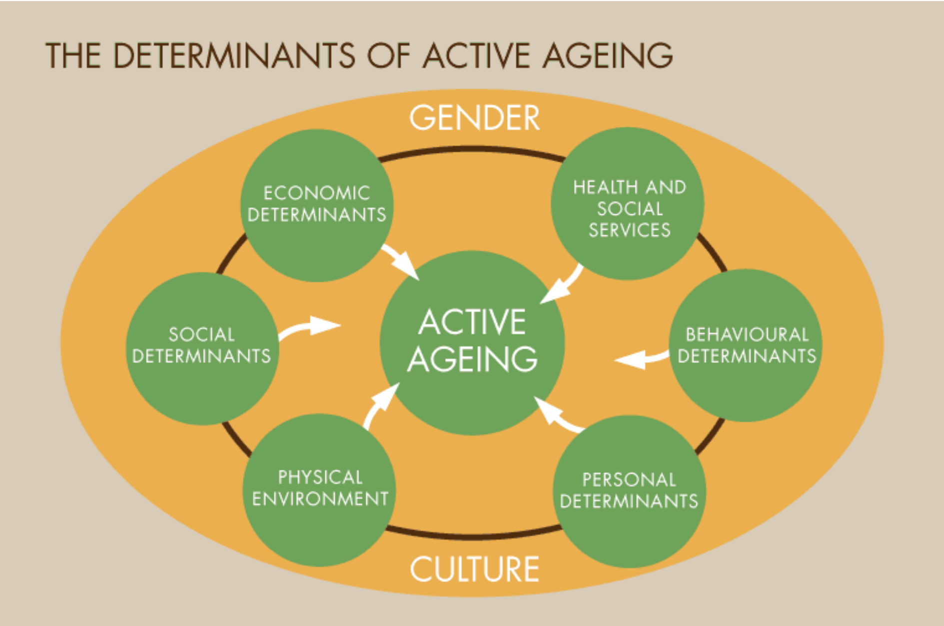



Figure 4. Main determinants of active aging. (Obtained from the http://wisdom.unu.edu).

One of these main factors is physical activity (PA) and how it influences to maintain the levels of autonomy and independence of older people. Successful ageing is defined as the ability to maintain low risk of disease or disability, high mental and physical function, and active engagement with life (10).

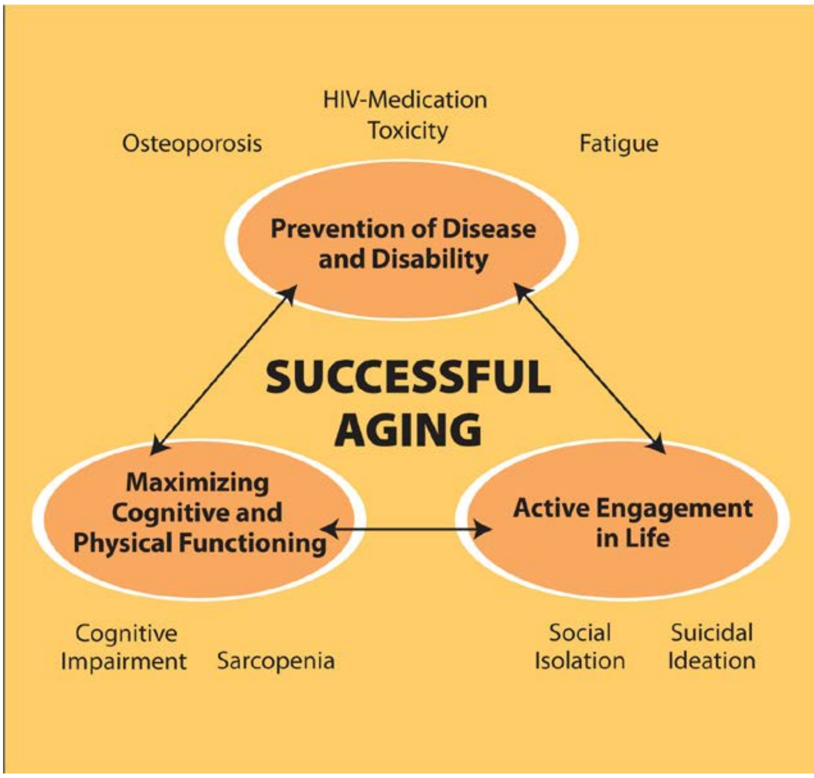



Figure 5. Components and interacctions in successful aging. (Obtained from the Vance et al. Successful Aging with HIV: A Brief Overview for Nursing. Journal of Gerontological Nursing. 2009 - Vol 35 · Issue 9: 19-25. DOI: 10.3928/00989134-20090731-04)

Taking into account the reconceptualization proposed by Dr Jadad, as a person ages and the capacities tend to be reduced affecting the HRQoL, the way this person or the social environment react will determine the health status.

Due to important changes in life style that have occurred in the last decades (mechanization and technification of work, increase of sedentary behaviors (SB), reduction of PA or poor quality nutrition), the gain in years of life has been accompanied by additional years of chronic poor health with an increase of chronic diseases. To minimize the presence of chronic diseases in older adults would reduce the total health and social costs and would improve elderly QoL. So that the greatest proportion of total expenditure on health care is now concentrated in the last few years of life, interventions that reduce morbidity in later life are likely to have significant financial and social benefits, in addition to gains in individual well-being. (7).

### *6.1.3* Factors affecting the aging process

#### 6.1.3.1 Genetics

Genetic variation has been shown to play an important role, alongside environmental factors, in producing variations in a wide range of markers of human aging and longevity (11). In practice, the goal to achieve this is to understand the mechanisms involved in premature aging or disability. Understanding how gene variants and environmental exposures lead to extended healthy life expectancy, could help to avoid early disability and premature mortality (12). For humans a successful aging (13) or aging well with good functioning is probably of more interest than extreme longevity.

#### 6.1.3.2 Lifestyle: physical activity, sedentary behaviours and nutrition.

Physical exercise has been widely proposed as a very effective way to maintain or improve physical and mental condition so as to prevent and treat major morbidity and mortality causes in industrialized countries, most of those, associated with the aging process (14-17). The practice of PA helps healthy aging and plays an important role in improving QoL among elderly (18-20). Some studies suggest that participating in regular moderate intensity PA (e.g., walking, cycling, or light sports) has significant benefits for health, including improved treatment of many diseases (21-23). The evidence of health benefits of PA is stronger for adults 65 years old and older than for any other age group, since the consequences related to inactivity are more severe for this age group (24, 25). According to WHO guidelines (26), regular and adequate levels of PA improve muscular and cardiorespiratory fitness and bone and functional health, reduce the risk of hypertension, coronary heart disease, stroke, diabetes, breast and colon cancer, depression and the risk of falls as well as hip or vertebral fractures and is fundamental to energy balance and weight control.

However, PA levels might not be the most effective way to measure the physical condition of older people and their capacity to carry out everyday activities independently (27-30). Fitness level has been proposed as an alternative variable to predict more properly certain aspects of health and QoL (31-33).

Physical inactivity, understood as not reaching the recommendations of PA, further aggravates the decline in physical condition along the aging process. Insufficient PA is 1 of the 10 leading risk factors for global mortality and is on the rise in many countries, adding to the burden of non-contagious diseases (NCDs) and affecting general health worldwide. People who are insufficiently active have a 20% to 30% increased risk of death compared to people who are sufficiently active (26).

Therefore, the improvement in health-related physical fitness through a change in lifestyle involving regular exercise could be taken as one of the main non-pharmacological approaches that should be recommended to older adults (34-36). WHO´s PA recommendations for adults aged 65 years and above are 30 minutes per day or 150 minutes per week (26). (Table 1)

| ***WHO PA RECOMMENDATIONS FOR ADULTS AGED 65 YEARS AND ABOVE*** |
|---|
| 1. Should do at least 150 minutes of moderate-intensity physical activity throughout the week, or at least 75 minutes of vigorous-intensity physical activity throughout the week, or an equivalent combination of moderate- and vigorous-intensity activity. |
| 2. For additional health benefits, they should increase moderate intensity physical activity to 300 minutes per week, or equivalent. |
| 3. Those with poor mobility should perform physical activity to enhance balance and prevent falls, 3 or more days per week. |
| 4. Muscle-strengthening activities should be done involving major muscle groups, 2 or more days a week. |

Table 1. WHO physical activity recommendations for older adults. (26)

On the other hand, SB is emerging as a novel risk factor for most chronic diseases, including diabetes (37), cardiovascular disease (CVD) (38), and some cancers (39, 40). A greater number of hours spent sitting per day is associated with increased risk of chronic disease, CVD, poor physical fitness and HRQoL and all-cause mortality.

SB is defined as any waking behavior characterized by energy expenditure less than or equal to 1.5 metabolic equivalents while in a sitting or reclining posture (41).

The association between SB and cardio metabolic risk factors remains controversial. Thus, while some prospective studies have suggested that the time spent in SB predicts higher levels of fasting insulin (37) and other cardio metabolic risk factor (38), independent of the amount of time spent in moderate to vigorous physical activities (MVPA), other studies have found that the association between sedentary time and cardiovascular risk factor levels was attenuated (42-44) or disappeared(45) after adjusting for time spent in MVPA. In addition, no studies have succeeded in establishing an association between higher sedentary time and cardio metabolic health.

| | **SEDENTARY** | **NON SEDENTARY** |
|---|---|---|
| **NOT PHYSICALLY ACTIVE** | **A.** Not reaching the PA recommendations AND seated for long periods | **B.** Not reaching the PA recommendations BUT not seated for long periods |
| **PHYSICALLY ACTIVE** | **C.** Reaching the PA recommendations BUT seated for long periods | **D.** Reaching the PA recommendations AND is not seated for long periods |

Figure 6. Clasification of individuals by sedentary behaviour and physical activity.

Therefore, it is important to clarify whether the relationship between SB and cardio metabolic risk persists after adjusting by PA levels and even more crucial after adjusting by fitness levels, as there is no guarantee that practicing MVPA leads to high fitness levels in every individual, although a relationship exists. However, current international public health strategies for cardiovascular prevention highlight the importance of MVPA (26) (Figure 6). Therefore, it seems necessary to clarify the mediating role of MVPA and fitness levels on the potentially harmful effects of SB. (Figure 7)

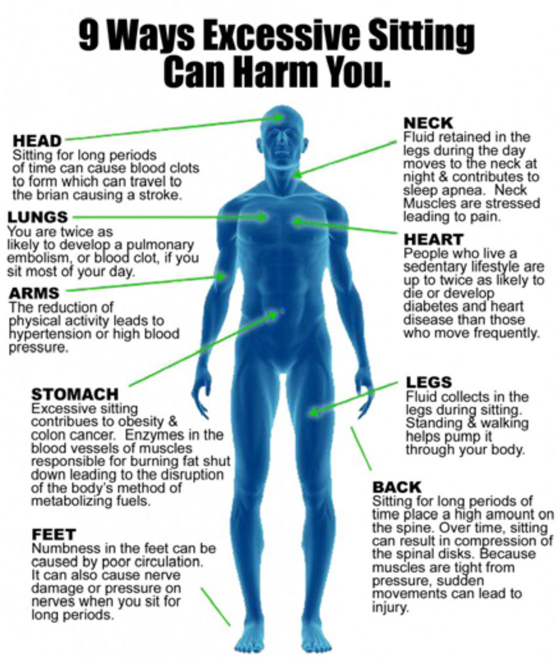



Figure 7. Differents ways of how excesive sitting time can produce harm. (Obtained from the guysandgoodhealth.com/do-you-know-the-dangers-of-prolonged-sitting/)

Last but not least, nutrition is critical for health and well-being at all stages in the life course, and, indeed, the nutrition of one generation may influence ageing in the next generation. While nutrition has immediate effects on metabolism and health, nutritional exposures can have very long legacies (46). There is wide evidence of the relationship between chronic diseases and feeding habits (47). Many of the diseases suffered by older individuals are the result of dietary factors, some of which have been operating since infancy. These factors are then compounded by changes that naturally occur with the ageing process (6). The diet election of a person, can also affect many degenerative diseases occurring to older people such as cardiovascular and cerebrovascular disease, diabetes, osteoporosis and cancer (48). Slight changes in dietary patters seem to affect risk-factor levels throughout life and may have an even greater impact in older people.

#### 6.1.3.3 Environment

The environment influences human health in many ways (through exposures to physical, chemical and biological risk factors, and through related changes in behaviour in response to those factors) which can affect QoL, years of healthy life lived, and health disparities. The WHO defines environment, as it relates to health, as “all the physical, chemical, and biological factors external to a person and all the related behaviors” (49). Environmental health focuses on preventing and controlling disease, injury, and disability related to the interactions between population and environment. According to the WHO, 13 million deaths annually are due to preventable environmental causes (49). As we grow older, the influence of environmental factors on our health becomes more important, and the influence of genetic factors become less important. For this reason, the environment in which older adults live could be crucial in contributing to their health.

Several environmental factors which are linked to urbanization can discourage people from becoming more active, such as: fear of violence and crime in outdoor areas, high-density traffic, low air quality, pollution and lack of parks, sidewalks and sports/recreation facilities (50).

#### 1.1.3.4 Homocystein levels

Hyperhomocystemia has been reported to be associated with cardiovascular disease, especially stroke (51-54). In a study conducted by Okura et al. (51) in elderly male patients, homocysteine was the strongest predictor of carotid resistive index in the multivariate model, what means that hyperhomocysteinemia is associated with carotid resistive index, a surrogate marker of cerebral vascular resistance.

On the other hand, levels of serum homocysteine are associated with high-sensitivity cardiac troponin levels (regulatory proteins found in skeletal and cardiac muscle used as biomarkers) in the elderly, indicating a relationship between homocisteine and subclinical myocardial damage (55). In older persons at risk of cardio-vascular diseases (CVD), those with high homocysteine are at highest risk for fatal and nonfatal coronary heart disease (56). Raised total homocysteine levels and folate deficiency are associated with poorer lifestyle. Thus, changes to a more healthful lifestyle among older adults may minimize the adverse vascular effects of elevated total homocysteine (57). In a study performed by Gopinaph et al. (57) in old adults, serum total homocysteine and folate levels were independent predictors of coronary heart disease and all-cause mortality. Bates et al. (52) found that total and primary vascular mortality is predicted by energy and protein intakes, and by biochemical indices including total homocysteine.

Elevated serum homocysteine levels also appear to be closely associated with chronic kidney disease (58).

Schroeksnadel et al. concluded in a study that homocysteine accumulation coincided with impaired both renal and heart function (53). At the same time, elevated total homocysteine is also associated with the presence of abdominal aortic aneurysm and aortic stiffness in older men what could mean that the strong association between homocysteine and cardiovascular mortality in the elderly may be mediated by aortic stiffness (59, 60).

In non demented, relatively healthy adults, elevated homocysteine is associated with lower cognitive scores and reduced cerebral white matter volume (61).

Due to the evident connection between all the above mentioned factors and health, homocysteine levels should be taken in account when studding old adult's health.

### 1.1.4. Fitness and older adults

When the concept "physical condition" is used in the elderly population, it refers to functional physical condition, which Rikli and Jones (62) define as "the physical and physiologic capacity to perform normal activities of daily living safely and independently and without undue excessive fatigue ". This concept is crucial as far as QoL is concern, since it determines the capacity to manage with autonomy within the society. Many independent older adults´ functions, often due to their sedentary lifestyles, are very close to their maximum capacity during normal daily activities. For example, climbing stairs or getting out of a chair requires near maximum effort for many older individuals. A high percentage of community-dwelling older adults are at risk for mobility problems, physical frailty and falls.

Although it is clear that a proper physical condition and functionality is necessary to keep older adults independent, there is controversy to determine the main components of functional physical condition. Rikli and Jones (62) affirm that functional capacity includes five elements: cardiovascular endurance, strength, flexibility, body composition (body mass index) and agility/dynamic balance. Those authors developed the Senior Fitness Test (SFT) to assess the functional fitness of older adults according to the disability models of Nagi and others (63, 64).

QoL in later years has been proposed to be deeply related to the ability to independently engage in self-selected activities (65). Therefore, research works that help clarifying the determinants of function in older adults are becoming increasingly important and a consistent aim of current public health policies.

A decrease in lower body strength has been identified as a powerful predictor of disability onset in later years by many authors (66-68). A reduction in muscular size and strength may negatively impact the older adult's performance of normal daily activities. Slow gait speed, as a single best indicator of functional limitations, has been used to identify frailty risk in older adults. However, whether these components are independent of each other or can be represented by underlying latent factors remains to be determined. For example, the Arm Curl, 8-Foot Up and-Go, and Chair Stand Tests, combined with cardiorespiratory fitness, might be categorized as components of physical capacity, whereas the Chair Sit-and-Reach and Back Scratch tasks clearly represent a flexibility component of fitness. Jointly, these capacities may all load on a common factor of "functional fitness".


Figure 8. Health related Physical Fitness Componenets. (Obtained from the http://montymillerfitness.com/6-components-health-related-fitness/)

1.1.4.1. Incidence of aging on aerobic condition

There is a decrease in the aerobic condition during the aging process, due to the lower functional capacity of circulatory, respiratory and blood systems. The organism experiences a progressive loss of elasticity of the blood vessels and consequently, an increase of the arterial tension. In addition, a decrease in lung volumes may be observed. These biological changes occur more rapidly in men than in women, although it is true that these differences between sexes tend to dissipate in the last decades of life. Changes in cardiovascular function are not due entirely to age, but to physical inactivity (69).

In a study conducted by Renaud et al. (70) with people aged 60 years, it was observed that after the application of a 12-week PA plan, statistically significant changes in aerobic capacity were found not only in the pulmonary and cardiovascular system, but also in the nervous system, thus increasing the levels of attention and agility in older adults.

The level of aerobic capacity of a subject is a clear indicator of the protection of cardiovascular diseases. On the other hand, the decline in aerobic capacity is related to loss of functional independence and QoL (71). Therefore, we can affirm that this physical capacity should be whenever possible, integrated in the recommendation of physical exercise for older people (72).

#### 1.1.4.2. Incidence of aging on balance

Balance is understood as the ability to maintain the stability of the body or recover it, and to react more or less adequately and quickly to the possible external stimuli that act away from our center of gravity. An improved balance facilitates movement control and reduces the risk of falls (73). In addition, deficit in proprioception, vision, vestibular sense, muscle function and reaction time contribute to balance disorder (74). As a result of impaired balance, older adults modify the locomotion pattern, with a reduction in walking speed, which leads to an increased risk of foot contact with obstacles and falls. It has been shown in the literature that balance has been improved after the implementation of an exercise program, what contributes directly to independence of older adults to carry out the tasks of daily living (75). Other authors observed that short intervention time through proprioception exercises may improve postural control in older people (76).

For all these reasons, the need to include balance and propioceptive work in physical exercise recommendations for older people is necessary.

#### 1.1.4.3. Incidence of aging on muscle strength

As the aging process progresses, there is a reduction in the number of muscle fibers, which takes place between 20-50% in muscle fibers type II and between 1-25% in the type I (77). In addition, there is a decrease in muscle oxidative activity and capillary density. Sarcomers, functional units of the muscle, are replaced in the muscle fiber by fat and fibrous tissue, which causes a shortening of the fiber and a reduction of the capacity of contraction. These changes lead to a reduction in both strength and muscle efficiency, as well as a decrease in the coordination of muscle action (78). A study by Lynch et al. (79) shows that during aging a more pronounced loss of muscle quality is achieved in the lower limbs than in the upper limbs, being more relevant in the concentric contractions than in the eccentric contractions in both sexes. This reduction in muscle strength begins to decline significantly from the age of 50 years. From this moment, the force declines around 15% per decade (80).

Women present lower levels than men for both handgrip and maximal leg extension strength, when comparing the same age groups (81).

In a study conducted by Goodpaster et al (82), which analyzed leg extensor strength in men and women aged 70 to 79 years, the results reflect annual declines of 3.4% in males and 2.6% in women, while the annual muscle loss ratio was 1%.

Regarding the consequences of aging deterioration on this physical capacity, it is important to emphasize that low levels of muscle strength, both in the lower limbs and hand grip, are important predictors of mortality in the elderly (83) as well as it has important consequences on the coordination and autonomy capacity of the subject to carry out activities of daily living.

Nevertheless, significant improvements in physical fitness have been observed following regular practice of physical exercise programs that included muscle strength as an intervention goal (84).

#### 1.1.4.4. Incidence of aging on muscle endurance

A reduction in both, muscle strength and endurance is associated with reduced overall strength, walking length, and balance problems that increase the risk of falls (85). On the other hand, muscular resistance predicts independence and mobility in the elderly and its importance lies in the physiological reserve of a person to develop activities without becoming fatigued (65). It is important to include the improvement of this capacity in PA programs in order to improve functional physical capacity, which will allow maintaining independence, increasing levels of spontaneous PA and participating autonomously in daily life activities.

#### 1.1.4.5. Incidence of aging on flexibility

Functional flexibility can be understood as one that allows performing the actions of daily life with safety, maintaining a perfect functioning of the muscular and articular systems (86).

Reduction in flexibility is progressive as the age advances but non-linear (81). The aging process increases muscle rigidity, degeneration of collagen molecules and damage to the articular cartilage which derives into a reduction of the articular mobility and, as a consequence, a deterioration of the flexibility, that is specific for each joint (72). The mean values of flexibility tend to be systematically higher in females than in males while deterioration in males is greater than in females. An increase and/or maintenance of flexibility of upper and lower limbs may results in a greater capability to perform activities of daily living as well as a very effective way to avoid possible injuries (72).

#### 1.1.4.6. Incidence of aging on body composition

As age advances, a decrease of the fat-free mass and an increase in fat mass occurs. This may influence the body mass index values. All these changes in body composition have important consequences. Anthropometric measures of abdominal fat (waist and hip circumference) are directly associated with mortality from cardiovascular diseases and cancer, regardless of body mass index (BMI). Therefore, a high waist circumference should be considered as a risk factor for mortality and a predictor of mobility and agility problems in older people (87, 88).

A study by Correa et al. (89), showed benefits obtained after the application of exercise programs, such as the decrease in body weight, abdominal perimeter and fat percentage. There is a clear association between low levels of fitness with body composition parameters, being physically active subjects less likely to have a high fat mass (90).

### *1.1.5 Disability, frailty and older adults*

Aging can be perceived in different ways depending on how the person understands the process. When the old person identifies aging as a negative process, he is not so much concerned with death as is the possibility of experiencing a long period of incapacity and dependence which, on many occasions, precedes it. This concern is increasingly shared by institutions and services that, due to the significant increase in the aging population, expect astronomical increases in the demand for services.

One of the most accepted definitions of frailty is the proposed by Fried et al. (91). Those authors define this term as the presence of three or more of the following criteria:

1. Unintentional weight loss of more than 5kg or 5% of body weight in a year.
2. Muscle weakness. Pressing force of less than 20% of the limit of normality.
3. Tiredness or low resistance to small effort
4. Slow walking speed.
5. Low level of physical activity.

The current approach to geriatric care is increasingly focused on comprehensive assessment, prevention of disabilities and protection of independence. For the prevention of disability the objective is to identify early risk factors or timely signs of impairment before it occurs or is irreversible. The main risk factors, markers and predictors of frailty are: chronic disease such as anemia, arterial hypertension, cardiovascular diseases, chronic kidney disease, diabetes mellitus, cancer, Parkinson, depression, and malnutrition. As secondary factors it can be named: sleep disorders, sensorial deficit, cognitive impairment, polypharmacy, gender, race and age, social determinants, level of autonomy, osteopenia, falls or sarcopenia (92).

The last two factors, the most related to deterioration of functionality during the aging process can be reduced using PA as a preventive tool.

### *1.1.6 Gender and sex differences in physical capacities in older adults*

Sex differences in humans are a fact. Sex is related to variations of certain aspects of functional fitness. An average man is taller and heavier than an average woman but women generally have a greater body fat percentage than men. For instance, males typically have higher cardiorespiratory fitness relative to body mass than females (the average VO2max is about 33 ml/kg/min for sedentary young women and around 42 ml/kg/min for sedentary young men (93). Generally, males also present greater muscular strength in both upper and lower body than females (men are over 30% stronger than women, especially in the upper body) (94). Therefore, sex was hypothesized to correlate with all aspects of functional fitness. While sex is a biological construct that refers to the biological differences between females and males, gender refers to the array of socially constructed roles and relationships, personality traits, attitudes, behaviours, values, relative power, and influence that society ascribes to men and women on a differential basis. Sex and gender are distinct and not interchangeable concepts (95). Numerous studies have focused on understanding gender differences in mobility disability among older adults, although the subject is not well understood yet. Frequently, studies have focused on understanding the biological differences in mobility disability between sexes, but not the differences due to interrelationships of sex and gender. Commonly, studies show that women have greater prevalence and incidence of mobility disability than men (96-98) although the magnitude of this difference varies across studies and locations worldwide.

A recent work carried out by Ahmed T, (99) with the data from the International Mobility in Aging Study (IMIAS) in which a total of 1995 community-dwelling older adults aged 65 to 74 years were recruited from different parts of the world to analyze mobility disability and low physical performance. The sample was classified into four gender roles (Masculine, Feminine, Androgynous, and Undifferentiated) using site-specific medians of femininity and masculinity as cut-off points according to the 12-item Bem Sex Role Inventory (BSRI) (95).The study found evidences that women have higher prevalence and incidence of self reported mobility disability and poor physical performance than men. Moreover, the gap between women and men is greater in low and middle income countries, compared with high income countries. However, little is known on whether these sex differences can be explained by gender-stereotyped traits.

### *1.1.7. What is known about the effects of SB, PA and fitness on HRQoL?*

It has been mentioned before the importance of getting deeper into the relationship between SB, PA and fitness level with HRQoL. To be able to understand the state of the art in order to plan the future steps, a review of the literature was conducted. The researchs focused on the relationship of SB and PA with HRQoL in the last 10 years are included below (Tables 2-4), although due to the novelty of the subject most of the studies were conducted in the past 6 years. There are many studies in the bibliography focusing on the relationship of SB and PA with mortality. Due that the objective of this doctoral work is the relationship of this 2 factors with HRQoL in healthy older adults, those articles were not included.

A total of 15 articles were selected and divided in three different groups: 1) Articles that included SB and PA in relation to HRQoL. 2) Articles that included PA in relation to HRQoL and 3) Articles that included the interaction of SB and PA but not related to HRQoL.

Table 2. Effects of sedentary behaviour (SB) and physical activity (PA) on health related quality of life (HRQoL)

| TITLE | AIM | SAMPLE | DESIGN | RESULTS |
|---|---|---|---|---|
| Objectively measured sedentary behavior and moderate-to-vigorous physical activity on the health-related quality of life in US adults: The National Health and Nutrition Examination Survey 2003-2006. Kim J, 2016 | To determine combined associations of objectively measured SB and MVPA on the risk of poor HRQOL in the general US population, after controlling for potential confounding factors. | 5359 adults | Cross-sectional | Both increasing MVPA and reducing time spent in SB may be useful strategies to improve HRQoL. |
| Longitudinal association of physical activity and sedentary behavior during leisure time with health-related quality of life in community dwelling older adults Balboa-Castillo T, 2011 | This study examined the longitudinal association between leisure time PA, leisure SB, and HRQoL in older community-dwelling adults in Spain. | 1,097 persons aged 62 and over. | Longitudinal study at 6 years | Greater leisure time PA and less leisure SB were independently associated with better long-term HRQoL in older adults. |
| Health-related quality of life, physical activity, and sedentary behavior of adults with visual impairments.<br><br>Haegele J, 2016 | To determine the associations of physical activity and sedentary behavior with HRQoL among a sample of adults with visual impairments. | 80 subjects | Cross-sectional | PA significantly predicted HRQoL yet, SB did not. |
| Differences in Health related quality of life between three clusters of physical activity, sedentary time, depression, anxiety and stress.<br><br>RebarA, 2014 | How these factors cluster together as profiles of subgroups of people and whether the clusters differed as a function on physical and mental health-related quality of life. | 1,014 adults | Cross-sectional | People with higher amounts of sitting time had significantly lower health-related quality of life than people with lower sitting time or high amounts of stress. |
| Profiles of resistance training behaviour and sedentary time among older adults: association of HRQoL and psychosocial health<br><br>Bampton E, 2015 | Understand the association of health-related quality of life and psychosocial factors with resistance training and sedentary behaviours profiles. | 358 older adults 55 years or older | Cross-sectional | Resistance training, regardless of sedentary time, was significantly associated with HRQoL and psychosocial health. |
| 10-year cumulative and bidirectional associations of domain-specific physical activity and sedentary behaviour with health-related quality of life in French adults: Results from the SU.VI.MAX studies.<br><br>Omoro A, 2016 | The longitudinal associations of 10-year cumulative levels of PA and SB with HRQoL and the reverse associations. | A sample of 2093 French adult | Longitudinal of 10 years | The 10-year cumulative level of high PA, both leisure-time and occupational, predicted a higher HRQoLwhile the10-year cumulative level of high screen-viewing time and high total sitting time was associated with lower HRQoL. |

| | | | | |
|---|---|---|---|---|
| Joint association of objective-measured sedentary behaviour and physical activity with HRQoL<br><br>Laprinzi P, 2015 | To examine the joint effect of PA and SB on HRQoL. | 5,536 subjects | Cross-sectional | PA but not SB was associated with HRQoL. |
| Cross-Sectional Associations between Multiple Lifestyle Behaviours and Health-Related Quality of Life in the 10,000 Steps Cohort<br><br>Duncan M,2014 | The relationships between these lifestyle behaviours, independently and in combination, and (HRQoL). | A total of 10,478 participants | Cross-sectional | Engaging in a greater number of poor lifestyle behaviours was associated with a higher prevalence of poor HRQOL. This association was exacerbated when sleep quality was included in the index. |

Table 3. Effects of physical activity on health related quality of life

| TITLE | AIM | SAMPLE | DISIGN | RESULTS |
|---|---|---|---|---|
| Changes in HRQoL after 12 months of exercise linked to primary care are associated with fitness effects in older adults<br><br>Gusi N, 2015 | To analyze the effects of 1 year of participation in a physical activity (PA) program linked to a health-care setting on physical fitness (PF) and health-related quality of life (HRQoL) and to determine the relationships between PA, PF and HRQoL in middle-aged and older adults. | 3214 participants | Intervention 12 months | PF is positively related with HRQoL. PA significantly improved PF, especially the PF components more impaired at baseline |
| Association of physical fitness with health-related quality of life in early post menopause<br><br>Moratalla-Cecilia N, 2016 | To assess the association of different components of physical fitness with HRQoL in early post menopause and to test which physical fitness components are independently associated with the physical and mental components of HRQoL. | 67 early postmenopausal women. | Cross-sectional | Higher physical fitness is associated with better HRQoL in early post menopause. Lower-body flexibility and upper-body muscle strength were the most important independent fitness indicators, explaining *30 % of HRQoL. |
| Effects of a 12-Month Multicomponent Exercise Program on Physical Performance, Daily Physical Activity, and Quality of Life in Very Elderly People With Minor Disabilities: An Intervention Study<br>Taguchi N, 2009 | To determine the effects of a 12-month multicomponent exercise program on physical performance, daily physical activity, and HRQOL among very elderly people with minor disabilities. | 65 elders (median age: 84 years) | Intervention, 12 months | After 12 months of exercise training, the intervention group had significant improvements in lower-limb strength and on the sit-and-reach test; these effects were not observed in the control group. The control group had significant decreases in grip strength, 6-minute walking distance, walking speed, and stride length; these decreases were not observed in the intervention group. No clear differences in HRQOL measurements or changes in physical activity were detected between groups. |
| Effect of changes in moderate or vigorous physical activity on changes in health-related quality of life of elderly British women over seven years<br><br>Choi M, 2012 | The effect of changes in moderate or vigorous physical activity (MVPA) on trajectories in health-related quality of life (HR-QoL) over 7 years in British elderly women. | 1,926womenfromt heBritishWomen's Heart and Health Study | Longitudinal of 7 years | Women who remained inactive over the 7 years of follow-up had the largest reduction in their EQ-5D scores. Compared to these women, women that increased their MPVA level from ''inactive'' to ''low'' or to ''moderate-high 'were more likely to maintain or improve their HR-QoL over 7 years. |

*Table 4. Interaction between sedentary behavior and physical activity*

| TITLE | AIM | SAMPLE | DESIGN | RESULTS |
|---|---|---|---|---|
| Evolución de los niveles de condición física en población octogenaria y su relación con un estilo de vida sedentario<br><br>Arribas A, 2014 | To determine the changes in physical fitness over two years of following up in octogenarian people and to check whether a sedentary lifestyle modify these variations. | 182 subject (48 men, 134 women) with a mean age of 82,3 ± 2,3 years | Longitudinal of 2 years | In 2 years of following up, there are adverse changes in the level of physical fitness in octogenarians. Long periods of sitting time may translate into a loss of agility. Walking speed and endurance seem to be the components of physical fitness more affected by the ageing process in this population; and this loss is not determined by the hours of sitting per day. |
| Sedentary behavior and physical activity are independently related to functional fitness in older adults<br><br>Santos D, 2012 | Association of PA and SB in Functional fitness | 312 subjects aged between 60 and 103 years | Cross-sectional | Elderly who spend more time in PA and less in SB exhibit improved functional fitness and other cofounders. |

## 6.2 Statement of the Research Problems

There are a limited number of studies analyzing the effects of SB and PA on HRQoL in healthy older adults (studies carried out in population with diseases such as cancer, diabetes type I or transplanted patients were not included). From the 15 articles included in this review, only 8 focused on the relation of both factors, SB and PA on HRQoL. Almost all of the studies were carried out from 2011 till the present time, having been, 7 of the 8, published in the last 2 years. This fact makes clear the growing importance that the subject is acquiring. There is still a lot of work to do in order to clarify the harmful effects of SB on humans and if regular PA or high levels of fitness could counteract the negative effects of SB. It seems that there is agreement in the scientific community about the harmful effect on physical, mental and cognitive health of long periods of sitting time (ST). What is still to determine is, if regular PA or a high fitness level could compensate those effects. Taking a look of the reviewed literature, most of the studies agreed that PA and SB are related factors. Independently, both are related to HRQoL. While SB is negatively related to HRQoL, PA relationship is positive. When analyzing the interaction of both factors on HRQoL, most of the studies conducted found that high levels of SB together with low levels of PA is the combination related to poorest

HRQoL. To the best of our knowledge, no studies to date have investigated the relationship of SB and fitness levels on HRQoL. This doctoral thesis aims iat clarifying this aspect (study 2). From the 8 studies centered on the relationship of SB and PA on HRQoL, only 2 had a longitudinal design. More longitudinal studies that get deeper into this subject are necessary, as the research from which the data for this doctoral thesis were obtained (study 3).

The second group of articles reviewed studied the effects of PA on HRQoL. All of the articles included, but one, agreed that the higher the PA or fitness levels are, the better HRQoL. From the 4 articles included in this group, 2 had an intervention design, 1 was a longitudinal study and the last one a cross-sectional research. Three of the 4 studies used fitness or functional fitness as a factor, while the other used PA, but none of them took in account SB as a cofactor. Anew, more longitudinal studies are needed.

The third group includes articles that analyze the effects of SB and PA on physical fitness or physical function but without relating the results to HRQoL. Articles agreed that subjects that expend less time sitting and more time at physical activities present a greater fitness or function level.

Due to elderly is associated with a natural decrease in physical capacity, to know how physical and functional fitness progress in older adults along time is crucial. The study 1 of the present thesis analyzes the evolution of physical fitness in older adult in 4 years. To set this deterioration is relevant for a better understanding of the influence of SB and PA in losses of fitness.

On the other hand, to prevent dependent living in elderly has become a priority goal in public health. Dependency situations in this population are associated with high social problems, such as elevated sanitary costs or familiar overload (100). To identify the factors that may influence that older adults reach functional limitations, functional decline or activities of daily living dependence, could be a helpful tool.

## 2. CHAPTER 2. STRUCTURE OF THE THESIS

This thesis consists of 10 chapters. Chapter 1 contents a general introduction of the whole thesis. Chapter 2 includes the structure of the thesis. Chapter 3 contains the objectives. Chapter 4 achieves the general material and methods used in the present thesis. Chapter 5 describes the comparation of handgrip tests with dynamometer in different body positions. In chapters 6 to 8, core of the thesis, are included the experimental studies presented in manuscript format meeting the requirements of the scientific journals to which they were submitted, divided in introduction, material and methods, results, discussion and conclusions. Chapter 9 includes a general discussion of the whole thesis and summarizes the main findings of the three studies. Finally, chapter 10 contains the specific and general conclusions of the thesis.

Therefore, there are some repetitions among chapters in the thesis. For the reader's benefit, references of each chapter are removed and placed at the end of the thesis.

# 3. CHAPTER 3. OBJECTIVES

**General objective**

To analyze the evolution of physical condition over time as well as the effects of ST per day, changes of SB over a 4 year period of time and different physical conditions and fitness levels on the self-reported HRQoL of a sample of 3135 Spanish older adults.

**Specific objectives**

Study 1:

- To assess the changes in physical condition in a 4 year period in a sample of community dwelling Spanish older adults.

Study 2:

- To analyze the effect of sedentary time by fitness levels on HRQoL in a sample of community dwelling Spanish older adults.

Study 3:

- To analyze the effect of changes in sedentary time in a 4 year period by fitness levels on HRQoL in a sample of community dwelling Spanish older adults.

# 4. CHAPTER 4. GENERAL MATERIAL AND METHODS

The data of this doctoral thesis were obtained from The EXERNET-longitudinal study. (Red de Investigación en Ejercicio Físico y Salud para Poblaciones Especiales)

## 4.1 The EXERNET study

The EXERNET net is focused on 4 different populations: 1) children, 2) adolescents, 3) disabled and 4) older adults. This fourth group is the main focus for this doctoral thesis. Data for this work were collected at 2 different phases of the study.

1) from the cross-sectional study on physical fitness and body composition evaluation and its relation with healthy lifestyle among non-institutionalized elderly (Acronym: EXERNET; project number: 104/2007) supported by the Institute of Social Services and the Elderly (Instituto de Mayores y Servicios Sociales - IMSERSO), under the coordination of Prof. Ignacio Ara Royo (Universidad de Zaragoza), that took place between June 2008 and November 2009. The working group was composed by six research groups belonging to six different research centers:

1. GENUD Research Group, University of Zaragoza, Zaragoza.
2. ImFINE Research Group. Department of Health and Human Performance. Faculty of Physical Activity and Sport Sciences-INEF. Technical University of Madrid. Madrid.
3. GENUD Toledo Research Group, University of Castilla-La Mancha, Toledo.
4. Unit of Sports Medicine, Cabildo of Gran Canaria, Gran Canaria.
5. AFYCAV Research Group, Faculty of Sport Sciences, University of Extremadura, Cáceres.
6. Institute of Biomedicine (IBIOMED), University of León. León.

2) A longitudinal study called "EXERNET longitudinal study: Influence of life style on physical condition involution, body composition and quality of life among non-institutionalized older adults over 65 years (Estudio Longitudinal EXERNET: Influencia del estilo de vida en el deterioro de la condicion fisica, la composicion

corporal y la calidad de vida en personas mayores de 65 años no institucionalizadas). Acronym: EXERNET; project number: (147/2011) supported by the Ministerio de Sanidad, Política Social e Igualdad-IMSERSO under the coordination of Prof. Ignacio Ara Royo (Universidad de Castilla La-Mancha), that took place between April 2011 and November 2012 and in which the same working groups participated with the exception of the Institute of Biomedicine (IBIOMED), University of León. A third phase from the longitudinal study is currently running under the coordination of Prof. Germán Vicente Rodriguez.

*4.1.1 Subject recruitment*

For the cross-sectional study, non-institutionalized elderly from 6 Regions in Spain: Madrid, Aragón, Castilla y León, Castilla- La Mancha, Extremadura and Canarias were evaluated. For the longitudinal study, only 5 regions were included: Madrid, Aragón, Castilla- La Mancha, Extremadura and Canarias.

First phase of the study

The sample was selected by means of a multi-step, simple random sampling, taking into account, first, the location that ensured the geographic and cultural diversity of the sample, then 3 different cities of each region (the capital of the region and two other cities; one of 10 000-40000 inhabitants and another of 40 000-100 000 inhabitants) and, finally, by random assignment of the civic and sports centers. For an estimated error of 2±1.5%, and a variability p=q=0.5 the established number of subjects was 3000 in order to guarantee a representative sample of the whole country. The recruitment of participants in the study was carried out by snowball sampling and invited to participate through, bulletin board at the civic and sports centers, personal communication and advertisements in local newspapers. The total number of subjects was uniformly distributed in the six initial regions and in their corresponding cities. Data collection took place from June 2008 to November 2009. After finishing the field work a total of 3136 elderly people, 724 men and 2412 women, were finally eligible for the study.

Second phase of the study

For the second phase, all the subjects that had participated in the first phase were contacted via telephone and asked if they were interested in taking part in the second phase. From the initial sample of 3136 in the first phase, 1164 (37.12%) subjects agreed to participate in the second phase. The exactly same protocol carried out in the first phase was repeated for the second phase with the exception of handgrip dynamometer test to measure handgrip strength. This test was not performed in the first phase but was included in the second phase due to the important of dynamometry and its correlation to health and mortality in old adults (101).

Drop-off reasons

Among the reasons for the subjects for not continuing, it can be cited; death (1.7%), bad health or physical problems (25.4%), not reached by telephone (35.4%), do not want to participate (7.7%), no free time for it (14.4%), do not have possible transportation (0.3%) or others (15.2%). If summarized, the health-related reasons for not participating (death, health problems or do not want to participate), the dropping off percentage rises to 34.8%.

### *4.1.2 Study design*

All the data were collected on the same day by the following order: First, filling in the questionnaire by personal interviews. The questionnaire consisted in a first part of different questions about lifestyle habits, PA practice and personal items (income, educational level, marital status, etc.) and a second part consisted on the EuroQol EQ-5D-3L (EQ-5D-3L) and the EQ-Visual Analogue Scale (EQ VAS). Secondly, a physical examination and body composition measurements were performed. After the initial physical examination, a bio-impedance analysis was also performed. The last part was the physical tests performance. The physical tests used in the present study were executed in the same order by all the subjects.

### *4.1.3 Ethical issues*

All applicable institutional and governmental regulations concerning the ethical issues of human volunteers were followed during this study. The study was performed according to the principles established with the Declaration of Helsinki (1964) as revised in 2000 in Edinburgh, and approved by the Research Ethics Committees of

Aragón (Spain) (18/2008). All participants were informed by letter about the nature and purpose of the study (Appendix). Written informed consent was obtained from each participant in both phases (Appendix).

The exclusion criteria for the first phase were: people aged < 65 years; those suffering from cancer and/or dementia; those who were living in nursing homes and/or were not independent or able to take care of themselves; and those subjects using walking aids**.** For the second phase, the inclusion criterion was to have participated in the first phase.

### *4.1.4 Materials and Equipment*

The materials and equipment used to collect the data for the study are listed below in Table 5.

Table 5. Materials and equipment used to collect the data and analysis.

| | **Type of analyses** | **Equipment/Materials** | **Manufacturer/Battery** |
|---|---|---|---|
| ***For the health status*** | Health Relative of Quality of Life | EuroQoL 5D-3L questionnaire Spanish version. | EuroQol Group. |
| ***For anthropometric and body composition*** | Weight and body composition. Bioimpedance | TANITA BC-418 | Tokyo, Japan |
| | Height | Portable stadiometer | SECA Hamburg, Germany |
| | Waist and hip circumferences | Flexible non-elastic measuring tape | (Rosscraft) ISAK society |
| ***For physical fitness*** | Static balance | Stopwatch | Jonhson & Nelson |
| | Lower body strength | Standardized chair (Height = 43.18 cm) and stopwatch | |
| | Upper body strength | Dumbbells (2.5kg for women and 4kg for men) and stopwatch | |
| | Lower body flexibility | Standardized chair (Height = 43.18 cm) and a ruler of 40 cm | |
| | Upper body flexibility | A ruler of 40 cm | |
| | Agility/Dynamic balance | Standardized chair (Height = 43.18 cm), a cone, measuring tape and stopwatch | |
| | Walking speed | 4 cones, measuring tape and a stopwatch | |
| | Aerobic capacity | 7 cones, measuring tape and a stopwatch | |
| | Handgrip strength | Hand Grip Digital Dynamometer | Takei 5401Takei Scientific instruments Co., Ltd. No.619, Yashiroda, Akiha-ku, |

| | | | |
|---|---|---|---|
| | | | Niigata-City, Niigata-Pref. 956-0113, Japan). |

*4.1.4.1 General information*

The information was collected through personal interviews using a structured questionnaire that includes personal information and current and former lifestyle habits (Appendix 1).

*4.1.4.2 Assessment of Health- Related Quality of Life (HRQoL)*

HRQoL was assessed using the Spanish version of the EuroQol-5D-3L questionnaire (EQ-5D-3L) which is a common tool used in elderly people. (Appendix).The EQ-5D-3L consists of two parts, the EQ-5D-3L descriptive system and the EQ visual analogue scale (EQ_VAS). The EQ-5D-3L first part assesses five dimensions, namely mobility, self-care, usual activities, pain-discomfort, and anxiety-depression. The respondent is asked to indicate his/her health state in each of the five dimensions according to one of three levels: “no problems”, “moderate problems”, or “severe problems”. The responses in each dimension were also collapsed into a two-tier variable consisting of “I perceive problems” and “I do not perceive problems”. The scores obtained at the 5-dimensions part, can also be quantitative measured in the “Time Trade Off” scale (TTO). The results, scored from 1 to 3 in each dimension, are transformed using an excel program (http://www.euroqol.org/about-eq-5d/valuation-of-eq-5d/eq-5d-5l-value-sets.html) into a value from 0 (worst score possible) to 1 (best score possible in the TTO scale). The EQ_VAS records the respondent’s self-rated health on a 20cm vertical, visual analogue scale where the endpoints are ranged “Best imaginable health state” (100 points) and “Worst imaginable health state” (0 points). This information can be used as a quantitative measure of health outcome as judged by the individual respondents. The EQ_VAS was used to assess the perceived health of each subject at that moment, establishing values equal to or more than 80 points as a good indicator of perceived health (Appendix). For the purpose of this doctoral thesis, the EQ_VAS was not used.

*4.1.4.3 Assessment of Sedentary Behavior and Sitting Time*

To assess the SB of the sample in study 2, the cross-sectional one, a specific question was included in the structured questionnaire. The ST per day was stratified into 3 levels: level 1 (ST1) was assigned to ST < 2 h/day, level 2 (ST2) was assigned to ST from 2 to 4 h/day and level 3 (ST3) was assigned to ST > 4 h/day.

To measure the SB changes of the sample in the longitudinal study, that is the study 3, subjects answered the same question again in the questionnaire from phase 2. Three levels were taken into account according to the modification in ST from results of the first and second phase. Level 0 (SB0) was set for no change in ST from the first phase to the second phase, level 1 (SB1) was set for decreasing ST from phase 1 to phase 2, that means improving SB and level 2 (SB2) was set for increasing ST from phase 1 to phase 2, what means worsen SB.

*4.1.4.4 Assessment of anthropometric measures and body composition*

Weight was measured without heavy clothing and without shoes with an electronic scale (Type TANITA BC-418, Tokyo, Japan) to the nearest 100 g, and height was measured in barefoot positioning the subjects' head in the Frankfort plane with a portable stadiometer with 2.10 m maximum capacity and a 0.001 m error margin (Type SECA, Hamburg, Germany). Body mass index (BMI was calculated as body weight in kg divided by the square of height in m. Waist and hip circumferences were measured in centimeters with a flexible non-elastic measuring tape (Rosscraft) to the nearest millimeter, according to the methods of the ISAK society. Individuals were in a standing position with feet together and arms resting by their sides. Waist circumference (WC) was taken as the narrowest point between the inferior rib border and the iliac crest. The hip circumference (HC) measurement was taken at the point yielding the maximum circumference over the buttocks, with the tape held in a horizontal plane. Waist-to-hip ratio was calculated by dividing WC (cm) by HC (cm). Training workshops were organized to harmonize the assessment of anthropometric measurements before starting the first phase of the study. These anthropometric measurements were validated in the phase 1 by the investigators in a random sample of 100 persons. Intra-observer reliability values were greater than 99% for height and WC and interobserver reliability for both measurements were greater than 97% and 87%, height and WC, respectively. The complete harmonization process and reliability assessment has been previously published by Gómez-Cabello et al. (102).

*4.1.4.5 Assessment of body mass, percentage of fat mass and muscle mass*

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 body mass, percentage of body fat (%BF) and the muscle mass. Individuals removed shoes, socks and heavy clothes prior to weighing. Bioimpedance analysis is inexpensive, easy to use and readily reproducible. Prediction equations have been validated for multiethnic adults and reference values established for adult white men and women, including elderly people (102).

*4.1.4.6 Assessment of physical fitness*

An extended and detailed manual of operations was designed for and thoroughly read by every researcher involved in the field work before the data collection started in both phases (Appendix). In addition, a workshop training week was carried out in Toledo (Spain) in June 2008, in order to standardize and harmonize the assessment of the physical fitness tests. During this workshop, physical fitness tests measurement was standardized. For interobserver assessment, we studied 10 elderly from the same city in Toledo. During the same morning, these elderly were measured at the same time by each of the five observers while doing the physical fitness test. The field workers were strongly advised to always perform the same fitness test in order to minimize the potential inter-rate variability within each centre. The instructions given to the participants in every test were standardized to ensure that the same verbal information was given to all participants. Health-related physical fitness components that is, muscular strength, balance, flexibility speed/agility and aerobic capacity, were assessed by the physical fitness tests described below. The scientific rationale for the selection of all of these tests has been published earlier and has been validated in elderly population. The following physical fitness components were assessed: static balance by the “one leg test”, lower and upper body strength by the “chair stand test” and “arm curl test”, respectively, lower and upper body flexibility by the “chair sit-and-reach test” and “back scratch test”, respectively, agility/dynamic balance by the “8-foot up-and go test”, speed by the “30-meter walk test” and aerobic endurance by the “6-minute walk test” (See Appendix). All the tests were performed only once, except the “one leg test”, which was performed twice with each leg, the “8-foot up-and-go test” and the “30-m walk test”, which were also performed twice. On the other hand, in the “arm curl test”, battery establishes that women and men should use 5-lb and 8-lb dumbbells, respectively. However, in Spain the basic weight measure is the kilogram; therefore, subjects used 2.5 and 4 kilograms, respectively (103).

*4.1.4.7 Statistical analysis*

The analysis of the data was performed with the Statistical Package for Social Sciences (SPSS) version 20.0 for Windows (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.). Descriptive statistics are shown as mean ± standard deviation (SD) unless otherwise stated. Statistical significance level was set at P-values <0.05. The detailed description of statistic procedure is presented in each study.

# 5. CHAPTER 5. Comparison of handgrip strength performance according to different initial body positions in elderly.

## 5.1 INTRODUCTION

Dynamometer tests are non-invasive, inexpensive, fast and simple to execute. The simplicity in the portability of the device makes the tests very accessible for any kind of research. On the other hand, due different physical problems, elderly are often limited to perform the test in a standing position, which some studies have demonstrated to obtain the highest scores comparing to sitting or lying position (104).

Handgrip strength has been identified as an important predictor of health-related outcomes in older adults, such as frailty, disability and mortality (105), as low values in handgrip tests are associated with falls, impaired health-related QoL and prolonged length of stay in hospital (106). Low levels of handgrip strength are considered one of the major characteristics of frailty (107). Some studies have shown that adults might need help or are unable to perform heavy tasks with their hands at an earlier age than activities related with aerobic capacity (AC) such as walking or climbing stairs (108, 109).

In relation to the handgrip performance, there are several studies in the literature that have analyzed the influence of the body position during the test performance. Some of these investigations have examined the influence of the elbow position during the test (104, 110). Other studies have focused on the body position comparing lying, sitting or standing (111, 112). It relation to this, it seems to be an agreement that the highest scores in dynamometer tests can be reached with the subject in a standing position with the elbow in full extension when performing the test with the dominant hand (113-115).

As dynamometry could be especially useful to identify older adults at risk for developing dependence, it is important to know the best and most effective way to perform the measurement in this population group and even more, to clarify the correlation between the results of dynamometry in the different body position. It is important to standardize the protocols in order to prevent errors that could lead to a wrong interpretation of the results. The different values obtained according to the protocol and body positions used, could hinder the data comparison in between different researches. Thus, as these data are missing in older adults, to validate the dynamometer tests in different body position could be useful. This doctoral thesis studied the dynamometer test results comparing handgrip tests in a standing and a sitting position in a population of non-institutionalized Spanish elderly from the EXERNET-longitudinal study. Ultimately, results of this study may help adequately measuring upper-extremity strength despite some physical limitations that can be found in aged populations and can also help a better understanding of the physical condition status of our sample.

As handgrip strength has been identified as an important predictor of health-related outcomes in older adults, such as frailty, disability and mortality (105), and low values in handgrip tests are associated with falls, impaired HRQoL, frailty (107) and prolonged length of stay in hospital (106), to validate dynamometry in different body position could help researchers to maximize the results.

## 5.2 METHODS

### 5.2.1 Study sample

For this study, only the sample from the region of Madrid of the EXERNET multi-center longitudinal study was included. A total of 207 subjects (72 males, 135 females) aged 68 and older volunteered to be included.

### 5.2.2. Anthropometric measures

Weight, height and BMI were calculated.

### 5.2.3. Handgrip assessment.

Four different hand-grip strength tests were performed twice with the elbow full extended (right and left hand, in standing and sitting position) with a Takei 5401 Hand Grip Digital Dynamometer (Measuring range: 5.0 to 100 kgf, minimum measurement unit: 0.1 kgf. Japan). The four tests were measured in all volunteers as follow; first, right hand in standing position (RHSTD) followed by left hand in standing position (LHSTD), twice, and then right hand in sitting position (RHSIT) and left hand in sitting position (LHSIT) two times as well. After the sign of "Go", the subjects pressed the dynamometer as hard as possible. After 3 seconds, the subjects stopped the pressure and the highest score stayed recorded in the device. Between tests, volunteers rested for one minute. The best score from the two recorded from each hand and body position was used for the study. When subjects were not able to perform the test in a concrete body position or with a specific hand, the other tests were measured anyway. Scores from the 4 tests performed (RHSTD, LHSTD, RHSIT and LHSIT) as well as maximal strength in standing (MxSTD) and maximal strength in sitting position (MxSIT), and sum of both sides in standing position (∑STD) and sum of both sides in sitting position (∑SIT) were analyzed for the study.

5.2.4. Statistical analysis.

Chi$^2$ test as contingency table to test the association and independency of the variables was performed. Bivariate correlation algorithms by Pearson correlation were used to establish the independency and correlation of the different tests. Due to differences in strength depending on sex (as reported in the literature) the sample was divided by sex. Significance was set at $p<0.05$.

5.3 RESULTS

Seventy-two men and 135 women participated in the study. Mean age was 74.7±6.9 years, 74.9±4.4 years for men and 74.5±4.5 years for women. Descriptive statistics values are shown in Table 6.

Table 6. Descriptive statistics values

| | **N** | **AGE** | **WEIGHT** | **HEIGHT** | **BMI** |
|---|---|---|---|---|---|
| MEN | 72 | 74.9±6.91 | 73.58±11.29 | 159.41±8.79 | 28.89±3.08 |
| WOMEN | 135 | 74.5±4.41 | 69.75±10.30 | 154.31±7.46 | 29.19±4.20 |
| TOTAL | 207 | 74.7±4.48 | 71.12±10.79 | 156.14±8.31 | 29.08±3.83 |

All values in Mean±SD

The highest scores were obtained, in both sexes with RHSTD, (31.97±7.0 kg for men and 19.76±5.7 kg for women) while the lowest results were obtained with LHSIT, (29.65±6.81 Kg for men and 18.04±4.64 Kg for women). Mean values from RHSTD, LHSTD, RHSIT, LHSIT, MxSTD, MxSIT, ∑STD and ∑SIT are shown in Table 7.

Table 7. Mean values from dynamometer tests.

| SEX | RHSTD | LHSTD | RHSIT | LHSIT | MxSTD | MxSIT | ∑STD | ∑SIT |
|---|---|---|---|---|---|---|---|---|
| MEN | 31.97±7.03 | 30.63±7.51 | 31.59±6.68 | 29.65±6.80 | 32.67±7.00 | 32.19±6.56 | 62.68±14.10 | 61.23±12.89 |
| WOMEN | 19.76±5.63 | 18.54±5.20 | 19.11±5.54 | 18.04±4.94 | 20.33±5.45 | 19.64±5.34 | 38.25±10.49 | 37.13±10.18 |

RHSTD: right hand in standing position, LHSTD: left hand in standing position, RGSIT: right hand in sitting position, LHSIT: left hand in sitting position, MxSTD: maximal score in standing position, MxSIT: maximal score in sitting position, ∑STD: sum in standing position, ∑SIT: sum in sitting position.

Contingency tables presented a $p<0.005$ in all cases. Right and left handgrip tests presented dependent correlation between both standing and sitting positions. The highest Pearson correlation was found in men in ∑STD with MxSTD (r=0.98) and in women in ∑SIT with MxSIT (r=0.99). For a greater utility of the results, only homogeneous variables were taken into account. Pearson correlation tests showed a positive correlation in men in RHSTD with RHSIT (r=0.95), in LHSTD with LHSIT (r=0.96, in MxSTD with MxSIT (r=0.96) and in ∑STD with ∑SIT (r=0.97) (all $p<0.001$). In women, a positive Pearson correlation was found in RHSTD with RHSIT (r=0.94), in LHSTD with LHSIT (r=0.92), in MxSTD with MxSIT (r=0.94) and in ∑STD with ∑SIT (r=0.95) (all $p<0.001$).The poorest correlation was found in men in RHSIT with LHSTD (r=0.83) and in women in RHSTD with LHSIT (r=0.83). The strongest correlation of these combinations appeared to be in both sexes in ∑STD with ∑SIT (all $p<0.001$). Results from correlations values among body positions are shown in Table 7.

Table 8. Pearson correlation between tests by sexes. P=0.000 in all cases

| Male | RHSTD | LHSTD | RHSIT | LHSIT | MxSTD | MxSIT | ∑STD | ∑SIT |
|---|---|---|---|---|---|---|---|---|
| RHSTD | 1 | | | | | | | |
| LHSTD | .882 | 1 | | | | | | |
| RHSIT | .950 | .826 | 1 | | | | | |
| LHSIT | .857 | .959 | .825 | 1 | | | | |
| MxSTD | .976 | .933 | .923 | .888 | 1 | | | |
| MxSIT | .949 | .879 | .978 | .880 | .955 | 1 | | |
| ∑STD | .967 | .972 | .914 | .939 | .982 | .941 | 1 | |
| ∑SIT | .946 | .933 | .956 | .954 | .949 | .973 | .970 | 1 |
| Female | RHSTD | LHSTD | RHSIT | LHSIT | MxSTD | MxSIT | ∑STD | ∑SIT |
| RHSTD | 1 | | | | | | | |
| LHSTD | .863 | 1 | | | | | | |
| RHSIT | .940 | .874 | 1 | | | | | |
| LHSIT | .830 | .923 | .895 | 1 | | | | |
| MxSTD | .975 | .921 | .926 | .870 | 1 | | | |
| MxSIT | .919 | .914 | .976 | .948 | .939 | 1 | | |
| ∑STD | .968 | .960 | .943 | .907 | .984 | .951 | 1 | |
| ∑SIT | .912 | .921 | .977 | .969 | .924 | .989 | .951 | 1 |

RHSTD: right hand in standing position, LHSTD: left hand in standing position, RGSIT: right hand in sitting position, LHSIT: left hand in sitting position, MxSTD: maximal score in standing position, MxSIT: maximal score in sitting position, ∑STD: sum in standing position, ∑SIT: sum in sitting position.

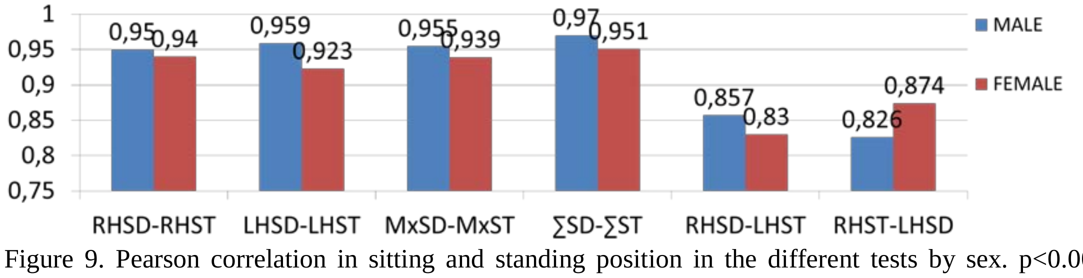



Figure 9. Pearson correlation in sitting and standing position in the different tests by sex. $p<0.001$ in all cases.

## 5.4 DISCUSSION

Handgrip strength tests can be a very helpful method to assess the integrity of upper extremity function in relation to everyday activities dependence (108, 112, 116). On the other hand, dynamometer tests can also predict functional limitations, functional decline and mortality (100).

According to the results obtained from the sample of this study, the highest scores were obtained, in both sexes with RHSTD and the lowest results were found with LHSIT. These results agree with other studies that also found higher scores in dynamometer tests performed with the right hand in standing position (104, 112, 113). In the study of Liao et al. (104) three different test positions with the same dynamometer were measured and compared; sitting with the elbow at 90º, standing with the elbow at 90º and standing with the elbow full extended. Results from this study showed that data from the sitting and standing positions with thr elbow at 90º were not significantly different, while scores from test in a standing position with the elbow full extended were significantly higher. This study did not take into account the relationship between the positions of sitting and standing with the elbow full extended. That could mean that the significant different found between measurements in a sitting position with the elbow at 90º and in a standing position with the elbow full extended were mainly due to the elbow and not to the body position. On the other hand, there are some works in the literature that studied the relationship between strength in the dominant and the non-dominant hand. The study from Werle et al (115) showed lower values in the non-dominant hand in a Swiss population.

In the present study, the correlation of all the different tests performed was extremely high (the lowest score was r=0.83, the highest score was r=0.99). This could be interpreted as when the upper extremity position is maintained with the elbow in full extension, there are no significant differences in the values obtained with the body in a standing or sitting position. These results are in concordance with the results from Richards (112). In order to be able to compare the results from different subjects when it is not possible to perform all the tests in the same testing position, results from the present study support that the best correlation between body position is the sum of both hands in standing and sitting positions in both sexes. In the case that subjects could not perform the test with a concrete hand, the options to avoid should be with RHSTD-LHSTD for male subjects and RHSIT. LHSIT for women (r=0.88 and r=0.90, respectively).

In spite of this fact, it could easily happen that elderly are not able to perform the handgrip test with a concrete hand or in a particular position, which limits the options of researchers. In order to minimize such errors, the best correlation between measurements should be used.

## 5.5 CONCLUSION

The highest scores for hand grip dynamometry are obtained with elderly subjects in a standing position with the elbow full extended when tests are performed with the dominant hand. If elderly subjects have limitations in performing dynamometry in a standing position or with the dominant hand, an optimal correlation between other measurement options should be taken into account. According to the present study, the most optimal correlation was found with the sum of both hands in a standing and sitting position. That means that when subjects are not able to perform the dynamometry test in a standing position, the data to be used should be the sum of both hands in sitting position.

**6. CHAPTER 6. STUDY 1:** Evolution of physical fitness in a 4 year period of a Spanish sample of older adults from the EXERNET longitudinal study.

6.1 Abstract

Background: Active aging is defined as the process of optimizing opportunities for physical, social and mental health throughout life. One of the factors for achieving successful aging is maintaining high physical function. Fitness assessment tests in older people should be able to determine the real capacity of the individual to perform properly activities of daily living. Due to disability rate increases with age, 50% of the Spanish people over 80 years of age have problems to perform independently daily activities. The purpose of this study was to determine sex- and age-specific physical fitness changes in a four-year period in Spanish elderly.

Methods: 1,164 subjects (835 females and 246 males) older adults from the EXERNET longitudinal study participated in the study. The SFT battery, the one leg test and the 30 m walk test were performed at two different moments in the interval from 2008 and 2012. Anthropometric data were also collected. Subjects were classified in four different age groups: AG1 subjects from the lowest age till 69 years, AGR2 subjects from 70 till 74 years, AGR3 subjects from 75 till 79 years and AGR4 subjects from 80 years and older. Means and standard deviation were obtained from covariates and age. Comparison between groups was examined with repeated measure ANOVA.

Results: Males from AGR1 showed significant poorer scores at follow-up in speed and endurance ($p<0.05$) and those from AGR3 in agility and arm flexibility tests. In females, higher results were found in leg strength from AGR1, AGR2 and AGR4 and in arm strength in all of the AGR while lower scores were collected in arm flexibility from AGR2, AGR3 and AGR4, in agility from AGR3 and AGR4 and in speed and endurance from all AGR (all $p<0.05$).

Conclusion: Physical condition evolution is sex and age dependent, although to stay physically active could help maintaining or reducing the negative effects of aging. Balance and leg flexibility remained stable during the follow-up study. Leg and arm strength

increased in women but arm flexibility, agility, speed and endurance decreased. Agility and endurance decreased in men

## 6.2 Introduction

Since the WHO introduced the term active aging in the late 90´s, many studies have tried to understand the main factors influencing this process. Active aging is defined as the process of optimizing opportunities for physical, social and mental health throughout life (9). Physical deterioration due to aging is a natural process in life. To know how life style influences this natural process can help to determine the levels of fitness needed to maintain daily living independence in elderly as well as a good QoL. One of the factors for achieving successful aging is maintaining high physical function.

Fitness assessment tests in older people should be able to determine the real capacity of the individual to perform properly activities of daily living (housekeeping, shopping, participating in social and recreational activities, sports, etc.) (65) by maintaining strength, endurance, flexibility and sufficient mobility (103) as well as to keep a QoL that allows this population to live plenty. Many researchers have studied and analyzed the relationship between PA levels, different lifestyles and health-related issues in the elderly (68, 117, 118) However, few studies have tried to determine fitness levels in Spanish elderly and how it is related to their HRQoL (119). In 2004, one study was published where data on a representative sample of non-institutionalized Spanish elderly showed that PA levels are associated with a higher HRQoL (119). In 2012, data from the EXERNET cross-sectional study provided sex-and age-specific physical fitness normative values for independent and non-institutionalized Spanish elderly. The normative values of the article show an important tool of evaluation and correct interpretation of Spanish elderly fitness status, helping to identify elderly with low physical fitness (103). In 2015, Pedrero-Chamizo et al. (120) published a study showing that higher levels of physical fitness were associated with better perceived health among older adults.

In Spain, elderly population has tripled in the last 100 years (121). In 1900, 5.2% of the Spanish population was over 65 years (0.6 over 80 years old), in 2015 this percentage raised to 18.4% (5.8% over 80 years) and the estimated data for 2050 are 36.5% and 15.3% for people over 65 and 80 years, respectively (122). Life expectancy has increased in Spain from 34.8 years in 1900 to 82.9 years in 2016 (123). It is well known that age is related to a decline of PA and physical capacity in general (124-126). Due to disability rate increases with age, 50% of the Spanish over 80 years old have problems to perform independently daily activities, what affects directly to their HRQoL. As the population in Spain continues to age, gerontologists, exercise scientists and clinicians will continue to investigate the inevitable decline in functional fitness and possible methods to attenuate this decline. However, the absence of published reference values in the Spanish population keeps speculating on what the outcome or the development of this population in the coming years will be.

The elderly longitudinal EXERNET multi-center study provides a unique opportunity to establish the evolution in time of physical condition levels in the Spanish elderly population using a common and well-standardized method of measurement. The purpose of this study was to determine sex- and age-specific physical fitness changes in a four-year period in Spanish elderly.

## 6.3 Methods and material

The longitudinal data used for this work were obtained from “The EXERNET-longitudinal study”. The protocol of the EXERNET study has been published elsewhere (103, 127).

### 6.3.1 Study sample

A total of 1,164 subjects (835 females and 246 males) participated in the longitudinal study. Those who volunteered, were asked to perform the same exactly protocol as in the first phase.

### 6.3.2 Study protocol

The protocol was carried out as follow: 1) filling in the questionnaire specifically designed for the study by personal interviews with questions about lifestyle habits, PA practice and socio-economic items (income, educational level, marital status, etc.). 2) Blood pressure, heart rate, height and hip and wrist perimeters were measured as part of the physical examination followed by a body composition test by bio-impedance analysis, 3) the physical tests battery performed by all the subjects in the same order. All the data were collected on the same day.

To make maximum use of the data, all valid data on physical fitness tests were included in this report. Consequently, sample sizes vary for the different physical fitness tests.

6.3.3 Physical fitness assessment

The following physical fitness components were assessed: static balance by the one leg test (128), lower and upper body strength by the chair stand test and arm curl test, respectively (65), lower and upper body flexibility by the chair sit-and-reach test and back scratch test, respectively (65), agility/dynamic balance by the 8-foot up-and-go test (65), speed by the 30-m walk (129) and aerobic endurance by the 6-min walk test (62). All the tests were performed only once, except the one leg test, which was performed twice with each leg, the 8-foot up-and-go test and the 30-m walk test, which were also performed twice.

6.3.4 Anthropometric measures and body composition

Anthropometric data were also collected to describe the sample (weight, height and BMI). Body composition was measured by bio impedance technique.

6.3.5 Socio-economic factors or questionnaires

In order to describe the sample, socio-economic factors (sex, age, marital status, educational level, income, regular PA practice and walking time and time spent on daily activities a day) were included in the questionnaire designed in the first phase specifically for the EXERNET multi-center study. The same questions were answered by the individuals in both first and second phase.

6.3.6 Statistical Analysis

Descriptive values were analyzed as means and standard deviation (SD) both at phase 1 and phase 2. Mean difference and 95% CI were also analyzed. All variables were considered to follow a normal distribution after testing the histograms. Comparison between phases was examined with repeated measure ANOVA with a modification in the analysis sintaxis in order to obtain all pairs combinations. Covariates as mentioned above were taken into account and included in the model. A Bonferroni adjustment for multiple comparisons was applied. The sample was splitted by sex to set the differences in physical condition independently. In order to adjust the changes in physical condition in the 4 year longitudinal period to the different ages, the sample was splitted into 4 AGR (as specified in the bibliography) as following, taking into account the age of the subjects in the first phase: AGR1 subjects from the lowest age till 69 years, AGR2 subjects from 70 till 74 years, AGR3 subjects from 75 till 79 years and AGR4 subjects from 80 years and older. IBM SPSS Statistics 20.0 software was used to analyze the data (IBM Corp. Released

2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.), and statistical significance level was set at $p<0.05$.

## 6.4 Results

A total sample of 1,164 (264 male) participated in the present longitudinal study. Descriptive values for the total sample as well as by sex at baseline and follow up are shown in Table 9.

**Table 9.** Total sample characteristics and by sex at baseline and follow-up. Values showed as Means (SD). **n=1,164**

| | Total | | Male | | Female | |
|---|---|---|---|---|---|---|
| | Baseline | Follow up | Baseline | Follow up | Baseline | Follow up |
| Age (y) | 71.50 (5.01) | 74.26 (4.99) | 71.06(4.89) | 73.86(4.94) | 71.63(5.03) | 74.38(5.00) |
| Gender (Male) | 264 (22.7%) | 264 (22.7%) | | | | |
| Height (cm) | 155.64 (8.12) | 155.36 (8.09) | 160.30(9.22) | 159.91(9.07) | 154.23(7.18) | 153.99 (7.24) |
| Weight (Kg) | 70.51 (10.88) | 70.29 (11.08) | 72.77(10.14) | 72.71(10.43) | 69.82(11.01) | 69.59(11.18) |
| BMI ($Kg/m^2$) | 29.12 (4.09) | 29.11 (4.17) | 28.33(3.39) | 28.44(3.63) | 29.36(4.26) | 29.31(4.30) |
| Fat Mass, % | 37.08 (6.84) | 37.05 (6.88) | 33.41(7.57) | 33.21(7.48) | 38.20(5.18) | 38.23(6.23) |
| Physically active (%) | 86.4 | 80.0 | 76.3 | 71.0 | 89.3 | 82.7 |
| Educational status (%) | | | | | | |
| Primary or lower | 83.90 | 86.90 | 78.8 | 81.6 | 85.4 | 85.4 |
| Secondary or higher | 16.10 | 13.11 | 21.2 | 18.4 | 14.6 | 14.6 |
| Marital Status (%) | | | | | | |
| Single | 4.50 | 4.30 | 2.3 | 2.0 | 5.2 | 5.0 |
| Married | 63.90 | 62.0 | 88.5 | 89.1 | 56.7 | 54.1 |
| Divorced | 3.10 | 2.80 | 3.8 | 3.2 | 2.9 | 2.7 |
| Widow | 28.40 | 30.71 | 5.4 | 5.2 | 35.2 | 38.2 |
| Income (%) | | | | | | |
| <600€/month | 42.14 | 32.9 | 29.3 | 20.6 | 45.8 | 36.5 |
| 600-900€/month | 33.90 | 38.3 | 38.0 | 36.8 | 32.7 | 38.7 |
| >900€/month | 24.00 | 28.8 | 32.8 | 42.6 | 21.5 | 24.8 |

Mean differences from follow up minus baseline with the 95% CI by sex and sex and AGR are presented in Table 10 11 respectively.

Table 10. Mean difference from follow up minus baseline values with 95% confidence intervals (CI) and $Eta^2$ parcial for the difference by sex.

| | Male | Female | $\eta^2_p$ |
|---|---|---|---|
| Balance | -3.13 | -0.36 | |
| | (-7.55/1.30) | (-2.18/1.45) | **0.001** |
| Leg Strength | -0.54 | **0.51*** | |
| | (-1.33/0.25) | **(0.17/0.85)** | **0.006** |
| Arm strength | 0.16 | **1.26*** | |
| | (-0.74/1.06) | **(0.87/1.65)** | **0.005** |
| Leg flexibility | -0.30 | 0.19 | |
| | (-2.14/1.54) | (-0.59/0.97) | **0.000** |
| Arm flexibility | -1.04 | **-1.79*** | |
| | (-2.55/0.49) | **(-2.45/-1.14)** | **0.001** |
| Agility | **0.37*** | **0.31*** | |
| | **(0.07/0.67)** | **(0.18/0.44)** | **0.000** |
| Speed | 0.51 | **0.79*** | |
| | (-0.9/1.12) | **(0.53/1.05)** | **0.001** |
| Aerobic capacity | **-20.78*** | **-22.21*** | |
| | **(-37.38/-4.18)** | **(-29.06/-15.35)** | **0.000** |

Bonferroni adjustment. **Significance: * p<0.05.** Negative values indicate decrease, positive values indicate improvement.

Table 11. Mean difference from follow up minus baseline with 95% confidence intervals (CI) and Eta2 parcial for the difference by sex and AGR.

| | Male | | | | Female | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | AGR1 | AGR2 | AGR3 | AGR4 | AGR1 | AGR2 | AGR3 | AGR4 | $\eta^2_p$ |
| Balance | -1.73 (-5.75/2.29) | -2.54 (-7.37/2.29) | -2.36 (-8.48/3.76) | -5.87 (-20.59/8.84) | -0.09 (-2.34/2.17) | -0.06 (-2.56/2.43) | 0.78 (-2.30/3.87) | -2.09 (-7.55/3.36) | 0.000 |
| Leg Strength | 0.23 (-0.51/0.98) | -0.52 (-1.42/0.39) | -0.52 (-1.68/0.64) | -1.37 (-3.95/1.22) | **0.54*[1] (0.12/0.96)** | **0.76*[1] (0.29/1.23)** | -0.32 (-0.90/0.27) | **1.05*[1] (0.02/2.08)** | **0.005** |
| Arm strength | 0.30 (-0.54/1.14) | -0.12 (-1.16/0.92) | -0.01 (-1.31/1.98) | 0.46 (-2.48/3.40) | **1.26*[1] (0.78/1.74)** | **1.42*[1] (0.89/1.96)** | **0.84*[1] (1.18/1.50)** | **1.51*[1] (0.35/2.67)** | **0.001** |
| Leg flexibility | -0.19 (-1.92/1.53) | -0.64 (-2.75/1.46) | 1.06 (-1.77/3.90) | -1.42 (-7.37/4.53) | -1.19 (-1.92/1.53) | -0.64 (-2.75/1.46) | 1.06 (-1.77/3.90) | -1.42 (-7.37/4.53) | 0.002 |
| Arm flexibility | -0.27 (-1.73/1.14) | -0.95 (-2.70/0.80) | **-3.32*[2] (-5.51/-1.12)** | 0.42 (-4.53/5.37) | -0.65 (-1.45/0.16) | **-1.51*[2] (-2.40/-0.62)** | **-1.80*[2] (-2.92/-0.69)** | **-3.20*[2] (-5.18/-1.22)** | **0.004** |
| Agility | 0.23 (-0.05/0.51) | 0.32 (-0.03/0.66) | **0.64*[2] (0.20/1.07)** | 0.30 (-0.69/1.29) | -0.05 (.0.21/0.11) | **0.06*[2] (-1.12/0.24)** | **0.36*[2] (0.14/0.58)** | **0.87*[2] (0.49/1.26)** | **0.003** |
| Speed | **0.70*[2] (0.12/1.28)** | 0.25 (-0.46/0.95) | 0.12 (-0.83/1.07) | 0.99 (-0.96/2.95) | **0.34*[2] (0.01/0.66)** | **0.59*[2] (0.23/0.95)** | **0.88*[2] (0.43/1.33)** | **1.36*[2] (0.59/2.14)** | **0.005** |
| Aerobic capacity | **-19.24*[2] (-34.14/-4.33)** | -14.06 (-32.14/4.01) | -9.23 (-34.18/15.72) | -40.60 (-95.29/23.89) | **-15.41*[2] (-23.89/-6.94)** | **-19.99*[2] (-29.38/-10.59)** | **-31.78*[2] (-44.44/-21.13)** | **-20.65*[2] (-41.29/0.00)** | **0.005** |

Bonferroni adjustment. **Significance: * p<0.05. [1]: improve, [2]: decrease (in the results from baseline to follow up). AGR: Age groups. AGR1 subjects from the lowest age till 69 years, AGR2 subjects from 70 till 74 years, AGR3 subjects from 75 till 79 years and AGR4 subjects from 80 years and older.**

Consistently, results show a decline in physical capacity due to age as the results of the different AGR reflect. In almost every test performed, poorer scores were measured in older subjects respect the younger ones. Results from the 8 tests at baseline and follow-up for male and female by AGR are presented in Table 12 and Table 13, respectively, and in figures 10 to 17.

Table 12. Male Min and Max values with mean (SD) and 95% CI from the 8 fitness tests by age groups at baseline and follow-up

| MALE | BASELINE | | | | FOLLOW-UP | | | |
|---|---|---|---|---|---|---|---|---|
| Test (n) | AGR1(n=117) | AGR2(n=69) | AGR3(n=53) | AGR4(n=12) | AGR1 | AGR2 | AGR3 | AGR4 |
| Balance (sec) (1093) | 2.16-60<br>36.74(21.84)<br>-2.30/5.75 | 0-60<br>33.43(21.17)<br>-2.30/7.37 | 0.63-60.0<br>28.27(21.08)<br>-3.73/8.48 | 1.79-60.0<br>21.31(22.56)<br>-8.84/20.59 | 0.09-60.0<br>38.69(20.74) | 1.70-60<br>29.22(21.83) | 0.0-60.0<br>28.87(21.58) | 0.0-60.0<br>19.52(20.04) |
| Leg strength (rep) (1094) | 8-25<br>15.10(3.06)<br>-0.98/0.51 | 7-22<br>15.46(3.09)<br>-0.39/1.42 | 6-21<br>14.75(3.18)<br>-0.64/1.68 | 9-20<br>13.33(3.96)<br>-1.22/3.95 | 8-28<br>16.11(4.03) | 5-25<br>14.95(3.43) | 4-24<br>15.18(3.64) | 7-27<br>13.92(3.91) |
| Arm strength (rep (1096)) | 10-30<br>17.59(3.28)<br>-1.14/0.54 | 12-31<br>18.04(3.46)<br>-0.92/1.16 | 9-25<br>17.04(3.80)<br>-1.16/0.92 | 11-22<br>15.83(3.69)<br>-3.40/2.48 | 13-28<br>18.04(3.61) | 10-28<br>17.85(3.79) | 6-27<br>17.37(4.10) | 4-28<br>16.47(4.70) |
| Leg flexibility (cm) (1095 | -34.0/22.0<br>-4.56(11.09)<br>-1.53/1.92 | -35.0/20.0<br>-3.18(11.33)<br>-1.46/2.75 | -23.0/25.0<br>-3.58(11.13)<br>-3.90/1.77 | -22.0/15.0<br>-6.83(13.16)<br>-4.53/7.37 | -29.0/14.0<br>-4.08(10.55) | -38.0/21.0<br>-3.37(11.34) | -34.0/24.0<br>-2.72(12.83) | -31.0/15.0<br>-6.80(12.12) |
| Arm flexibility (cm) (1091 | -42.5/9.0<br>-10.14(11.16)<br>-1.14/1.73 | -29/12<br>-7.15(9.42)<br>-0.80/2.70 | -42.0/18.5<br>-10.15(13.17)<br>1.12/5.51 | -37.0/29.0<br>-9.04(16.75)<br>-5.37/4.53 | -34.0/8.0<br>-8.41(9.85) | -39/6.70<br>-10.88(11.5) | **-68.0/12.0[2]**<br>**-10.25(13.41)***  | -44.0/6.0<br>-12.48(11.73) |
| Agility (sec) (1099) | 3.60-7.59<br>5.14(0.72)<br>-0.51/0.05 | 3.28-7.68<br>5.21(0.77)<br>-0.66/0.03 | 3.75-12.89<br>5.75(1.62)<br>-1.07/-0.20 | 5.40-8.91<br>6.65(1.13)<br>-1.29/0.69 | 3.53-8.50<br>5.32(0.99) | 3.58-10.25<br>5.52(1.21) | **3.78-24.90[2]**<br>**5.83(2.59)*** | 3.85-9.50<br>6.21(1.35) |
| Speed (m) (1060) | 9.66-21.18<br>15.13(2.40)<br>-1.28/-0.12 | 8.69-24.54<br>15.80(2.70)<br>-0.95/0.46 | 9.31-30.33<br>16.50(3.47)<br>-1.07/0.83 | 14.06-24.33<br>18.62(3.35)<br>-2.95/0.96 | **8.81-23.88[2]**<br>**15.66(3.36)*** | 9.72-26.81<br>15.86(3.27) | 9.06-36.30<br>16.14(8.84) | 10.00-25.90<br>17.83(3.97) |
| Endurance (m) (1060) | 363.40-731.40<br>564.98(65.27)<br>4.33/34.14 | 386.4-700.0<br>568.4(64.68)<br>-4.01/32.14 | 184.0-690.0<br>505.78(113.71)<br>-15.72/34.18 | 400.2-596.2<br>494.72(53.10)<br>-14.09/95.29 | **335.80-726.70[2]**<br>**559.22(81.56)*** | 311.5-727.0<br>547.2(85.64) | 202.40-722.20<br>449.97(88.40) | 184-644<br>486.18(103.75) |

***= significant differences between baseline and follow-up. *p*<0.05 according to ANOVA analysis taking into account as covariates: sex, age, marital status, educational level, income, regular physical activity practice, walking time and time spent on daily activities a day. [1]: improve, [2]: decrease (in the results from baseline to follow up).**

Table 13. Female Min and Max values with mean (SD) and 95% CI from the 8 fitness test by Age groups at baseline and follow-up

| FEMALE | BASELINE | | | | FOLLOW-UP | | | |
|---|---|---|---|---|---|---|---|---|
| Test (n) | AGR1(n=326) | AGR2(n=277) | AGR3(n=185) | AGR4(n=60) | AGR1 | AGR2 | AGR3 | AGR4 |
| Balance (sec)(1093) | 0.10-60.0<br>31.78(21.36)<br>-2.17/2.34 | 0.01-60.0<br>28.29(20.89)-<br>2.43/2.56 | 1.0-60.0<br>22.02(18.99)<br>-.3.86/2.30 | 0.38-60.0<br>21.66(21.40)<br>-3.36/7.55 | 0.0-60.0<br>31.26(21.31) | 0.00-60.0<br>29.90(21.47) | 0.0-60.0<br>23.85(20.57) | 0.0-60.0<br>20.899(20.23) |
| Leg strength (rep)(1094) | 7-28<br>14.64(3.22)<br>-0.96/-0.12 | 4-24<br>14.32(3.09)<br>-1.23/-0.29 | 3-24<br>14.14(3.69)<br>-.027/0.90 | 5-23<br>13.14(3.42)<br>-2.08/-0.02 | **1-28[1]**<br>**15.29(3.77)*** | **0-30[1]**<br>**15.03(3.89)*** | 2-25<br>14.17(3.73) | **0-25[1]**<br>**13.35(4.14)*** |
| Arm strength (1096)(rep) | 5-30<br>17.48(3.98)<br>-1.74/-0.78 | 4-29<br>16.96(3.75)<br>-1.96/-0.89 | 7-25<br>16.57(3.55)<br>-1.50/-0.18 | 7-22<br>16.0(3.66)<br>-2.67/-0.35 | **9-30[1]**<br>**18.76(3.59)*** | **7-33[1]**<br>**18.81(4.04)*** | **6.30[1]**<br>**17.25(3.76)*** | **8-27**<br>**17.22(3.93)*** |
| Leg flexibility (cm)(1095) | -34.0/33.50<br>-0.59(10.32)<br>-0.80/1.15 | -34.6/27.0<br>-1.20(9.77)<br>-0.85/1.31 | -31.7/18.5<br>-2.06(8.95)<br>-1.22/1.49 | -30.0/24.0<br>-4.36(9.93)<br>-3.64/1.01 | -40.00/19.0<br>0.11(8.89) | -34.0/26.5<br>-0.98(10.48) | -34.5/29.20<br>-1.75(10.43) | -32.0/22.0<br>-3.18(10.68) |
| Arm flexibility (cm)(1091) | -42.0/16.0<br>-6.56(9.02)<br>-0.16/1.45 | -40.0/22.0<br>-7.61(10.28)<br>0.62/2.40 | -47.0/21.0<br>-8.92(11.08)<br>0.69/2.92 | -40.0/15.0<br>-7.59(10.53)<br>1.22/5.18 | -42.0/11.50<br>-6.82(9.10) | **-37.0/11.7[2]**<br>**-8.13(9.98)*** | **-58.0/15.5[2]**<br>**-9.79(11.04)*** | **-46.0/23.0[2]**<br>**-10.22(11.02)*** |
| Agility (1099)(sec) | 3.62-9.47<br>5.60(0.98)<br>-1.11/0.29 | 3.64-11.28<br>5.78(1.12)<br>-0.24/0.12 | 4.06-11.19<br>6.07(1.36)<br>-0.58/-0.14 | 3.87-15.97<br>6.64(2.23)<br>-1.26/-0.49 | 3.80-10.31<br>5.58(1.11) | 3.22-12.78<br>5.69(1.39) | **4.0-15.06[2]**<br>**6.13(1.55)*** | **3.56-30.40[2]**<br>**6.86(3.02)*** |
| Speed (m)(1060) | 9.53-28.08<br>16.67(2.69)<br>-0.66/-0.01 | 10.0-28.48<br>17.39(3.01)<br>-.095/-.023 | 10.56-34.65<br>17.93(3.35)<br>-1.33/-0.43 | 11.09-55.12<br>19.30(5.51)<br>-2.14/-0.59 | **10.57-33.55[2]**<br>**16.98(3.20)*** | **9.84-44.10[2]**<br>**17.40(3.97)*** | **10.44-40.31[2]**<br>**18.62(4.29)*** | **10.22-61.0[2]**<br>**20.17(7.11)*** |
| Endurance (m)(1060) | 266.8-726.8<br>538.84(75.02)<br>6.94/23.89 | 184-768.0<br>525.75(84.43)<br>10.59/29.38 | 184.0-841.8<br>508.06(97.07)<br>21.13/44.44 | 184.0-667.0<br>475.88(102.83)<br>0.00/41.29 | **263.2-808.4***<br>**532.8(76.85)[2]** | **160-736.0*[2]**<br>**518.01(91.23)** | **184.0-760.0*[2]**<br>**480.98(105.1)** | **172.0-708.0*[2]**<br>**460.92(106.32)** |

***= significant differences between baseline and follow-up. P<0.05 according to ANCOVA analysis taking into account as covariates: sex, age, marital status, educational level, income, regular physical activity practice and walking time and time spent on daily activities a day. [1]: improve, [2]: decrease (in the results from baseline to follow up).**

When analyzing the physical tests only by sex (Table 10), no significant differences between the baseline and follow-up data were found in the balance and leg flexibility tests in any of both sexes. Male presented significantly decreases in agility and endurance while female scored significant higher results in leg and arm strength but poorer values in arm flexibility, agility, speed and endurance (all $p<0.05$).

When an analysis by both, sex and AGR, was made (results are shown in Table 11, 12 and 13), no statistical differences were found in balance and leg flexibility tests in any sex or AGR. Males from AGR1 showed significant poorer scores at follow-up in speed and endurance ($p<0.05$) and those from AGR3 in agility and arm flexibility tests. On the other hand, when referring to females, higher results were found in leg strength from AGR1, AGR2 and AGR4 and in arm strength in all of the AGR while lower scores were collected in arm flexibility from AGR2, AGR3 and AGR4, in agility from AGR3 and AGR4 and in speed and endurance from all AGR (all $p<0.05$).

## 6.5 Discussion

The main aim of the present study was to evaluate the changes in fitness levels measured by physical tests over a 4 years period. The present study pretends to help understanding in a deeper way the involution process that befalls with aging. The physical deterioration by age can be observed when comparing physical tests results in the 4 different AGR. These results are consistent with those found by Toraman (85) in a study to assess the effects of short (six weeks) and long (52 weeks) term detraining on functional fitness in elderly people, and to determine whether these effects differ according to age in elderly people, that changes in functional capacity after short and long term detraining are actually affected by age in the elderly. In the present study, differences by sex were also found in all of the physical tests performed. Male performed better than female in balance, leg and arm strength, agility, speed and endurance and worst in leg and arm flexibility although a tendency in the result differences to soften with age could be appreciated. Although women prototypically have less physical strength than men at their peak in early adulthood, the rate of decline across their remaining life span is lower than that of their male counterparts. In developed nations, older women often have a longevity advantage over older men (130). For this reason, older women may have lower physical fitness than older men, but their physical fitness will age more slowly than in men.

According to the results obtained, there were no relevant changes at follow-up point in the balance and leg flexibility in any of the analysis performed (sex and sex+AGR). That means that those capacities did not decrease during the study time as it could have been expected. The fact that 80% of the subjects remained active by follow-up could be the reason that explained that those physical capacities remained stable. These findings are consistent with those from Kimura et al (130), who concluded in a study performed in 122 individuals (60- 83 years old at baseline) during a 7 years period that higher levels of physical fitness may delay the onset of physical disability and loss of independence associated with aging. The findings from a study carried out by Moreira-Antunez et al. (131) indicated that there was an association between neuropsychological functions and physical exercise training in older adults, which suggests that their neuropsychological status is associated with an increase in aerobic fitness. According to that, we observed significant improvements in the results at follow-up point in women in both leg and arm strength tests. Females from AGR1, AGR2 and AGR4 performed higher values in leg strength while greater scores were observed in arm strength from all of the AGR. These results could reflect the effect of PA in the fitness level. Many studies have demonstrated the positive relationship between practicing PA and improvements in fitness levels in elderly (132-135). Seco et al., (21) studied 227 subjects aged 65 and older during 12 months (9 months of a training program and 3 months detraining follow-up). They observed significant improvements in strength (measured with a hand dynamometry), leg flexibility and balance at the end of the training program and flexibility and balance improvements were maintained at the end of the detraining. Our results showed also an improvement in strength in women and no changes in balance or leg flexibility or in strength in men. The sample analyzed for the present study did not participate in any intervention, although they were mostly active. This fact could explain the maintenance of balance, flexibility and strength (in males) in our sample but no improvements. Nonetheless, some physical capacities showed a decrease during the study period. For males, decreases were observed in agility and endurance in general and arm flexibility and agility also from the AGR3 and endurance from the AGR1. On the other hand, female results also decreased in general in arm flexibility, agility, speed and endurance. Arm flexibility decreased in AGR2, AGR3 and AGR4, agility in AGR3 and AGR4 and speed and endurance in all of the AGR. Other authors have found similar results. Muñoz-Arribas et al. (136) found in a study carried out with octogenarians during a 2 years period that scores from agility, speed and endurance decreased. Gusi et al. (137) found in a study carried out on 3,214 older adults (mean age 70.91±7.44) from the ELAY project in Spain that individuals that had participated in that controlled fitness program, reported greater lower limb flexibility and endurance after 1 year of participation in a PA program. Those authors found also improvements in endurance after the participation in the fitness program. That tends to sound logic taking in account that the ELAY program was based on walking on active flexibility movements.

When comparing the data obtained from the subjects in the present study to results obtained from the same tests in other studies, we observed that our sample data had similar values that those found by Chung et al. (138) in leg and arm strength but higher than results from the studies by Sardinha et al. (139) or Adamo et al. (140) in arm strength. Those authors performed the SFT also in a sample of male and female older adults. Our sample presented lower values than the other authors like Adamo or Chung in leg and arm flexibility. Results from Furtado et al. (23) reflected lower values as the obtained by our female sample in leg strength, agility and endurance but higher scores in leg and arm flexibility in baseline. This study carried out an 8-months training program in older women. Results at the end of the training program showed more similar values to our results, although values from leg and arm flexibility were still higher in Furtado´s study. According to the Criterion-Referenced Fitness Standards for Maintaining Physical Independence in Older Adults proposed by Rikkli and Jones in 2013 (62), the sample used for the present study was placed at the percentile 50 in most of the tests. In the case of leg and arm strength, females in the percentile 40 and even lower in the oldest AGR reached the criterion. On the other hand, in the agility test results, it was necessary to descend till the percentile 60 to reach the criterion. That could be interpreted as that 50% of the individuals that participated in the present study are not at risk of dependence they presented a greater leg and arm strength for what could be considered necessary to maintain independence but the agility should be improved. Leg and arm flexibility values could be also be improved.

## 6.6 Conclusion

Physical condition evolution is dependent from sex and age although to remain active could help maintaining or reducing the decline in fitness level during a 4-year period of time in older adults. Balance and leg flexibility remained stable during the study follow-up. Leg and arm strength increased after a 4 years period in females but arm flexibility, agility, speed and endurance decreased. Agility and endurance also presented lower values after the 4 years period in males.

BALANCE

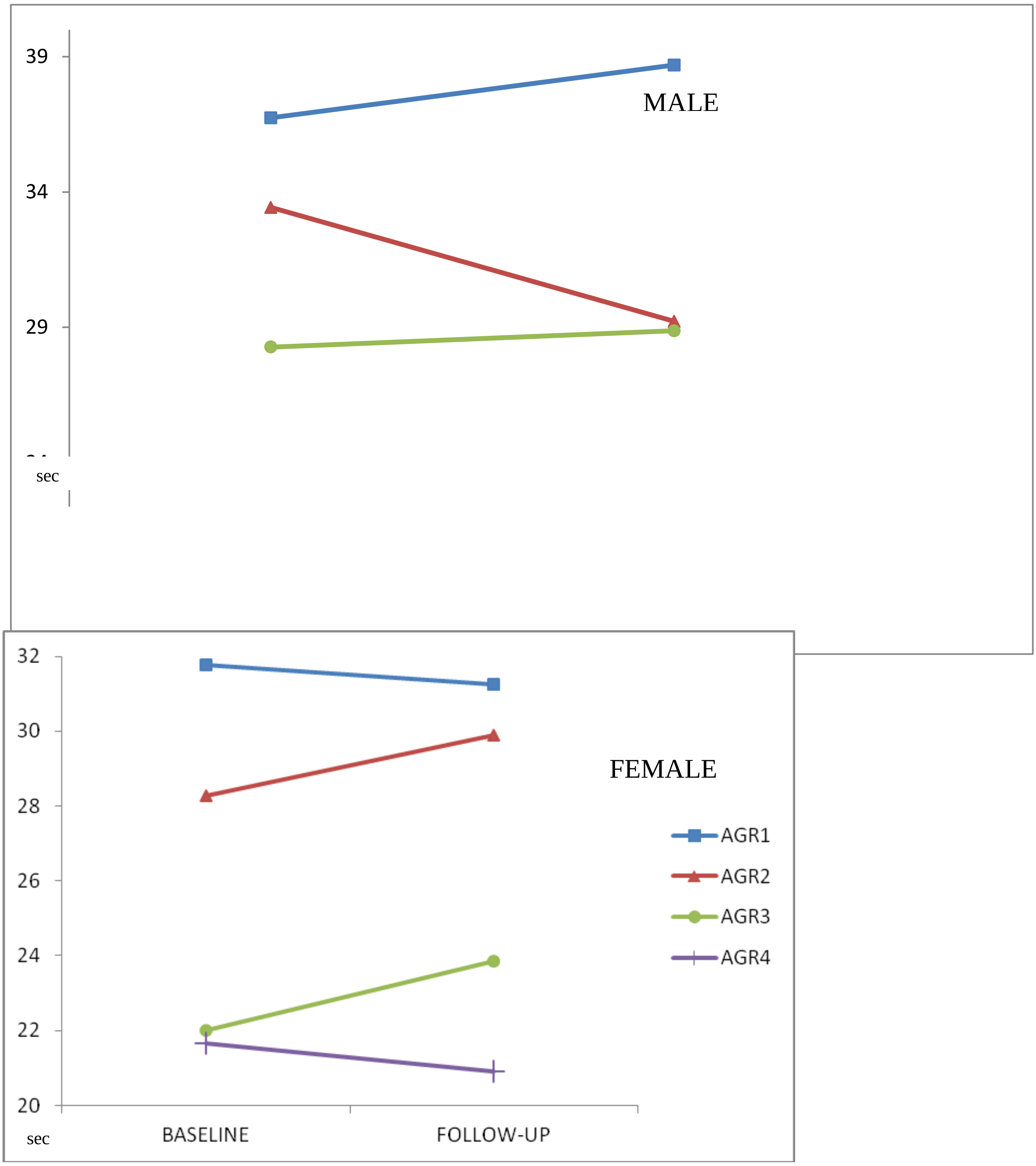



Figure 10. Balance mean results by sexes. AG1: from the lowest age till 69 yrs, AGR2: from 70 till 74 yrs, AGR3 from 75 till 79 yrs and AGR4: from 80 yrs and older.

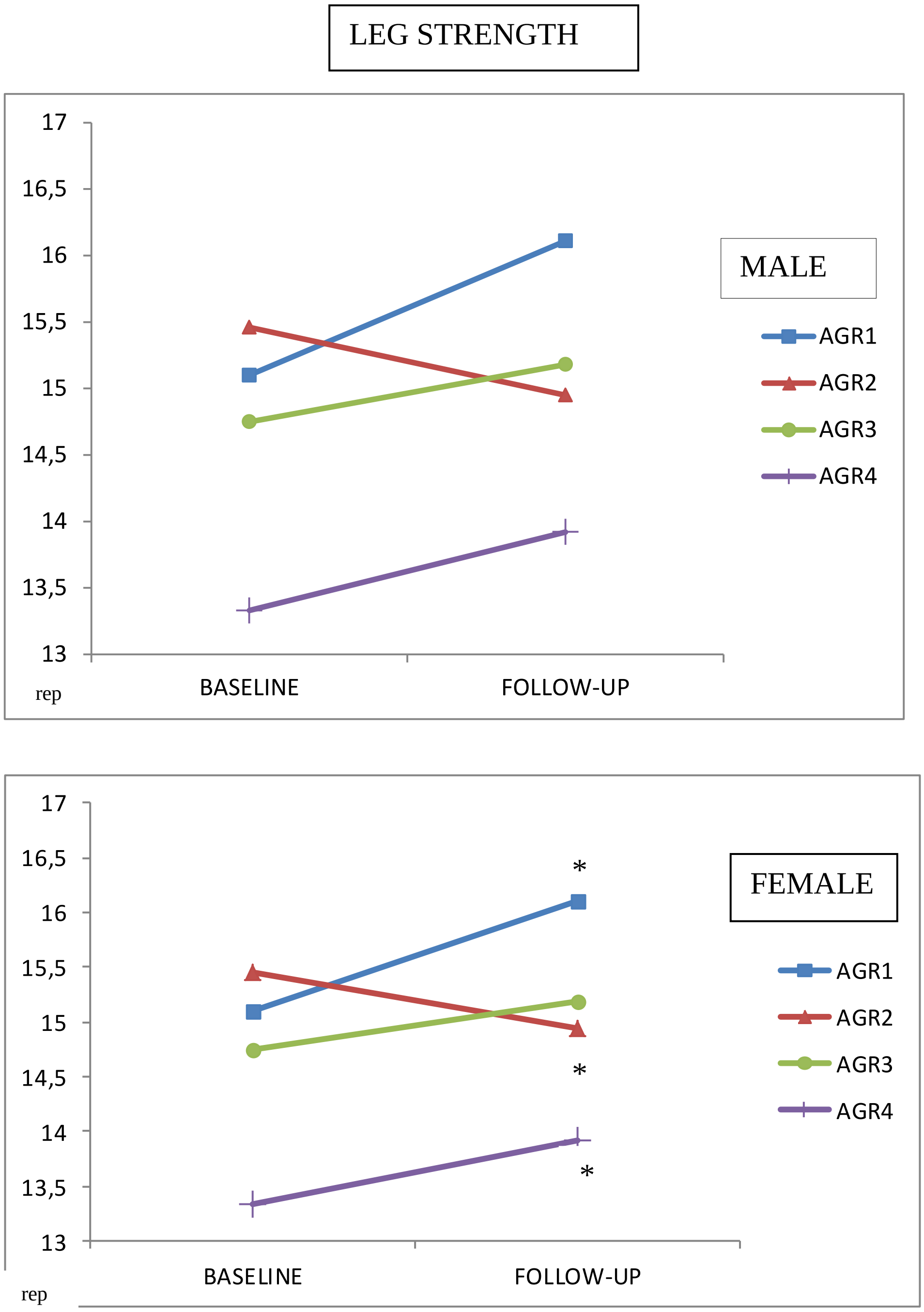
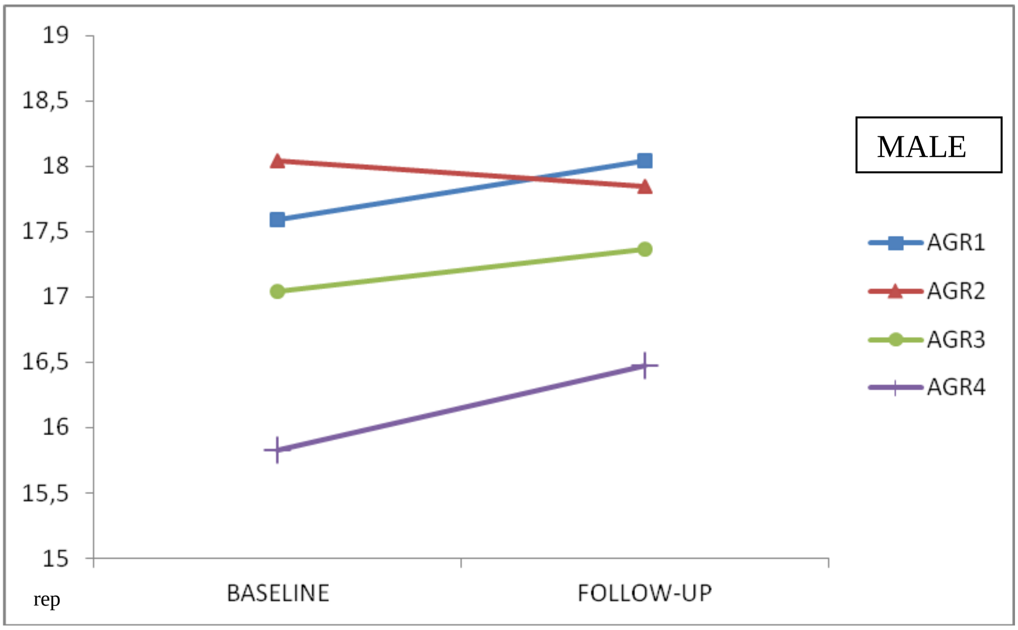



Figure 11. Leg strength mean results by sexes. AG1: from the lowest age till 69 yrs, AGR2: from 70 till 74 yrs, AGR3 from 75 till 79 yrs and AGR4: from 80 yrs and older.

ARM STRENGTH



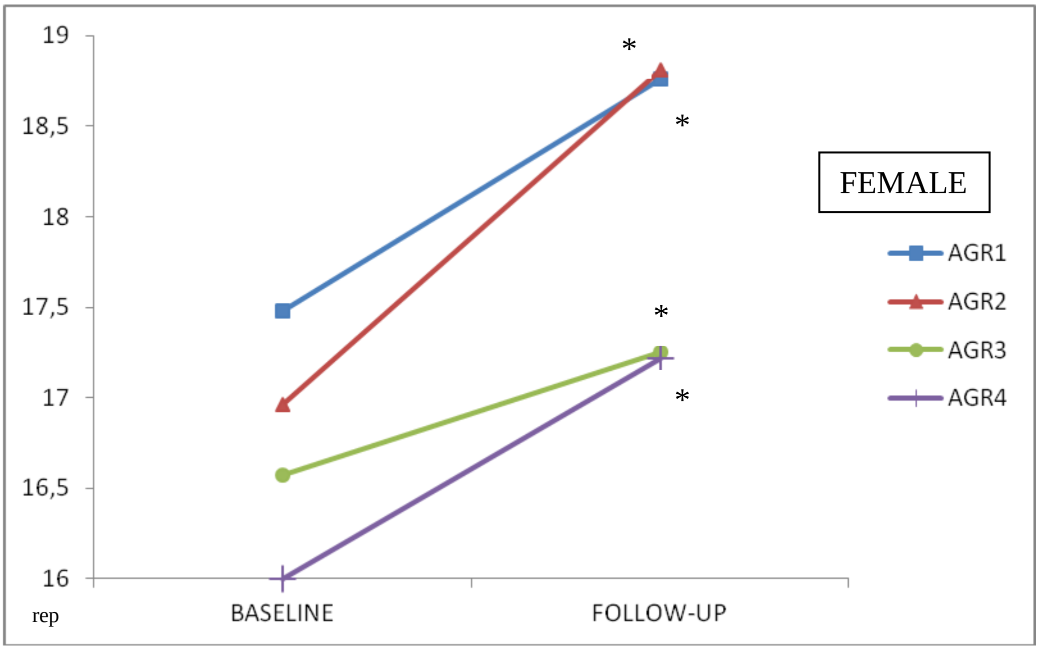




Figure 12. Arm strength mean results by sexes. AG1: from the lowest age till 69 yrs, AGR2: from 70 till 74 yrs, AGR3 from 75 till 79 yrs and AGR4: from 80 yrs and older.

LEG FLEXIBILITY

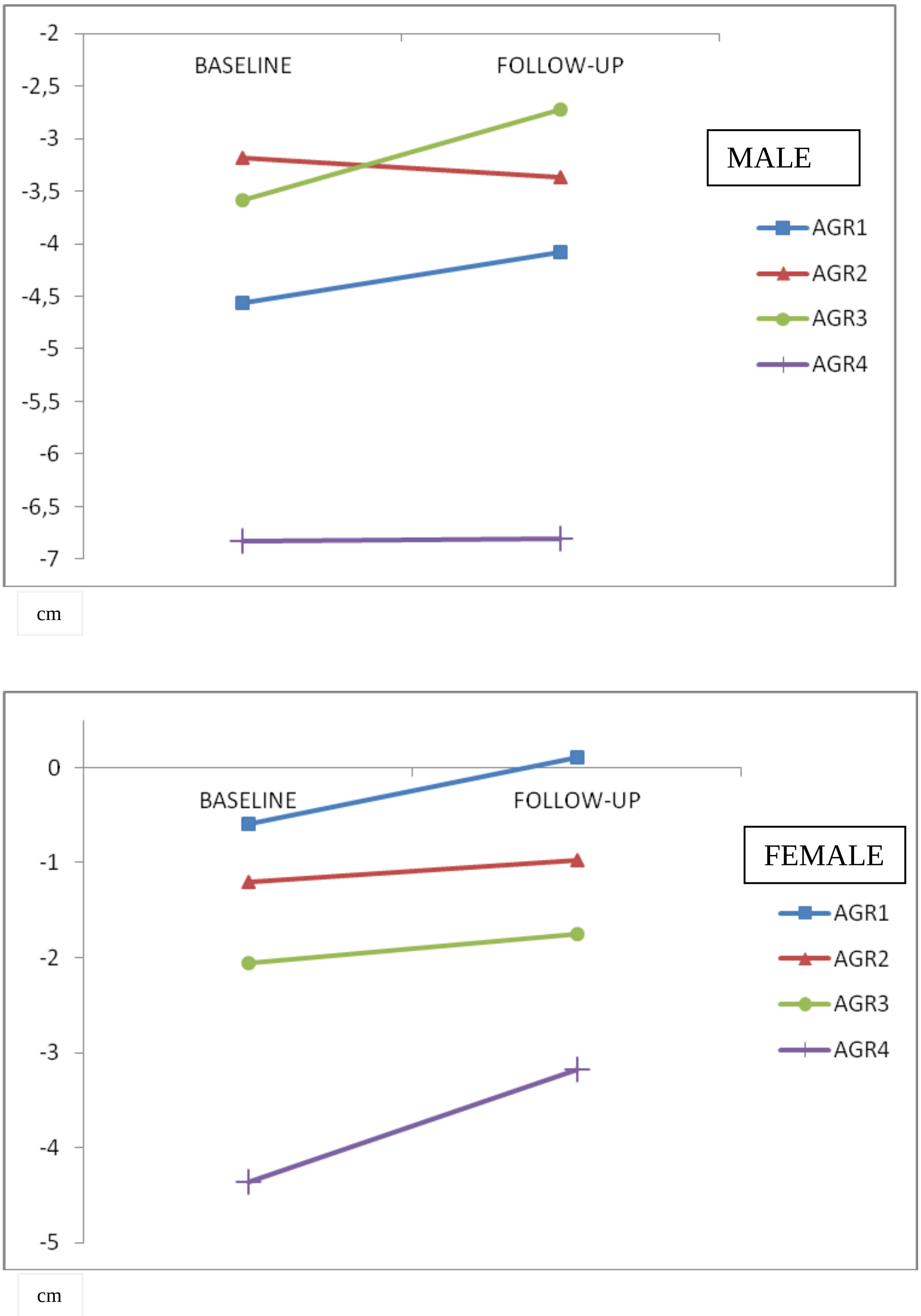



Figure 13. Leg flexibility mean results by sexes. AG1: from the lowest age till 69 yrs, AGR2: from 70 till 74 yrs, AGR3 from 75 till 79 yrs and AGR4: from 80 yrs and older.

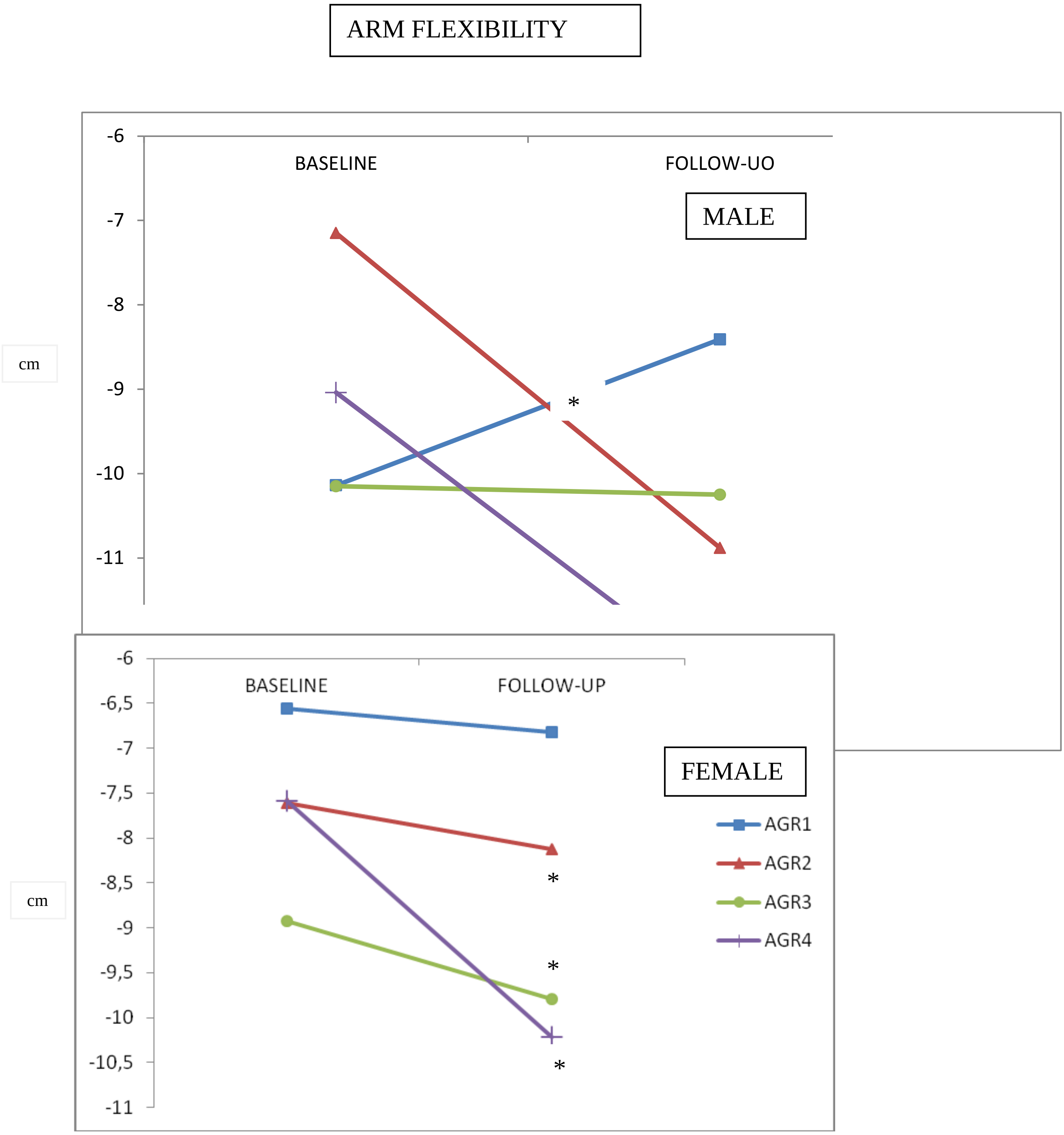



Figure 14. Arm flexibility mean results by sexes. AG1: from the lowest age till 69 yrs, AGR2: from 70 till 74 yrs, AGR3 from 75 till 79 yrs and AGR4: from 80 yrs and older.

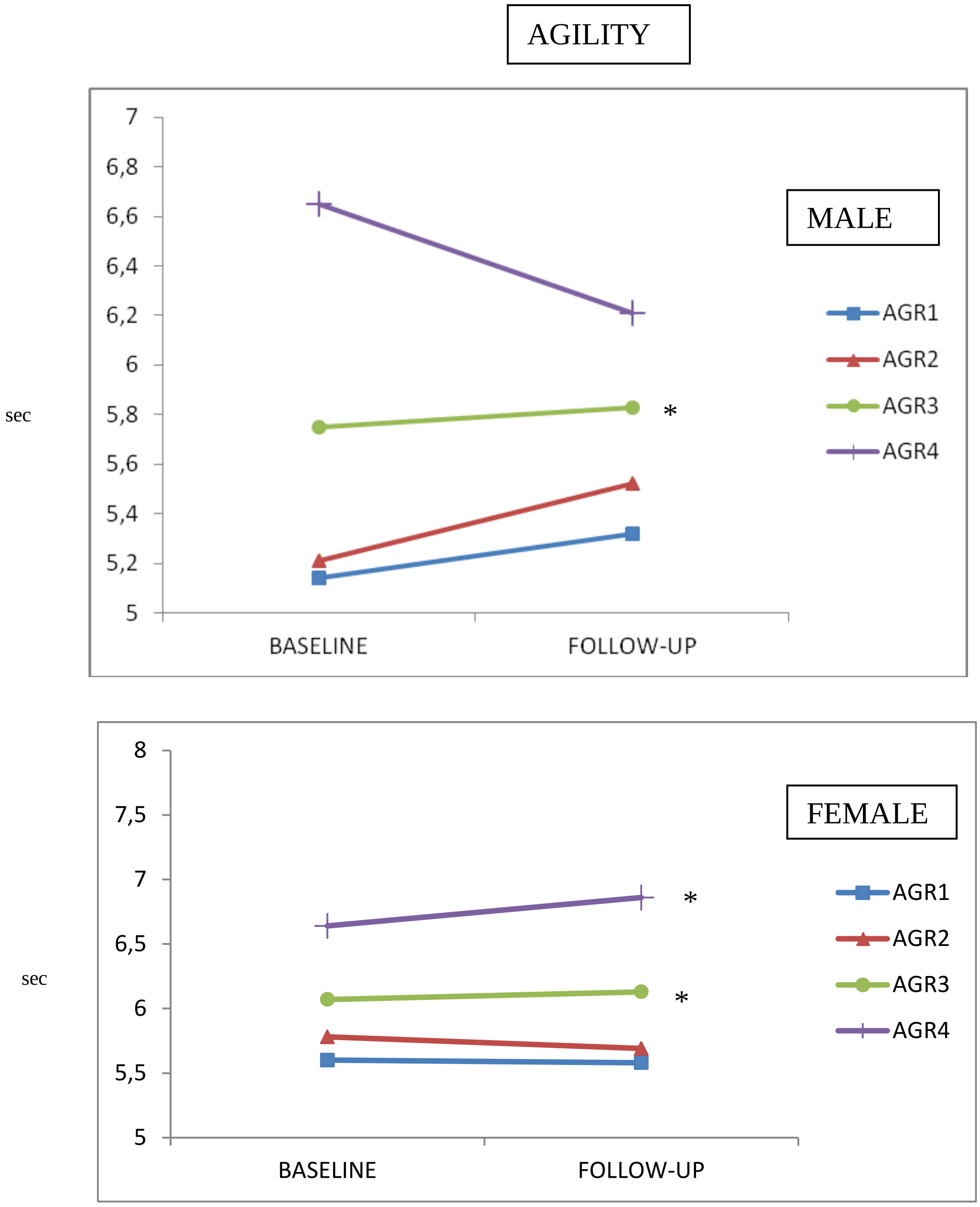



Figure 15. Agility mean results by sexes. AG1: from the lowest age till 69 yrs, AGR2: from 70 till 74 yrs, AGR3 from 75 till 79 yrs and AGR4: from 80 yrs and older.

SPEED

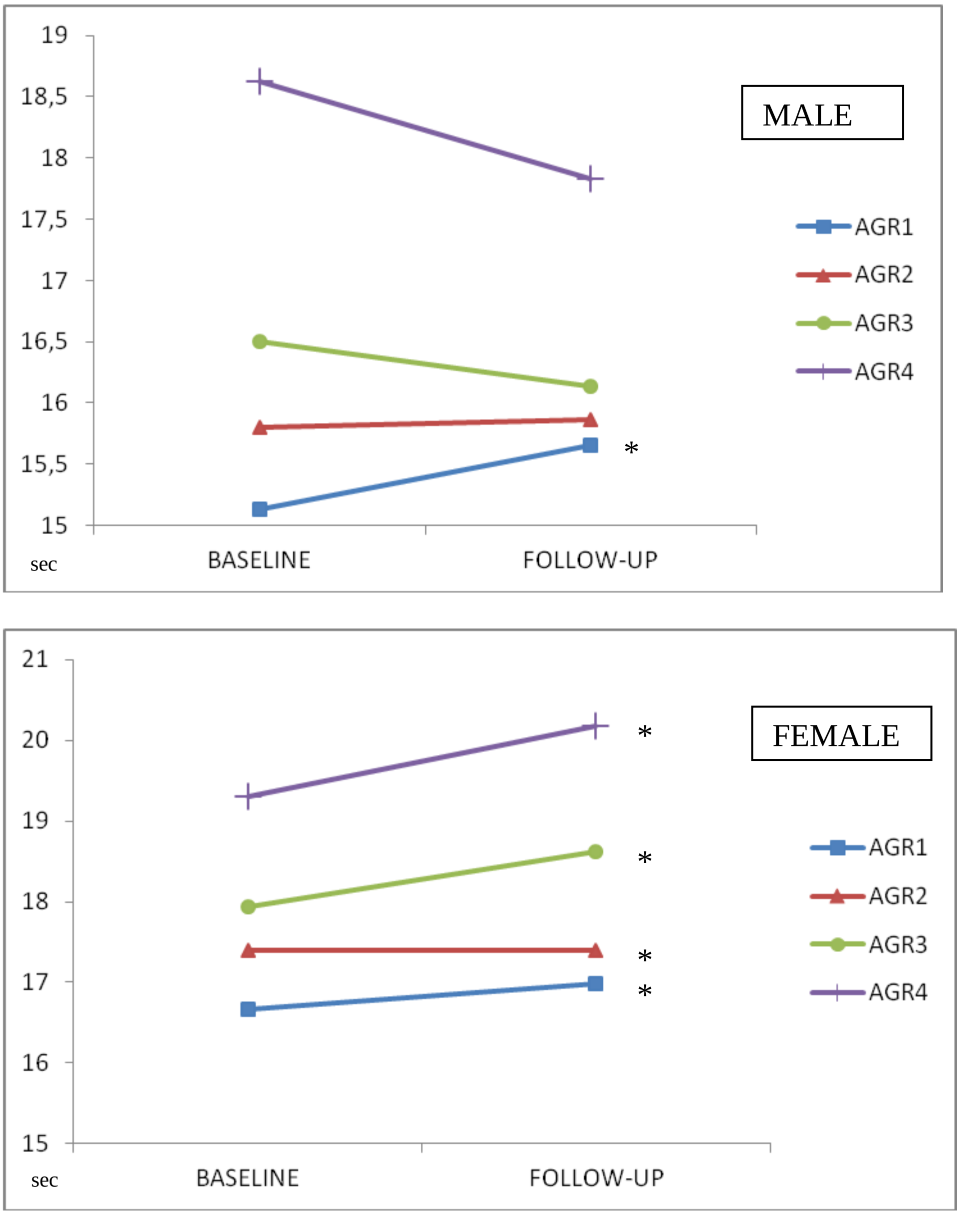



Figure 16. Speed mean results by sexes. AG1: from the lowest age till 69 yrs, AGR2: from 70 till 74 yrs, AGR3 from 75 till 79 yrs and AGR4: from 80 yrs and older.

ENDURANCE

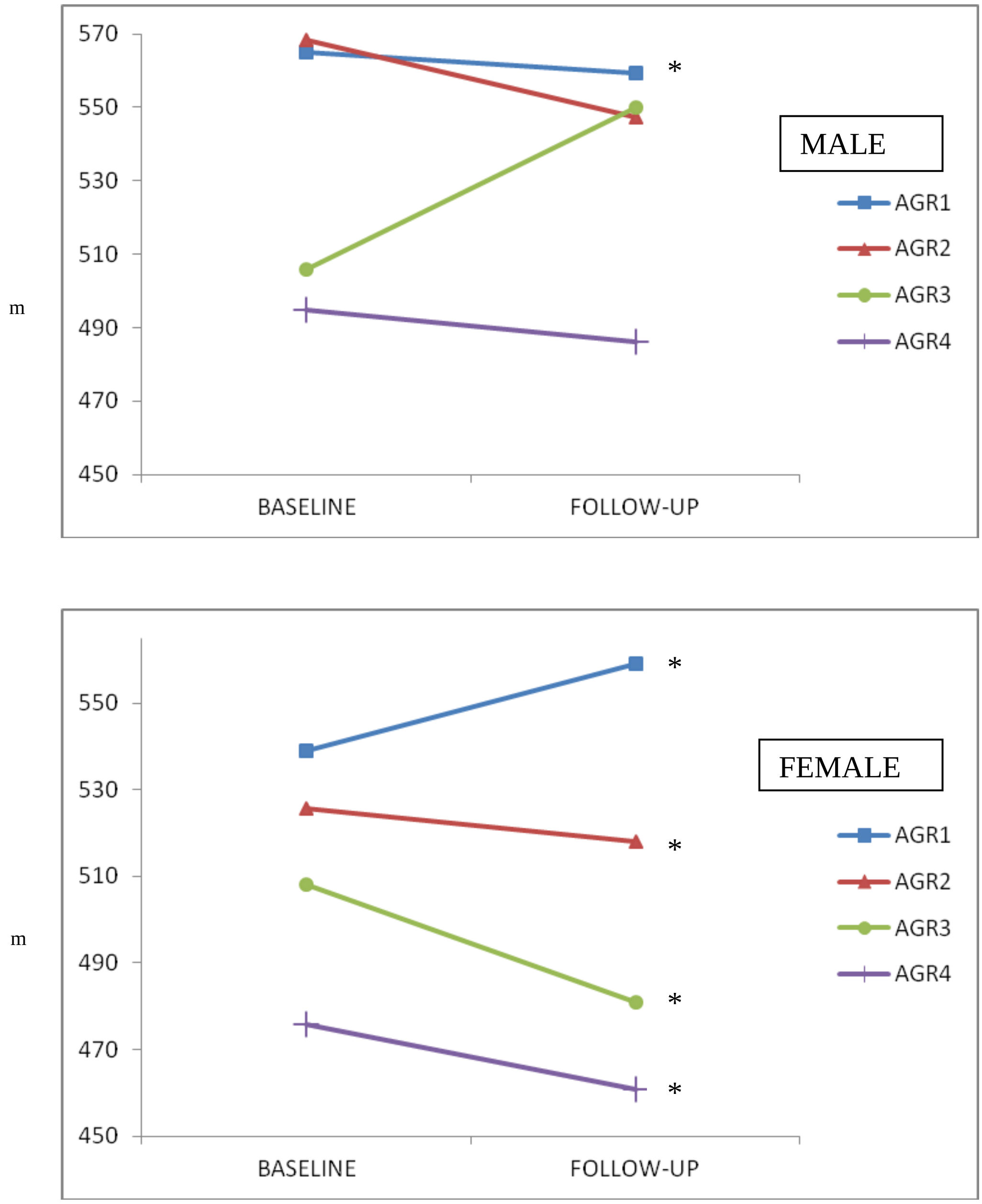



Figure 17. Endurance mean results by sexes. AG1: from the lowest age till 69 yrs, AGR2: from 70 till 74 yrs, AGR3 from 75 till 79 yrs and AGR4: from 80 yrs and older.

Agility and endurance tests score better when the time used is shorter. Because of that, better scores are showed lower in the figure and poorer results are represented higher.

**7. CHAPTER 7. STUDY 2**: Effects of sitting time by different fitness levels on health related quality of life in Spanish older adults.

**7.1 Abstract**:

**Background:** Pphysical exercise has been proposed as an effective tool to maintain or improve physical and mental condition, HRQoL and prevent and treat major morbidity and mortality causes associated with the aging process. SB is emerging as a novel risk factor for most chronic diseases. The aim of the present study was to analyze the relationship between different levels of fitness and ST with the HRQoL in a Spanish elderly population. **Methods:** A total of 3,136 Spanish elderly (723 males) were considered. A questionnaire consisted in a first part of different questions about lifestyle personal items (income, educational level, marital status, etc.) and a second part, the EuroQol EQ-5D-3L questionnaire was filled. ST per day was stratified in 3 levels according to a specific question included in the questionnaire: level 1 (ST1) for ST < 2 h/day, level 2 (ST2) for ST from 2 to 4 h/day and level 3 (ST3) for ST > 4 h/day. Anthropometric and body composition measurements as well as physical tests were also performance (lower and upper body strength by the chair stand test and arm curl test, respectively and aerobic endurance by the 6-min walk test (Rikli and Jones, 2001). Based on the results, the sample was divided into 3 groups: low, medium and high fitness level. Total strength (TStr), aerobic capacity (AC) and both together (TStr+AC) were analyzed. **Results:** Results from TStr, AC and TStr+AC showed statistic significant differences between ST3 and ST2 in relation to HRQoL in the low fitness level group (p=0.021; p=0.009; p=0.004 results from AC, TStr and Tstr+AC, respectively) but did not show significant differences in the medium or high fitness level groups. ST3 showed statistically significant differences with ST1 in the low fitness level group only by AC and TStr+AC. **Conclusion:** Greater ST is related to poorer HRQoL in subjects with low physical condition. High fitness level is positively related to HRQoL. Individuals with high ST present a lower risk of suffering problems of mobility, self-care or daily activities.

7.2 Introduction

Active aging, understood as the process of optimizing opportunities for physical, social and mental health throughout life (141) has been an important subject of study for researches.

Trying to understand the main factors influencing this process such as PA or fitness is crucial in order to maintain a good HRQoL as ageing advances. Therefore, physical exercise has been widely proposed as a very effective tool to maintain or improve physical and mental condition (16, 18, 20, 21, 142) so as to prevent and treat major morbidity and mortality causes in industrialized countries, most of those, associated with the aging process (17, 143, 144).

On the other hand, SB, defined as any being awake behavior characterized by energy expenditure less than or equal to 1.5 metabolic equivalents while in a sitting or reclining posture (145) is emerging as a novel risk factor for most chronic diseases, including CVD (143, 146, 147), diabetes (37), and some cancers (39-41). A greater number of hours spent sitting per day is associated with increased risk of chronic disease, CVD, poor physical fitness and all-cause mortality.

The association between SB, fitness level and HRQoL remains controversial. While some evidences confirm that a greater fitness level is related to higher HRQoL (146, 148), to the best of our knowledge, no studies have investigated the interaction of both, SB and fitness level in relation to the HRQoL. Since the consequences related to inactivity are more severe for adults 65 years old and older than for any other age group (144, 149), it is important to clarify if SB is related to poorer HRQoL independently or if it is mediated by fitness level in elderly.

The aim of the present study was to analyze the relationship between different levels of Fitness and ST with the HRQoL in a Spanish elderly population.

## 7.3 Methods

### 7.3.1 Study design:

The present study is a descriptive, cross-sectional work that includes data from “The EXERNET multi-center study”. The full protocol of the EXERNET study has been published elsewhere (103, 127).

### *7.3.2 Study sample:*

For the present study, a total of 3,136 Spanish elderly (723 males) were considered. To make maximum use of the data, all valid data on questionnaires, anthropometric values and physical fitness tests were included in this report. Consequently, sample sizes may vary for the different parts.

*7.3.3 Study protocol:*

All the data were collected on the same day in the following order: First, filling in the questionnaires by personal interviews (lifestyle and EuroQol EQ-5D-3L questionnaires) (150-152). Secondly, a physical examination and body composition measurements were performed followed by a bio-impedance analysis. The last part was the physical tests performance. The physical tests used in the present study were executed in the same order by all the subjects.

7.3.4 *Health-related quality of life (HRQoL):*

HRQoL was measured by means of the EuroQol EQ-5D-3L scores, obtained from the results of the 5 dimensions, 'mobility', 'self-care', 'usual activities', 'pain/discomfort' and 'anxiety/depression', transformed into a value, the time trade-off method (TTO). TTO values rage between 0 (the poorest score of HRQoL) and 1 (best HRQoL possible) (151).

*7.3.5 Sedentary Behaviours (SB) assessment:*

To assess the SB of the sample, a specific question was included in the structured validated questionnaire (153). The ST per day was stratified in 3 levels: level 1 (ST1) was assigned to ST < 2 h/day, level 2 (ST2) was assigned to ST from 2 to 4 h/day and level 3 (ST3) was assigned to ST > 4 h/day.

*7.3.6 Physical fitness assessment*

The following physical fitness components were assessed: lower and upper body strength by the chair stand test and arm curl test, respectively (Rikli and Jones, 2001) and aerobic endurance by the 6-min walk test (Rikli and Jones, 2001). All the tests were performed only once. All the participants performed the tests in the same order, as written above. To establish the fitness level, scores from the tests were clustered in 3 different groups; upper and lower body strength to assess total strength (TStr), aerobic endurance to assess AC and total strength plus endurance (TStr+AC) to assess a general fitness level. In each of these 3 groups, subjects were divided in 3 different levels; low (<percentile 25), medium (between percentiles 25 and 75) and high (>percentile 75).

*7.3.7 Anthropometric and body composition measures*

Weight, height and BMI were measured. Bio impedance analysis was also performed.

*7.3.8 Covariates*

Sex, age, marital status, educational level, income, %BF and BMI were reported by study participants in the EXERNET questionnaire. Previous analyses suggest that these socio-demographic characteristics may have an independent association with HRQoL and, could be considered potential confounders in multivariable analyses (30).

*7.3.9 Statistical analysis*

All descriptive statistics are presented as means and SD for quantitative variables and as percentage in categorical variables. To establish the influence of ST and fitness on the QoL, two different models were analyzed with a logistic binomial regression (Model A, using the socio-demographic variables without adjusting by fitness components and Model B, adjusted also by fitness, arm and leg strength and aerobic capacity). Logistic binomial regression was also used to determine the relationship of ST to the 5 dimensions of the EQ-5D-3L (mobility, self-care, daily activities, pain-discomfort and anxiety-depression) by the different fitness levels in the 3 different fitness groups. For that propose, the results from the dimensions of the EQ questionnaires were re-codified into a binomial variable; problems and no problems. The sample was splitted by fitness groups and levels. ST1 was set as the reference group to compare the other groups with. In order to establish the correlation between the ST and the HRQoL total score by fitness levels an ANOVA univariate analysis was carried out using the EQ-5D-3L index value (TTO) as dependent variable. Life-style and socio-demographic variables as well as sex and age were used as adjustment covariates. Estimated odds ratios (OR) from exp ß with 95% confidence intervals (CI) are reported.

The statistical analysis was performed with SPSS (IBM SPSS Statistics for Windows, version 23.0; Armonk, NY, (USA), and the statistical significance was set at $p < 0.05$.

7.4 R*esults*

A total sample of n=3,136 composed this study from which 723 (23.3%) were males. Descriptive values of the sample are shown in Table 14.

**Table 14. Characteristics of the participants**

| | **Total n=3,101** | Male (n=723) | Female (2,378) |
|---|---|---|---|
| Age (y) | 72.10 (5.33) | 72.27 (5.44) | 72.05 (5.29) |
| Gender | | 23.3% | 76.7% |
| Height (cm) | 155.73 (8.08) | 165.29 (6.75) | 152.82 (5.90) |
| Weight | 70.33 (11.37) | 76.96 811.09) | 68.31 (10.67) |
| BMI ($Kg/m^2$) | 29.01 (4.23) | 28.16 (3.55) | 29.26 (4.37) |
| Fat Mass, % | 36.89 (6.94) | 29.01 (5.25) | 39.34 (5.41) |
| Physically active | 2,379 (85.4%) | 488 (75.8%) | 1,902 (90.9%) |
| Educational status (%) | | | |
| Primary or lower | 84.03 | 75.8 | 86.5 |
| Secondary or higher | 15.97 | 24.2 | 13.5 |
| Marital Status (%) | | | |
| Single | 4.96 | 4.0 | 5.2 |
| Married | 61.58 | 86.4 | 54.1 |
| Divorced | 2.66 | 2.9 | 2.6 |
| Widow | 30.79 | 6.6 | 38.2 |
| Income (%) | | | |
| <600€/month | 43.14 | 22.4 | 49.7 |
| 600-900€/month | 32.50 | 37.7 | 30.8 |
| >900€/month | 24.36 | 39.9 | 19.4 |
| Leg Strength (rep) | 14.53 (3.55) | 15.27 (3.81) | 14.31 (3.44) |
| Arm Strength (rep) | 17.29 (3.98) | 17.91 (4.10) | 17.10 (3.93) |
| Aerobic capacity (m) | 525.28 (94.48) | 560.31 (98.14) | 515.08 (90.69) |

All values are Mean (SD) unless otherwise stated.

Results from the analysis of the five dimensions of the EQ-5D-3L questionnaire in relation to ST groups are shown in Table 15. Results are presented in 2 different models. ST1 was used as the reference value for the other 2 groups. Results in both mobility and self-care dimensions presented statistic significant differences in both models A and B in the two ST groups with the reference group. In the usual activities dimension only in the ST3 in both models A and B significant differences were found. In the pain-discomfort dimension no significant differences were found in any case. Anxiety-depression dimension presented significant differences only in ST3 in model B, although a tendency is also observed in model A.

Table 15. Estimated Odds Ratios (OR) from exp ß and 95% confidence intervals (CI) for perceived problems in each EQ-5D-3L dimensions by sitting time (n=3,010)

| **Sitting time (h/day)** | MODEL A | | MODEL B | |
|---|---|---|---|---|
| **MOBILITY** | **OR (95%CI)** | ***p*** | **OR (95%CI)** | ***p*** |
| **ST1 (ref)** | 1 | | 1 | |
| ST2 | 0.677 (0.488 to 0.941) | **0.020** | 0.647 (0.454 to 0.923) | **0.016** |
| ST3 | 0.763 (0.606 to 0.961) | **0.022** | 0.741 (0.575 to 0.954) | **0.020** |
| **SELF-CARE** | | | | |
| **ST1 (ref)** | 1 | | 1 | |
| ST2 | 0.426 (0.193 to 0.942) | **0.035** | 0.387 (0.165 to 0.911) | **0.030** |
| ST3 | 0.536 (0.328 to 0.877) | **0.013** | 0.484 (0.283 to 0.828) | **0.008** |
| **USUAL ACTIVITIES** | | | | |
| **ST1 (ref)** | 1 | | 1 | |
| ST2 | 0.764 (0.517 to 1.141) | 0.188 | 0.737 (0.476 to 1.140) | 0.170 |
| ST3 | 0.686 (0.514 to 0.915) | **0.010** | 0.688 (0.500 to 0.947) | **0.022** |
| **PAIN-DISCOMFORT** | | | | |
| **ST1 (ref)** | 1 | | 1 | |
| ST2 | 0.927 (0.697 to 1.234) | 0.605 | 0.869 (0.645 to 1.171) | 0.357 |
| ST3 | 0.891 (0.721 to 1.100) | 0. 281 | 0.866 (0.693 to 1.082) | 0. 204 |
| **ANSIETY-DEPRESION** | | | | |
| **ST1 (ref)** | 1 | | 1 | |
| ST2 | 0.892 (0.660 to 1.205) | 0.456 | 0.809 (0.588 to 1.114) | 0.194 |
| ST3 | 0.810 (0.647 to 1.013) | 0. 065 | 0.810 (0.618 to 0.997) | **0. 047** |

Model A: Adjusted by age, sex, height, weight, BMI, fat mass (%), income, education, marital status. Model B: Adjusted by model A, leg strength, arm strength and endurance. ST1: less than 2h/day sitted. ST2: 2-4h/day sitted. ST3 more than 4h/day sitted. Significance: ***p*<0.05**

When analysing the results by domains (tables 16, 17 and 18), to different models where used for the binomial regression. In the model A, each domain from the EQ questionnaire was set as the dependent variable, while only ST was used as covariate and as categorical. In order to be able to establish the influence of the socio-demographic environment of the sample, model B included these items as covariates, using ST as categorical, like in model A. The results from the model A showed in the TStr group are similar from those from model B in all of the dimensions. Only in daily activities in ST2 significant differences were observed in model A but no in model B in the medium fitness level group and in the anxiety-depression domain in ST3 differences were found in model B but not in model A in the low fitness group. In the AC and TStr+AC groups, similar results were found in the self-care, daily activities and pain-discomfort domains while significant differences where observed in the mobility and anxiety-depression dimensions in model B that were not found in model A. Results using only ST as categorical covariate showed significant differences in the TStr group in the mobility domain between ST1 and ST3 in the low fitness group and between ST1 and ST2 in the medium fitness level group (p=0.013 and 0.030, respectively). In the self-care domain the only significant difference was found between the ST1 and ST3 in the medium fitness level group (p=0.002). The daily activities dimension presented significant differences in both ST2 and ST3 with ST1 in the medium fitness level group (p=0.023 and p=0.006, respectively). In every case, the OR were smaller than 1. In the anxiety-depression domain, differences were found in the ST1 with ST2 in the high fitness level group (p=0.009). OR in this case were bigger than 1. No significant differences were observed in the pain-discomfort dimension. In the AC fitness group, no statistical significant differences were found in the mobility, pain-discomfort or anxiety-depression dimensions. In the self-care domain, differences were observed in the ST2 and ST3 with ST1 in the low fitness level group (p=0.019 and p=0.003, respectively) while in the daily activities domain differences were only found in the ST3 (p=0.020). In all cases, the OR were smaller than 1. When it came to the TStr+AC group, the self-care domain presented significant differences in the ST2 and ST3 with the ST1 in the low fitness level group (p=0.018 and p=0.001 respectively). The daily activities dimension presented statistical significant differences between the ST1 and the ST3 in the low fitness level group (p=0.028). The OR in those cases were smaller than 1. On the other hand, the anxiety-depression domain showed significant differences in the ST2 in the high fitness level group (p=0.002). In this case, the OR was bigger than 1. When the analysis was made using the socio-demographic covariates together with the ST (used as categorical), it could be observed that in the mobility domain significant differences appeared between the ST reference group, ST1 and the ST3 in the TStr group in the low (p=0.036) and the ST2 in the medium (p=0.018) fitness level group. In the AC and TStr+AC group differences appeared in the low (p=0.021 and p=0.022 for AC and TStr+AC respectively) fitness level group in the ST3 and in the high fitness level group (p=0.41 and p=0.036 for AC and

TStr+AC respectively) in ST2. What concerns to the self-care domain, significant differences were observed in the TStr group in the medium (p=0.022) fitness level group in ST3, in the AC group in the low (p=0.035, p=0.048 for ST2 and ST3 respectively) and medium (p=0.02) fitness group in ST3 and in the TStr+AC group in the low (p=0.039, p=0.017 for ST2 and ST3 respectively) fitness group. Results from the daily activities domain showed significant differences in the medium (p=0.022) fitness group in ST3 in the TStr group and in the low fitness group in AC and TStr+AC (p=0.008 and p=0.009 for AC and TStr+AC respectively) in ST3. In all the first 3 domains, the significant differences according to the results from the estimated OR from exp ß, refers to a smaller possibility of some problems happened comparing to the reference group . There were no significant differences in the pain-discomfort domain in any group or any fitness level group. Anxiety-depression domain reflected significant differences in the low (p=0.012) fitness group in the TStr group in ST3 and in the AC and TStr+AC groups in the medium (p=0.015, p=0.019, p=0.032, p=0.033 for ST2 and ST3 and AC and Tstr+AC respectively) fitness level groups with a smaller possibility of problems happening but in the high (p=0.012 and p=0.016 for AC and TStr+AC respectively) fitness level groups in ST2 the significant differences reflected a greater possibility of the problems happening.

Table 16: Estimated odds ratios (OR) from exp ß and 95% confidence intervals (CI) for perceived problems in each EQ-5D-3L dimensions by sitting time only or sitting time adjusted by covariates in three different levels of strength.

| STRENGTH | | MOBILITY | | SELF-CARE | | DAILY ACTIVITIES | | PAIN-DISCOMFORT | | DEPRESSION-ANXIETY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | A | B | A | B | A | B | A | B |
| LOW | SITTING TIME | | | | | | | | | | |
| | ST1 (ref) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | ST2 | 0.748 (0.462-1.213) | 0.780 (0.441- 1.388) | 0.593 (0.211-1.668) | 0.477 (0.118-1.925) | 0.890 (0.514-1.539) | 0.673 (0.344-1.318) | 0.714 (0.429-1.188) | 0.593 (0.334-1.053) | 0.823 (0.506-1.340) | 0.633 (0.358-1.121) |
| | ST3 | **0.636* (0.445-0.909)** | **0.657* (0.426-0.972)** | 0.661 (0.329-1.327) | 0.657 (0.253-1.708) | 0.718 (0.477-1.083) | 0.607 (0.366-1.009) | 0.796 (0.541-1.171) | 0.704 (0.444-1.116) | 0.710 (0.495-1.018) | **0.566 (0.368-0.872)*** |
| MEDIUM | | | | | | | | | | | |
| | ST1 (ref) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | ST2 | **0.621* (0.404-0.954)** | **0.577* (0.348- 0.957)** | 0.384 (0.145-1.020) | 0.503 (0.160-1.578) | **0.528* (0.294-0.914)** | 0.600 (0.312-1.157) | 1.081 (0.763-1.533) | 1.060 (0.703-1.599) | 0.723 (0.492-1.063) | 0.694 (0.446-1.083) |
| | ST3 | 0.769 (0.573-1.031) | 0.803 (0.160-1.578) | **0.366* (0.193-0.694)** | **0.482* (0.236-0.984)** | **0.591* (0.406-0.861)** | **0.690* (0.447-0.933)** | 1.048 (0.813-1.352) | 1.019 (0.757-1.372) | 0.877 (0.668-1.151) | 0.823 (0.600-1.128) |
| HIGH | | | | | | | | | | | |
| | ST1 (ref) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | ST2 | 0.472 (0.215-1.036) | 0.466 (0.184 -1.177) | 0.265 (0.032-2.188) | 0.000 (0.000) | 1.270 (0.527-3.058) | 1.622 (1.545-4.829) | 1.012 (0.607-1.687) | 0.995 (0.544-1.823) | **2.277* (1.229-4.219)** | **2.147* (1.024-4.501)** |
| | ST3 | 0.749 (0.459-1.222) | 0.662 (0.362-1.208) | 0.305 (0.088-1.056) | 0.253 (0.450-1.421) | 0.891 (0.446-1.779) | 0.869 (0.355-2.122) | 0.764 (0.527-1.108) | 0.707 (0.449-1.105) | 1.400 (0.849-2.311) | 1.135 (0.608-2.119) |

A: Model A (binomial regression of each EQ-5D-3L dimensions by sitting time without adjusting by covariates). B: Model B (binomial regression of each EQ-5D-3L dimensions by sitting time adjusting by covariates as age, sex, height, weight, BMI, fat mass (%), income, education and marital status). ST: Sitting time. ST1: less than 2h/day sitted. ST2: 2-4h/day sitted. ST3 more than 4h/day sitted. Significance: ***$p$<0.05**

Table 17: Estimated odds ratios (OR) from exp ß and 95% confidence intervals (CI) for perceived problems in each EQ-5D-3L dimensions by sitting time only or sitting time adjusted by covariates in three different levels of aerobic capacity.

| AEROBIC CAPACITY | | MOBILITY | | SELF-CARE | | DAILY ACTIVITIES | | PAIN-DISCOMFORT | | DEPRESSION-ANXIETY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | A | B | A | B | A | B | A | B |
| LOW | | | | | | | | | | | |
| | SITTING TIME | | | | | | | | | | |
| | ST1 (ref) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | ST2 | 0.666 (0.396-1.118) | 0.563 (0.306-1.037) | **0.175* (0.041-0.750)** | **0.117* (0.015-0.922)** | 0.692 (0.376-1.275) | 0.603 (0.296-1.228) | 0.887 (0.517-1.524) | 0.750 (0.394-1.431) | 0.691 (0.413-1.158) | 0.825 (0.446-1.525) |
| | ST3 | 0.719 (0.507-1.020) | **0.632* (0.413-0.967)** | **0.373* (0.196-0.707)** | **0.516* (0.238-0.994)** | **0.615* (0.408-0.926)** | **0.492* (0.297-0.814)** | 1.174 (0.801-1.721) | 1.030 (0.642-1.652) | 0.708 (0.497-1.010) | 0.739 (0.479-1.142) |
| MEDIUM | | | | | | | | | | | |
| | ST1 (ref) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | ST2 | 0.844 (0.555-1.284) | 0.877 (0.549-1.403) | 0.701 (0.284-1.735) | 0.710 (0.256-1.964) | 0.938 (0.564-1.560) | 0.865 (0.479-1.560) | 0.956 (0.671-1.363) | 0.869 (0.580-1.301) | 0.839 (0.547-1.286) | **0.544* (0.351-0.842)** |
| | ST3 | 0.903 (0.662-1.231) | 0.944 (0.664-1.343) | **0.422* (0.204-0.876)** | **0.442* (0.177-0.862)** | 0.796 (0.539-1.174) | 0.838 (0.533-1.311) | 0.981 (0.750-1.283) | 0.993 (0.730-1.351) | 0.922 (0.677-1.263) | **0.653* (0.472-0.902)** |
| HIGH | | | | | | | | | | | |
| | ST1 (ref) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | ST2 | 0.653 (0.298-1.429) | **0.288* (0.090-0.921)** | 1.667 (0.330-8.423) | 0.643 (0.055-7.460) | 0.886 (0.317-2.475) | 0.674 (0.159-2.857) | 1.474 (0.894-2.430) | 1.162 (0.639-2.110) | 0.648 (0.296-1.419) | **3.140* (1.391-7.087)** |
| | ST3 | 0.581 (0.323-1.044) | 0.541 (0.274-1.067) | 1.092 (0.270-4.425) | 0.738 (0.141-3.874) | 0.720 (0.323-1.607) | 0.714 (0.262-1.945) | 0.880 (0.601-1.290) | 0.645 (0.409-1.018) | 0.575 (0.320-1.033) | 1.617 (0.802-1.359) |

A: Model A (binomial regression of each EQ-5D-3L dimensions by sitting time without adjusting by covariates. B: Model B (binomial regression of each EQ-5D-3L dimensions by sitting time adjusting by covariates as age, sex, height, weight, BMI, fat mass (%), income, education and marital status). ST: Sitting time. ST1: less than 2h/day sitted. ST2: 2-4h/day sitted. ST3 more than 4h/day sitted Significance**: *$p$<0.05**

Table 18: Estimated odds ratios (OR) from exp ß and 95% confidence intervals (CI) for perceived problems in each EQ-5D-3L dimensions by sitting time only or sitting time adjusted by covariates in three different levels of strength+aerobic capacity.

| STRENGTH+AEROBIC CAPACITY | | MOBILITY | | SELF-CARE | | DAILY ACTIVITIES | | PAIN-DISCOMFORT | | DEPRESSION-ANXIETY | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | A | B | A | B | A | B | A | B |
| LOW | SITTING TIME | | | | | | | | | | |
| | ST1 (ref) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | ST2 | 0.691 (0.413-1.158) | 0.597 (0.326-1.093) | **0.172* (0.040-0.740)** | **0.111* (0.014-0.879)** | 0.709 (0.384-1.310) | 0.590 (0.290-1.202) | 0.829 (0.483-1.420) | 0.694 (0.365-1318) | 0.898 (0.537-1.502) | 0.776 (0.420-1.433) |
| | ST3 | 0.708 (0.497-1.010) | **0.627* (0.407-0.965)** | **0.309* (0.155-0.614)** | **0.374* (0.163-0.857)** | **0.624* (0.410-0.950)** | **0.464* (0.276-0.779)** | 1.035 (0.703-1.524) | 0.901 (0.559-1.451) | 0.806 (0.564-1.152) | 0.706 (0.455-1.098) |
| MEDIUM | | | | | | | | | | | |
| | ST1 (ref) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | ST2 | 0.839 (0.547-1.286) | 0.854 (0.529-1.378) | 0.690 (0.261-1.826) | 0.689 (0.229-2.072) | 1.023 (0.606-1.729) | 0.909 (0.495-1.670) | 0.933 (0.652-1.336) | 0.829 (0.551-1.248) | 0.716 (0.483-1.061) | **0.627* (0.410-0.961)** |
| | ST3 | 0.922 (0.674-1.263) | 0.941 (0.658-1.345) | 0.485 (0.228-1.029) | 0.535 (0.229-1.248) | 0.875 (0.584-1.309) | 0.903 (0.570-1.432) | 1.002 (0.764-1.314) | 0.979 (0.729-1.361) | 0.887 (0.666-1.181) | **0.709* (0.516-0.973)** |
| HIGH | | | | | | | | | | | |
| | ST1 (ref) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | ST2 | 0.648 (0.296-1.419) | **0.297* (0.093-0.950)** | 1.656 (0.328-8.371) | 0.632 (0.055-7.303) | 0.886 (0.317-2.475) | 0.693 (0.160-3.005) | 1.493 (0.905-2.464) | 1.232 (0.680-2.231) | **2.811* (1.448-5.455)** | **2.933* (1.303-6.602)** |
| | ST3 | 0.575 (0.320-1.033) | 0.545 (0.274-1.086) | 1.078 (0.266-4.368) | 0.737 (0.142-3.821) | 0.768 (0.348-1.696) | 0.780 (0.280-2.172) | 0.887 (0.605-1.301) | 0.636 (0.404-1.002) | 1.556 (0.873-2.772) | 1.685 (0.837-3.396) |

A: Model A (binomial regression of each EQ-5D-3L dimensions by sitting time without adjusting by covariates. B: Model B (binomial regression of each EQ-5D-3L dimensions by sitting time adjusting by covariates as age, sex, height, weight, BMI, fat mass (%), income, education and marital status). ST: Sitting time. ST1: less than 2h/day sitted. ST2: 2-4h/day sitted. ST3 more than 4h/day sitted Significance**: *$p$<0.05**

Table 19. .Mean difference from follow up minus baseline with 95% confidence intervals (CI) for the difference by fitness groups and fitness levels.

| | LOW | | MEDIUM | | HIGH | |
|---|---|---|---|---|---|---|
| **STRENGTH** | Diff X (95%CI) | p | Diff X (95%CI) | p | Diff X (95%CI) | p |
| ST1-ST2 | 0.004 (-0.033/0.026) | 1.00 | 0.005 (-0.014/0.056) | 1.00 | -0.008 (-0.033/0.016) | 1.00 |
| ST2-ST3 | **0.026 (-0.001/0.050)** | **0.034** | 0.014 (-0.029/0.001) | 0.072 | -0.015 (-0.035/0.006) | 0.254 |
| ST1-ST3 | 0.022 (-0.050/-0.001) | 0.298 | -0.013 (-0.025/0.052) | 0.081 | 0.006 (-0.021/0.030) | 1.00 |
| **AEROBIC CAPACITY** | | | | | | |
| ST1-ST2 | 0.005 (-0.027/0.037) | 1.00 | 0.002 (-0.016/0.021) | 1.00 | -0.014 (-0.037/0.008) | 0.388 |
| ST2-ST3 | **-0.030 (-0.054/-0.005)** | **0.010** | -0.012 (-0.028/0.004) | 0.222 | -0.002 (-0.027/0.023) | 1.00 |
| ST1-ST3 | **0.035 (0.001/0.069)** | **0.045** | 0.014 (-0.007/0.035) | 0.304 | -0.013 (-0.032/0.006) | 0.337 |
| **STRENGTH+ AEROBIC CAPACITY** | | | | | | |
| ST1-ST2 | 0.002 (-0.030/0.034) | 1.00 | 0.004 (-0.014/0.023) | 1.00 | -0.015 (-0.037/0.007 | 0.328 |
| ST2-ST3 | **-0.033 (0.058/-0.009)** | **0.003** | 0.014 (-0.007/0.035) | 0.332 | -0.002 (-0.026/0.023) | 1.00 |
| ST1-ST3 | **0.035 (0.002/0.069)** | **0.037** | -0.010 (-0.026/0.006) | 0.425 | -0.013 (-0.032/0.006) | 0.286 |

**Diff X: Mean difference. *Significance: p*<0.05**

Table 19 shows the mean differences between follow up mean and baseline means with the 95% CI according to the 3 different fitness groups. Results are also divided by fitness levels. Significant differences were only observed in the low fitness level group in all 3 fitness groups. No differences were found in the medium or high fitness level groups in any of the 3 fitness groups. Significant differences in the low fitness level group were seen only between the ST2 and ST3 in the TStr fitness group, while in the other 2 fitness groups, AC and TStr+AC, the differences were found not only between the ST2 and ST3 buy also between ST1 and ST3. No differences were observed in any of the fitness groups between ST1 and ST2. The partial eta squared (η2p) observed for the different groups (η2p= 0.012, η2p= 0.006, η2p= 0.007, η2p= 0.020, η2p= 0.004, η2p= 0.008, η2p= 0.024, η2p= 0.003, η2p= 0.009 for the low, medium and high fitness level groups in the TStr, AC and TStr+AC fitness groups respectively) showed a small effect size in all of the cases. Cohen (154) values were used to interprete the effect size as follow: 0.01 for a small effect, 0.06 for a medium effect and 0.14 for a big effect.

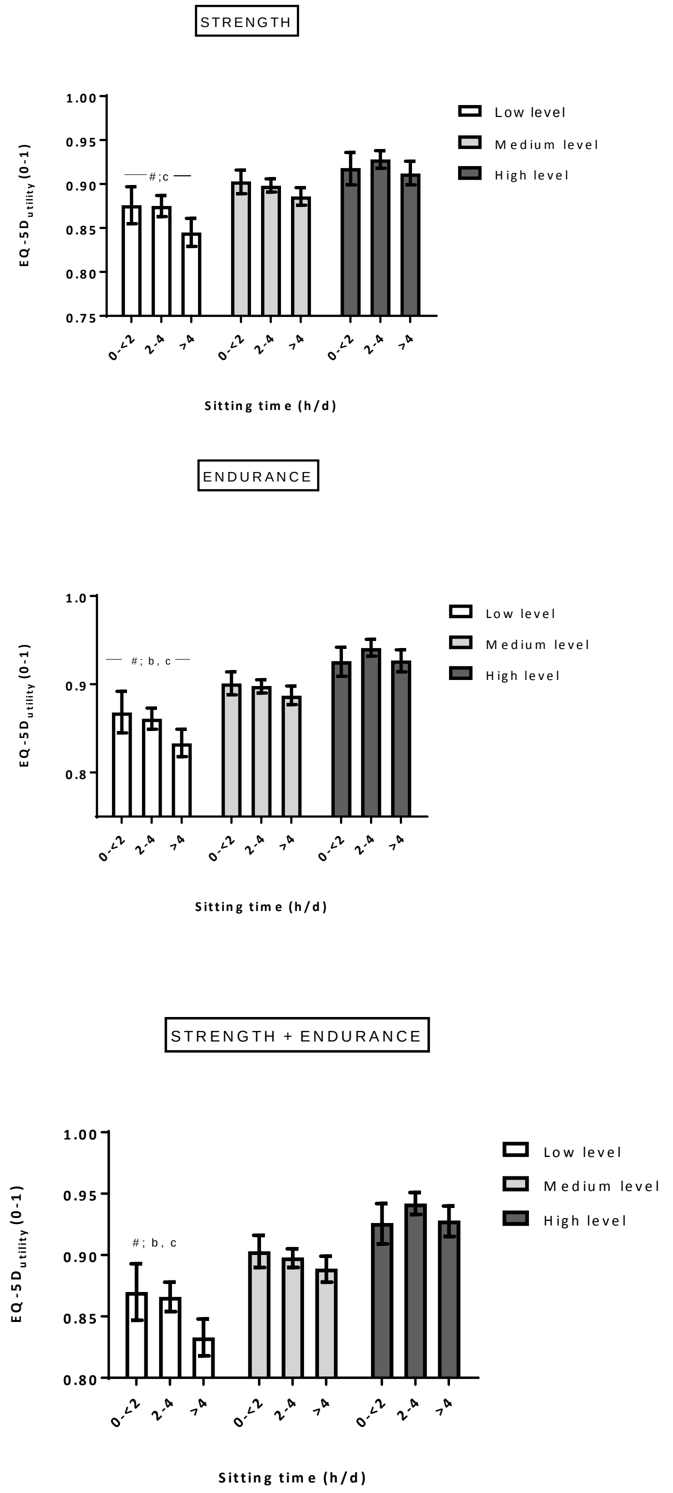



Figure 18. Effects of sitting time on HRQoL by 3 different fitness levels. ST1: less than 2h/day sitted. ST2: 2-4h/day sitted. ST3 more than 4h/day sitted. (#= significant differences $p<0.05$), a= between ST1 and ST2; b= between ST1 and ST3; c= between ST2 and ST3).

Figure18 manifests the relationship between ST and HRQoL total scores by the three different physical tests divided by three fitness levels. Significant differences were only found in the low fitness level group in the three physical tests. AC and TStr+AC presented significant differences in ST1 with ST3 and ST2 with ST3, while TStr showed significant differences only in ST2 and ST3. Low fitness seems to affect negatively to HRQoL.

### 7.5 D*iscussion*

According to the results presented in this work, when analysing the data from the 5 domains from the EQ-5D-3L, results showed differences depending on which domain was analysed. Basically, domains could be divided in two different groups whether they were more physical or psychosocial related. In the first 3 domains, mobility, self-care and daily activities, similar results were observed while in the last 2 domains, pain-discomfort was not affected and depression-anxiety, presented opposite results than the 3 first domains in the high fitness level group. The first 3 domains showed in all cases with significant differences a smaller probability that the event happens that in the reference value. Mobility, self-care and daily activities are deeply related to physical capacity and fitness. For this reason, it could be logical to think that subjects with higher physical condition should score also higher in these domains, presented smaller probability of problems. The results presented in this work show the opposite. In the present study subjects that sit more presented less self-percived probability of suffering mobility problems independently of fitness level. In older adults it could make sense that the less they move, the fewer problems they reflect in this domain. The subjects more active, those that spent less than 2 h/d sitted, might report more mobility problems only because they move more. According to Omorou et al. (155), if overall PA could be beneficial for HRQoL, not all domains might be equally beneficial. Those authors found that PA-HRQoL association was dependent on the domain-specific PA when PA was considered either a predictor or outcome of HRQoL. For these authors, taking into account the specific domains of PA and SB is important to design interventions to prevent HRQoL. So that the 3 first domains of the EQ-5D-3L are related to physical capacity, it seems logical to think that these areas of the HRQoL questionnaire are also related to PA. Gopinath et al. (156) also concluded that the association of SB with HRQoL may also depend on the specific domain under study.

Self-care and daily activities domains presented a similar trend, showing no differences in the high fitness group. The fact that the low and medium fitness groups presented a smaller probability of problems happening than the reference group could be also explained with the same argument than the mobility domain. Older adults with lower fitness would participate less in daily activities or their self-care activities would be also reduced. If these activities are reduced, it could be also logical to think that those subjects might report fewer problems.

Any significant differences were observed in the pain-discomfort domain in any of the fitness groups or levels. This could be interpreted as in older adults, the perception of pain and discomfort is not related to SB or fitness level, reflecting that this population experiences pain anyway, independently from fitness or SB. In a study conducted by Rustoen et al. (157) which divided the population in 3 groups according to age, although the participants in the older age group reported pain of longer duration and more comorbidities and received pain treatment more often, had higher total QoL scores, were more satisfied with their material comforts and social life, and reported better mood than the younger groups. That means that while for younger people, less than 65 years, to feel pain is directly linked to QoL, older adults integrate pain as something normal that does not interfere their perception of QoL.

In the anxiety-depression domain, when adjusted by fitness, results showed two different trends. The sample presented a smaller probability of problems happening when comparing to the reference group in the low fitness group in TStr group and in the medium fitness group in the AC and TStr+AC groups. It means that individuals with low or medium fitness level may suffer lower risk of depression and anxiety when they sit more than 2h/d than those individuals that sit less than 2h/d. That could be explained in relation to the other domains, where subjects also experienced less problems when they sitted more because their activities seem to be reduced. On the contrary, in the high fitness level group in AC and Tstr+AC groups, a greater probability of suffering depression and anxiety was observed. Individuals with higher fitness level could experiment a greater risk of suffering from depression and anxiety when they spend more than 2 h/d sitting comparing to those that spend less than 2 h/d. These results are consistent with those found by De Mello et al. (158). This study concluded that people who do not practice PA have a higher chance of exhibiting symptoms of depression and anxiety when compared to those who perform PA regularly. Similar results were found by Antunes et al. (159).On the contrary, different results were found by Olivares et al. (146), in a cross-sectional study carried out in 7,104 community-dwelling participants aged 50-99 years, from of the Exercise Looks After You (ELAY) Program, which included the EQ-5D-3L questionnaire and performed a battery of fitness tests. The authors concluded that there were significant correlations between all variables analysed and HRQoL except for anxiety/depression.

In order to be able to establish the interaction of some socio-demographic patterns with the ST level and the different domains of the EQ questionnaires, two different models were analyzed. Our results present similar tendency in both models although an influence of the socio-demographic factors can be observed. When only ST was taken into account, a smaller influence of ST on HRQoL was observed in almost every domain. When the socio-demographic factors were also taken into account, a higher influence was seen of ST on HRQoL. That may mean that the relations between different factors that could affect individuals´ lives, should not be interpreted in isolation. A bigger environment frame can help understanding in a deeper way those interactions.

When results were divided by fitness groups (AC, TStr and TStr+AC) and fitness levels (low, medium and high), it was observed that the low fitness level groups presented significant differences in the TTO score from the EQ-5D-3L questionnaire in all of the 3 fitness groups. This could be interpreted as the lower the fitness level is, the bigger influence the ST has in the HRQoL in general although that is not reflected in the domains. These results are consistent with the results found by others authors (14, 142) (15). In a study conducted by Moilanen et al. (142) with 1,165 Finnish perimenopausal women aged 45-64 years during 8 years of follow up, the authors reported no significant correlation between menopausal transition and change in global QoL but they found that women that increased their PA or had stable weight had improved their QoL. Moratalla-Cecilia et al. (160) reported in a study with early postmenopausal women that higher physical fitness is consistently associated with better HRQoL in this population. While those authors found that lower-body flexibility followed by upper-body muscle strength were the fitness components more strongly associated with HRQoL, our study showed that upper and lower limb strength and aerobic capacity correlated strongly with HRQoL. A possible reason for this discrepancy might be that the Mortalla-Cecilia study included only women while the present study was conducted in both sexes. On the other hand, Vuillemin et al. (15) found significant differences between inactive and vigorous leisure active time in a sample of

5,654 subjects from a French general adult population aged 35-60 years. Higher level of leisure active time was associated with higher level of HRQoL in both men and women whatever the dimension considered, after adjusting by several HRQoL correlated. These authors also found that meeting PA recommendations was also associated with higher HRQoL scores, except for bodily pain dimension in women (results concordant with the results from the present study). Same conclusions were found by Balboa-Castillo et al. (161) in a study carried out in Spain with 1,097 persons aged 62 and over, where greater leisure PA and less leisure ST were independently associated with better long-term HRQoL in older adults. This association affects both the physical and mental domains of HRQoL. Spending more leisure active time showed a positive linear trend with physical functioning, physical role, bodily pain, vitality, social functioning, emotional role and mental health. Individuals that met the ACSM/AHA recommendations on PA (162) presented better physical functioning, social functioning and emotional role. ST showed a gradual and inverse relation with the score on the scales of physical functioning, physical role, bodily pain, vitality, social functioning and emotional role.

### *7.6 Study strengths*

The sample used for the present study was representative for the Spanish population. On the best of our knowledge, no studies in Spain have investigated the relationship between physical fitness, ST and HRQoL in a sample of over 3000 older adults. This relationship has been mostly investigated in intervention trails and also mostly in population with chronic conditions. The present study focused in general population with no chronic diseases what could be easily extrapolated.

### *7.7 Study limitations*

The study here presented has some limitations. Firstly, the sample selected had a high percentage of physically active subjects what could not be the normal situation for elderly. Nevertheless, this fact could help identifying PA as a protective pattern associated with higher HRQoL levels. Secondly, no dietary recall was carried out making impossible to correlate nutritional status to HRQoL. On the other hand, chronic diseases or medical history were not collected, what makes difficult to stablish any correlation between past health status and HRQoL at the time of the study.

### *7.8 Conclusions*

ST is inversely related to HRQoL as measured by The TTO score. Higher ST seems to be related to poorer scores in HRQoL tests in elderly. High levels of fitness could help attenuating the negative effects of sitting time in the subjective perception of HRQoL. Thus, ST is negative related to QoL in general but more specifically in subjects with low fitness levels. Although the mobility, self-care and daily activities domains of the EQ-5D-3L questionnaire seem to be positively affected by a higher ST, this may be explain for the fact that older adults that expend long time seated might not experience problems in these domains because they do not move enough.

More longitudinal studies are needed to get deeper into these relationships to establish the effects of SB and fitness levels on HRQoL in elderly.

# 8. **CHAPTER 8. STUDY 3:** Effects of variations in sedentary time to HRQoL by fitness level in a 4years period of time in Spanish older adults. The EXERNET longitudinal study.


## *8.1 Abstract*

**Background:** Physical activity (PA) is important for maintaining health, mobility and well-being in older age. Despite that, adults over 60 year combine low levels PA with high levels of sedentary behavior (SB). A decline in physical capacity, due to less PA, too much ST or both together, could lead to a poorer QoL especially in older adults. To assess the link between ST, PA or fitness and HRQoL is basic to guarantee a successful aging. The aim of this study was to establish the relationship of changes in ST to HRQoL by fitness level in a 4-years period of time. **Methods:** 1,164 Spanish elderly were recruited. A lifestyle questionnaire (income, educational level, marital status, etc.) and the EuroQol EQ-5D-3L questionnaire were filled at baseline and follow-up. ST changes were stratified in 3 levels according to the modification of results in the first and second phase. Level 0 (SB0) was set for no change, level 1 (SB1) for decreasing ST and level 2 (SB2) for increasing ST. Anthropometric and body composition measurements as well as physical tests were also performed (lower and upper body strength by the chair stand test and arm curl test, respectively, and endurance by the 6-min walk test) (65). Based on the results for total strength (TStr), arobic capacity (AC) or the sum from both (TStr+AC), the sample was divided into 2 groups: -P75, for those under the percentile 75 and +P75 for those in the percentile 75 or above. **Results:** Results from -P75 and +P75 showed greater scores in the EQ-5D-3L in the +P75 group than in the -P75 for TStr, AC and TStr+AC. Significant differences were observed only between SB1 and SB2. While in the AC and TStr+AC groups the differences were found in the -P75 group, in the TStr group the differences appeared in the +P75 group (p= 0.010, p=0.014 and p=0.029 for AC, TStr+AC and TStr, respectively). In the TStr group, significant differences were seen between SB1 and SB2 in the +P75 group (p=0.029) but not in the -P75 one. Any statistical differences were found when comparing SB0 to SB1 or SB0 to SB2. **Conclusion:** Independently from fitness, a reduction of the total ST in a 4-year period could lead to greater HRQoL in older adults. High fitness levels were also related to greater HRQoL.

*8.2 Introduction*

Aging is commonly defined as the accumulation of diverse deleterious changes occurring in cells and tissues with advancing age that are responsible for the increased risk of disease and death (19).

This degeneration is often associated with a gradual decrease in functional capacity (reduction in strength, endurance, speed of reaction, agility and basal metabolism). This physical deterioration can lead to a reduction in PA and consequently, in fitness level as the same time that SB increase. It is well known that PA is important for maintaining health, mobility and well-being in older age (163). Despite these evidences, adults over 60 year are the less active segment of the population (164) at the same time that present a high level of SB (165).

SB can be defined as any waking behaviour characterized by energy expenditure less than or equal to 1.5 metabolic equivalents while in a sitting or reclining posture (166). SB have emerged as a new focus for research on PA and health in the past 10 years in order to clarify if too much ST is different than too little exercise. At the moment, studies show (144, 155, 167) that breaking up sedentary time can be beneficial due to the relationship of SB with premature mortality. Nevertheless, the question of if too much ST negative effects can be compensated by light, moderate, and/or vigorous activity or high fitness levels remains unclear.

A decline in physical capacity, due to less PA, too much ST or both together, could lead to a poorer QoL especially in older adults.

On the best of our knowledge, few longitudinal studies have focused on the relationship of ST, fitness level and QoL. Balboa-Castillo et al (161) investigated the longitudinal association of PA and SB during leisure time with HRQoL in community dwelling older adults finding that greater leisure active time and less leisure ST were independently associated with better long-term HRQoL in older adults.

On the other hand, life expectancy is defined as the average total number of years that a human expects to live (19). Global average life expectancy increased by 5 years between 2000 and 2015, the fastest increase since the 1960s (168). As result, the increasing number of older people in developed countries is a fact.

The combination of these three factors, reduction of PA by age, increases of sedentary time and more years to live, could result in a decrease of QoL, especially in the older group of population. To assess the link between ST, PA and HRQoL is basic to guarantee a successful aging.

The aim of this study was to establish the relationship of changes in sedentary time to HRQoL by fitness level (standard and high) in a 4years period of time.

*8.3 Methods*

The longitudinal data used for this work were obtained from “The EXERNET-longitudinal study”. The protocol of the EXERNET study has been published elsewhere (127).

*8.3.1 Study sample:*

A total sample of 1,164 Spanish elderly was recruited for this proposes from the EXERNET-longitudinal study. Subjects should have participated in the first phase of the EXERNET cross-sectional study and volunteer to repeat in the second phase.

*8.3.3 Study protocol:*

The same exactly protocol were performed as follow in both phases; 1) filling the questionnaire (lifestyle and the EuroQol EQ-5D-3L, 2) anthropometric measurements and body composition analysis by bio-impedance analysis, 3) the physical tests performed by all the subjects in the same order. All the data were collected on the same day

*8.3.4 Health Related Quality of Life (HRQoL):*

To assess the HRQoL the EuroQol EQ-5D-3L survey was used. For the purpose of this study, scores obtained at phase 2 (TTO-B) were analyzed to evaluate the HRQoL status of the sample at follow-up.

*8.3.5 Sedentary Behaviours (SB) assessment*

A specific question about time spending a day in sitting position was included in the questionnaire (153) in both phases. To measure the SB changes of the sample, three levels were taken into account according to the modification in ST from results of the first and second phase. Level 0 (SB0) was set for no change in ST, level 1 (SB1) was set for decreasing ST from phase 1 to phase 2, that means improving SB and level 2 (SB2) was set for increasing ST from phase 1 to phase 2, what means worsen SB.

*8.3.6 Physical fitness assessment*

Lower and upper body strength were measured by the chair stand test and arm curl test, respectively and aerobic endurance by the 6-min walk test (65). For the aim of this study, the sample scores from total strength, endurance and strength plus endurance were divided in two groups: one group with the subjects below the percentile 75 (-P75) and the other group with the subjects in the percentile 75 or above (+P75). Because one of the aims of the present study was to analyze the influence of the ST in the HRQoL by fitness level, the percentile 75 was considered the cut point to divide the sample in two groups; one with very good fitness condition and another one with standard fitness condition.

*8.3.7 Covariates*

For the purpose of this study, data at baseline were used as covariates.

*8.3.8 Anthropometric and body composition measures.*

Weight, height and BMI were collected. Body composition was measured by bio impedance technique.

*8.3.9 Statistical analysis:*

Descriptive values were analyzed as means and SD in both phases. Mean difference and 95% CI were also analyzed. Histograms graphics reveled all variables as normal distribution. Anthropometric and socio-economic variables were set as covariates. In order to establish the influence of fitness levels on HRQoL by changes in SB in the four year period, two models were analyzed. In the first model, Model A, results were adjusted by socioeconomic covariates as well as anthropometrics but without taking into account fitness covariates. The second model, Model B, takes into account fitness covariates such as strength and endurance levels. (Model A: Adjusted by age, sex, BMI, fat mass (%), income, education and marital status. Model B: Adjusted by model A, leg strength, arm strength and AC. Univariate general linear model (ANOVA) was used to establish the correlation between the dependent variable, TTO-B and the factors here analyzed, ST and Fitness levels. To contrast the simple effects between factors, a modification in the syntax was made. To observe the influence of covariates in the model, an ANOVA was also carried out. IBM SPSS Statistics 20.0 software was used to analyze the data (SPSS Inc., Chicago, USA), and statistical significance level was set at $p < 0.05$.

## *8.4 Results*

A total sample of 1,164 subjects participated in this longitudinal study. Descriptive data at baseline and follow up are presented in Table 20.

**Table 20.** Sample characteristics at baseline and follow-up **n=1,164**

| | Baseline | Follow up |
|---|---|---|
| Age | 71.50 (5.01) | 74.26 (4.99) |
| Gender (Male) | 264 (22.7%) | 264 (22.7%) |
| Height (cm) | 155.64 (8.12) | 155.36 (8.09) |
| Weight (Kg) | 70.45 (11.09) | 70.29 (11.08) |
| BMI (Kg/m$^2$) | 29.12 (4.09) | 29.11 (4.17) |
| Fat Mass, % | 37.08 (6.84) | 37.05 (6.88) |
| Educational status (%) | | |
| Primary or lower | 83.90 | 86.90 |
| Secondary or higher | 16.01 | 13.11 |
| Marital Status (%) | | |
| Single | 4.50 | 4.30 |
| Married | 63.90 | 62.10 |
| Divorced | 3.10 | 2.70 |
| Widow | 28.40 | 31.00 |
| Income (%) | | |
| <600€/month | 42.14 | 32.9 |
| 600-900€/month | 33.90 | 38.3 |
| >900€/month | 24.00 | 28.8 |
| Leg Strength (rep) | 14.49 (3.29) | 14.68 (3.87) |
| Arm Strength (rep) | 17.12 (4.01) | 17.98 (3.93) |
| Endurance (rep) | 529.65 (86.38) | 509.66 (98.16) |

All values are Mean (SD) unless otherwise stated

Figure 19 showed the results from the ANOVA univariate that analyzed the two different models, A without adjusting by fitness and B adjusted by fitness. As the figure shows, no significant differences were observed in any of the 3 SB groups in any of the 2 models. Independently from fitness, a greater TTO-B was observed when ST was reduced from phase 1 to 2 in both models. Subjects that increased the total ST during the study period reflected the poorest scores in the EQ-5D3L questionnaire in both models, while those who maintained similar ST showed TTO-B values between those from the other two groups.

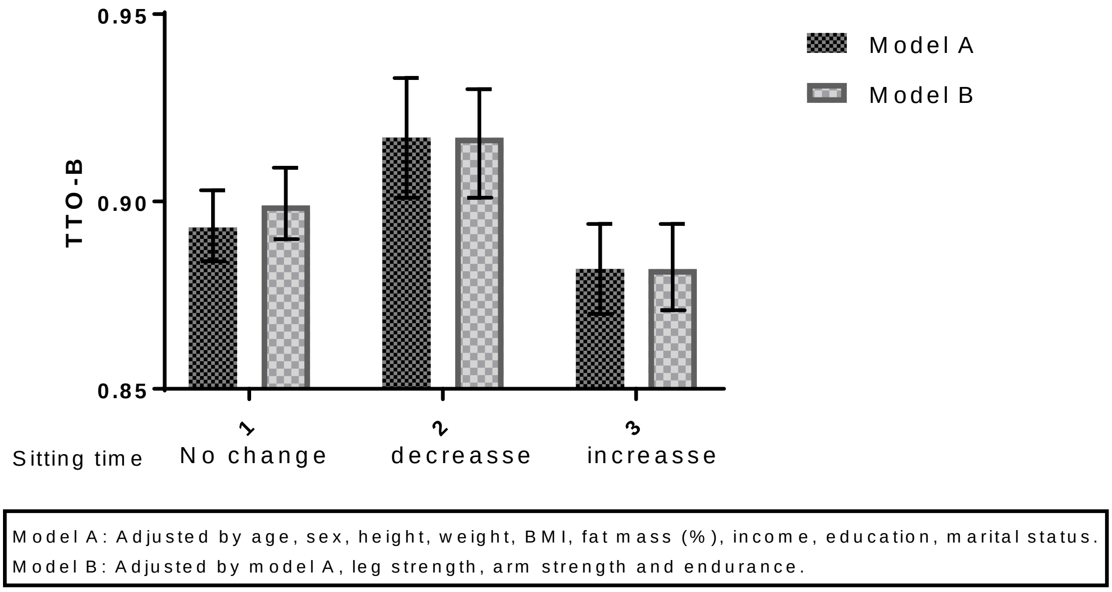



Figure 19. Influence of sitting time on Health Related Quality of Life by model A and B. No change: SB0, Decrease: SB1, Increasse: SB2

Table 21 shows the results from the difference of the means from phase 1 and 2 and the 95% CI of TTO-B scores by the changes in SB in the 2 phases. Results are presented for the 2 models analyzed. Significant differences were observed when comparing SB0 to SB1 and SB1 to SB2 in the model A while in model B differences were only observed when comparing SB1 to SB2.

Table 21. Mean differences and 95%CI of TTO-B by model A and B according to SB changes

| | Model A | | Model B | |
|---|---|---|---|---|
| | Diff X (95%CI) | P | Diff X (95%CI) | p |
| SB0-SB1 | **-0.024 (-0.046/-0.001)** | **0.038*** | -0.017 (-0.040/0.005) | 0.202 |
| SB0-SB2 | 0.012 (-0.007/0.030) | 0.399 | 0.017 (-0.001/0.036) | 0.076 |
| SB1-SB2 | **-0.035 (-0.060/-0.011)** | **0.002*** | -0.034 (-0.059/-0.010) | **0.002*** |

Diff X: mean differences of TTO-B. TTO-B: Quality of Life scores in phase B **$*P<0.05$**

To be able to establish the relationship between TTO-B and changes in SB over the four year period by fitness level, a modification in the syntax of the ANOVA univarite was performed and the sample was splitted by the fitness level groups, -P75 and +P75. The results of this analysis are presented in Table 22. Significant differences were only observed within the SB1 and SB2 groups, in the AC and AC+Tstr groups in the –P75 fitness level group and in the TStr group in the +P75 fitness level group.

Table 22: Mean differences of TTO-B with 95%CI by changes in SB according to fitness groups and fitness levels.

| | **Endurance (AC)** | | **Strength (Tstr)** | | **Endurance+Strength (AC+Tstr)** | |
|---|---|---|---|---|---|---|
| **-P75** | **DiffX (95%CI)** | **p** | **DiffX (95%CI)** | **p** | **DiffX (95%CI)** | **p** |
| SB0-SB1 | -0.025 (-0.052/0.002) | 0.082 | -0.015 (-0.042/0.012) | 0.540 | -0.024 (-0.051/0.003) | 0.101 |
| SB0-SB2 | 0.010 (-0.012/0.032) | 0.813 | 0.010 (-0.011/0.032) | 0.713 | 0.010 (-0.012/0.032) | 0.872 |
| SB1-SB2 | **0.035* (0.006/0.063)** | **0.010** | 0.026 (-0.054/0.003) | 0.099 | **0.034* (0.005/0.062)** | **0.014** |
| **+P75** | | | | | | |
| SB0-SB1 | -0.011 (-0.058/0.037) | 1.000 | -0.037 (-0.082/0.009) | 0.159 | -0.014 (-0.062/0.034) | 1.000 |
| SB0-SB2 | 0.017 (-0.020/0.054) | 0.839 | 0.016 (-0.024/0.056) | 1.000 | 0.020 (-0.018/0.057) | 0.633 |
| SB1-SB2 | 0.028 (-0.023/0.078) | 0.577 | **0.052* (0.004/0.101)** | **0.029** | 0.033 (-0.018/0.085) | 0.363 |

**DiffX: Mean differences. ****p***<0.05.Significant differences between SB1 and SB2.** –P75: under percentile 75, +P75: in percentile 75 or avobe. SB0: no changes in SB from phase 1 to 2. SB1: decrease in SB. SB2: increase in SB.

Figure 20 shows the correlation between both fitness levels groups and changes in SB over time with the TTO-B. Results show significant differences in the AC and AC+Tstr groups in the subjects that did not change the SB (SB0) and those that increased the SB (SB2) between the two fitness level groups, -P75 and +P75. No significant differences were observed between the fitness level groups in the TStr group.

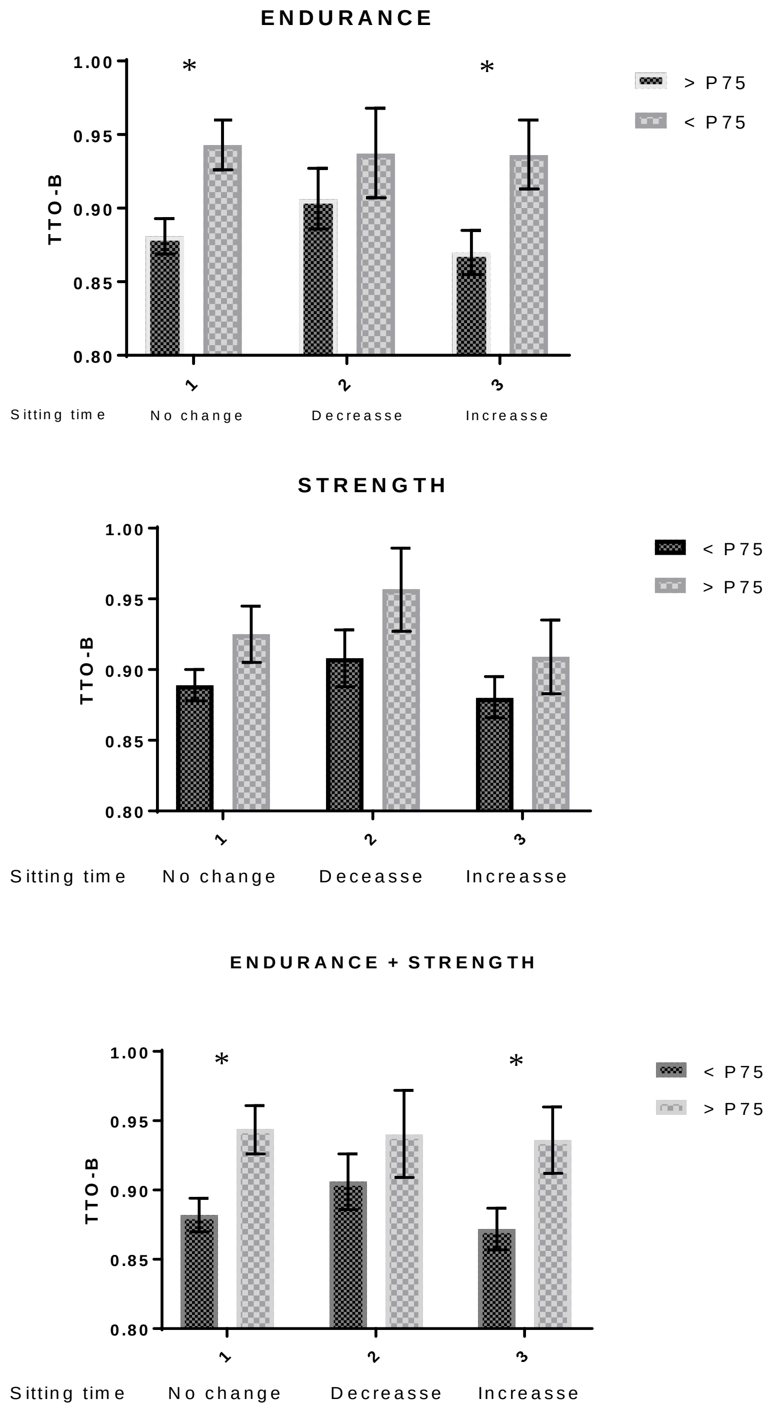



Figure 20. Effects of changes in sitting time on TTO-B by fitness. No change: SB0, Decrease: SB1, Increasse: SB2. < P75: under percentile 75, > P75: percentile 75 or above. *: significant differences between the fitness levels groups. **Significant differences: *$p$<0.05**.

*8.5 Discusion*

SB is an emerging risk pattern. The relationship between SB, HRQoL and fitness is a crucial topic to understand involution process in elderly.

According to the results found in the present study, independently from fitness, a reduction of the total ST in a 4year period could lead to greater HRQoL when comparing scores from EQ-5D-3L at baseline and follow up in a Spanish elderly population with those that maintained or increased total ST in that period. This could be interpreted as independently from physical condition, spending less ST per day in a four year period might be related to a greater TTO-B score. These results are consistent with many studies that have postulated that elevated ST per day correlates negatively to HRQoL (169-171). Schmid et al. (172) demonstrated in a sample of 1,677 subjects aged 50 years or older using accelerometers that, both high levels of sedentary time and low levels of vigorous PA were independent predictors of early mortality from any cause. Our data showed that the highest HRQoL levels were reached by those subjects that sitting less during the study time, follow by those that maintained the ST and the subjects that spent more time sitting in follow-up than at baseline reached the poorest HRQoL. That means that reducing the SB over time may lead to higher HRQoL. Results from in between the two models showed that while in the model not adjusted by fitness significant differences were seen between the group that maintained the ST with the group that reduced it and between the groups that reduced and increased ST, the results from the model adjusted by fitness showed only differences between the groups reduced and increased ST. That could mean that fitness may attenuate the negative effects of prolonged ST over time.

To the best of our knowledge, all of the studies carried out so far were focused on measure sedentary time and moderate to vigorous PA time per day. The present study used the fitness level measured according to the scores obtained after performing a battery of specific tests for older adults to assess their fitness level. It might be interesting to clarify if higher levels of fitness could attenuate the negative effects of SB, and not only the PA time. The present study found significantly greater HRQoL in those individuals who were above P75 in the 3 different fitness tests analyzed; independently of which fitness component was studied. Therefore, fitness levels above average result in an improvement of HRQoL. Our data showed that independently form ST, the subjects with higher fitness scored a significantly greater TTO-B. We consider important to keep in mind that HRQoL is an individual's or a group's perceived physical and mental health over time, what reflects the subjective and multidimensional perception of health (173), encompassing physical and occupational function, psychological state, social interaction and somatic sensation (174). As Loprinzi pointed out (175) in a recent study, prolonged SB could induce cardio metabolic consequences but these effects do not have a negative influence in the HRQoL perceived by the individual if the person is able to engage in MVPA. Our +P75 population, could also perceive a higher HRQoL although their ST per day were elevated.

On the other hand, although individuals placed in the percentile 75 or higher scored greater in the EQ-5D-3L in all of the 3 groups studied, statistic significant differences were only found when comparing subjects who reduced the SB to those who increased the SB. No statistical differences were observed between the group that did not change the SB and the group that increased or reduced the SB. These differences were found in the –P75 group in the AC and AC+Tstr groups and in the +P75 group in the TStr Group. Strength is known to play an important role in maintaining independence and capability for performing daily life activities (176-178). Therefore, subjects in the +P75 group in TStr scored significantly greater TTO-B than those in the –P75 group in all cases and the TTO-B from the +P75 group increased even more in the individuals that reduced the SB at follow-up. That could be interpreted as the sum of both, high levels of strength together with lower ST, resulted in a better perception of HRQoL. Some studies found similar results. Gusi et al. (137) performed a 12 months exercise program in which strength was specifically trained. They observed that after the program, the exercise group showed significant mild-moderate improvement in physical function and HRQoL outcomes, especially in adjusted models. At the same time, Samuel et al. (179) observed in a study with older adults that loss of muscle strength was associated with poorer functional ability and both were associated with reduced HRQoL, especially in the physical functioning domain.

When analyzing the AC or Tstr+AC groups, the statistical significance was found in the –P75 fitness level only between the group SB1 and SB2. That could be interpreted as for the subjects with lower endurance or endurance and strength together levels (what can be describe as a general fitness of participation in MVPA) (11), reducing SB could have leaded to improve the cardio metabolic system and reach a greater perception of HRQoL. Those results might lead to think which physical capacities are more determinant to maintain or improve HRQoL. When comparing the TTO-B results from the –P75 and

+P75 groups in each of the SB groups, results showed that in both, AC and AC+TStr groups, significant differences were seen between the two fitness level groups in the sample that maintained or increased the ST but any difference were observed in those that reduced the ST. These results indicate that maintaining or increasing SB over time might lead to poorer HRQoL when the fitness level is low, but those effects tend to disappear in the fitness is high.  Subjects that reduced ST over time presented a greater HRQoL even when the fitness level was low.

An important strength of the present study was the size of the sample. Large samples as the one used in this study are necessary to clarify and get deeper in the interaction between SB and fitness levels in the perception of HRQoL in older adults. Using fitness levels instead of PA to correlate with SB could be interesting as well as useful to evaluate the potential hazard of too much ST in the population due the fact that even if a person reach the daily PA recommendation, this person could not have a good fitness level. More longitudinal studies are needed to bring some light to the negative effects of SB in health and how a high fitness level may interact with it.

### *8.6 Conclusions*

Independently from fitness, a reduction of the total ST in a 4year period could lead to greater HRQoL in older adults. High fitness levels independently from ST are also related to greater HRQoL and could help counteract the negative effects on HRQoL of elevated ST over time. The combination of both, high fitness level and reduced ST leads to the highest HRQoL in older adults. More longitudinal studies that help clarifying the interaction between SB and fitness are needed, especially in older adults due to the tendency of this sector of the population to high levels of sedentary time and low fitness.

# 9. CHAPTER 9. GENERAL DISCUSSION

This thesis aims at analyzing the effect of SB and fitness on HRQoL in older adults. Additionally, in order to clarify the effects that aging could have in QoL, we studied the evolution of physical condition in our sample during a 4y period to get deeper into how aging affects fitness, due to the clear link with HRQoL. This part will summarize the main findings of the different studies as well as the discussion according to the published literature.

**Changes in physical capacity in a 4 year period in older adults**

The results presented here confirm the decline in physical capacity due to age already reported by other authors (5, 6, 11, 12). In almost every test performed, poorer scores were measured in older subjects respect the younger ones. One finding of this thesis is that although it is a fact that physical condition tends to reduce with age, to remain physically active over time could slow down the process and help maintaining higher levels of HRQoL and independence in older Spanish adults. The results presented in this document show that in a 4year period of time, several physical capacities, such as balance or leg flexibility remained stable. Other authors such as Seca (21) reported similar results in a study conducted during 12 months (9 months of a training program and 3 months detraining follow-up). They observed that flexibility and balance improvements achieved during the training phase were maintained at the end of the detraining phase. The individuals that participated in the present study maintained also the balance and leg flexibility values at follow-up although there was no intervention strategy performed with the sample. Nevertheless, the fact that 80% of the subjects reported being physically active during the follow up period could explain this result.

Differences by sex were also found in our results. Males scored higher in every test performed than females with the exception of leg and arm flexibility. Genetically, males tend to be stronger, faster (according to the NCSA, women generally produce about two-thirds the amount of total strength and applied force that men because of the different in muscle fiber size) (94) and have better aerobic capacity. Absolute values of VO2max are typically 40-60% higher in men than in women (93). This difference becomes more notably due to the variance in body weight and lean body mass. Therefore, to use the relative measure of maximal oxygen uptake is a more accurate comparison (180). Research has shown that the average young untrained male will have a VO2 max of approximately 3.5 liters/minute (absolute) and 45 ml/kg/min (relative), while the average young untrained female will score a VO2 max of approximately 2.0 liters/minute and 38 ml/kg/min. For sedentary middle-age males and females values will reach 35 and 30 ml/kg/min, respectively (180). That proves that differences tend to soften with age. On the other hand, musculoskeletal stiffness (what provokes less flexibility) seems to be significantly higher in men than in women (181), what also agrees with our findings.

It has been widely proposed that practicing regular PA may help preventing the deleterious effects of aging (130, 131). 80% of the individuals that participated in the present study declared to be physically active at follow up. When reviewing the results collected in males, we observed that balance, strength, flexibility and speed did not change significantly at follow-up. The only significant differences were observed in agility and endurance. Agility is commonly considered a quality derived from speed, coordination and flexibility. The male sample did not show significant differences either in leg flexibility or strength (directly relates to speed). Therefore, involution in agility must be related to coordination problems (whether cognitive or sensorial). Regarding endurance, it is a very complex capacity that encompasses cardiac and pulmonary systems. Among others, we can cite several factors affecting it along age; maximal heart rate, cardiac output, lunges volumes and capacity, thoracic wall compliance, pulmonary diffusion, ventilator mechanizes in exercise, physical working capacity (maximal oxygen consumption), neurological factors and body composition. All of these factors worsen with age, which somehow could explain the reduction of endurance in our subjects.

When referring to females, they scored significantly higher results in leg and arm strength but poorer values in arm flexibility, agility, speed and endurance. Arm flexibility was referred to the shoulder joint flexibility due to for the present study it was measured with the back scratch test. Range of motion is specific to a given joint and a movement and so, it is possible to be quite flexible in one movement at a given joint and, at the same time, present a very poor mobility in another joint movement (182). Flexibility variability increases with age, which could be related to differences in regular PA or exercise practice. Medeiros et al. (182) found in a study that loss of flexibility with aging is faster in some of the major body joints as compared to others, being the trunk and shoulders the ones most affected by aging. This could explain the fact that females from the study lost significatively arm flexibility after 4 years.

In summary, all of the changes observed in our sample (both males and females) could be considered predictable due to aging.

**Effects of ST and fitness levels in HRQoL**

It has been repeatedly commented in this doctoral thesis that the increase of SB in the last decades is related to mortality risk. Several studies have reported that too much ST affects negatively HRQoL, independently of MVPA. To the best of our knowledge, there is not any study investigating the relationship of SB and fitness with HRQoL in healthy elderly population. All the published studies focused, whether on ST vs. PA or, if fitness was included, the objective was to relate to mortality or other similar concepts, but not to HRQoL. The present work analyzes the data from two different perspectives. First, the cross-sectional study focused on the effects of sedentary time on HRQoL by fitness levels, trying to bring some light to the fact if too much ST could be counteracted by a very good fitness level. Our results tell us that elevated ST correlates in general with lower HRQoL but fitness levels may soften these negative effects. The results showed clearly that the greatest HRQoL scores were obtained by the subjects with lowest reported ST and highest levels of fitness.

The experts agree that too much ST is not the same than too less exercise. Individuals can meet public-health guidelines on PA, but if at the same time they have long periods of ST the metabolic health could be compromised anyway. Although breaking up sedentary time can be beneficial for maintaining health status, little is known about if these adverse health consequences are uniquely due to too much sitting, or if this fact can be accounted for by too little light, moderate, and/or vigorous activity or even by low fitness level. The lack of literature and researches in this field makes it hard to give a clear answer. In what the experts seem to agreed is that the less the ST and the higher PA and fitness is, the better HRQoL. For our sample, the greatest HRQoL scores were obtained by those individuals with the highest fitness levels and the shortest ST, reporting a progressive decrease of the QoL as the levels of physical fitness decreased and the ST increased. The EQ-5D-3L questionnaire provides information about 5 domains. The 3 first domains, daily activities, mobility and self-care, are related directly to physical fitness while the last 2 domains, pain-discomfort and anxiety-depression, are more related to psychological or emotional health in which physical health could have an influence but personal, emotional or social issues play probably a mayor role. When the estimated OR and 95% CI for perceived problems in each EQ-5D-3L dimensions by ST were analyzed, taking and no taking into account fitness levels, similar results were obtained in both models. In the 3 first domains a correlation between ST and the score obtained in each domain could be observed while the last 2 domains presented no correlation in either of the models. According to that, high levels of ST could affect the perception of the ability to perform daily activities, self-care necessities or mobility, independently of the physical fitness but not pain-discomfort and anxiety-depression.

In the cross-sectional study performed for this doctoral thesis different levels of fitness as well as different levels of ST were analyzed. The objective was to clarify the interaction of these two factors with QoL. ST is negative related to QoL in general but more specifically in subjects with low AC or Tstr. The subjects that spent more than 4 h/d sitting compared to those that spent less than 4 h/d and had low levels of AC and Tstr, presented poorer HRQoL. Moilanen (142), Sanchez-Villegas (14) and Vuillemin (15) found similar results. Moilanen found that women that increased their PA or had stable weight during menopausal transition had improved their QoL. Moratalla-Cecilia et al (160) reported in a study with early postmenopausal women that higher physical fitness is consistently associated with better HRQoL in this population. Vuillemin found that higher level of leisure active time was associated with a higher level of HRQoL in both men and women whatever the dimension considered. These authors also found that meeting PA recommendations was also associated with higher HRQoL scores, except for bodily pain dimension in women (results concordant with the results from the present study). Same conclusions were found by Balboa-Castillo et al. (161) in a study carried out in Spain on 1,097 persons aged 62 and over, where greater leisure active time and less leisure ST were independently associated with better long-term HRQoL in older adults. Olivares et al. (146) concluded in a study that the perception of problems, as measured by the EQ-5D-3L dimensions, were associated with a lower level of fitness, particularly for those dimensions that are more closely related to physical components. In the anxiety-depression dimension, when adjusted by fitness, differences were observed in the group that spent more than 4 h/d sitting comparing to those that spent less than 2 h/d. That means that subjects with better fitness experiment more depression and anxiety when they spend more than 4 h/d sitting comparing to those that spend less than 2 h/d. In the present study, as commented before, individuals that spent more time seated presented less probability of suffering mobility problems independently of fitness level. Due to PA and mobility tend to reduce with age, it could make sense that older adults that move less, reported fewer problems in the mobility domain. The more active subjects, those that spent less than 2 h/d sitted, might report more mobility problems as they move more. In relation to the two other physical domains, self-care and daily activities, older adults with lower fitness would participate less in daily activities or their self-care activities would be also reduced. A reduction in these activities could also lead those subjects to report fewer problems in these domains. Two different trends could be observed in the anxiety-depression domain, when adjusted by fitness. In the low fitness group in TStr group and in the medium fitness group in the AC and TStr+AC, the sample presented a smaller probability of problems happening when comparing to the reference group. This fact makes us think that individuals with low or medium fitness level may suffer lower risk of depression and anxiety when they sit more than 2h/d than those individuals that sit less than 2h/d. That could be related to the 3 first domains, where subjects also experienced less problems when they sitted more because their activities and the expectations seem to be reduced. On the contrary, in the high fitness level group in AC and Tstr+AC groups, a greater probability of suffering depression and anxiety was observed. Individuals with higher fitness level could experiment a greater risk of suffering from depression and anxiety when they spend more than 2 h/d sitting compared to those that spend less than 2 h/d. The fact that the physical capacity of those individuals is good could make it harder for them to spend longer periods seated.

So that individuals are very complex, some environmental factors may affect HRQoL, even more, as it has been already mentioned, because this concept is an individual and subjective perception of QoL. Socio-demographic factors should be taken into account when analysing other interactions.

When variations of ST were analysed in a 4-year period of time, the longitudinal data presented in this document, results showed that independently from fitness, a reduction of the total ST in this period could lead to greater HRQoL when comparing scores from EQ-5D-3L at baseline and follow up with those that maintained or increased total ST in that period. Our results showed significant differences between the groups that increased SB and the group that reduced SB. This could be interpreted that independently from physical fitness, decreasing ST over time might be related to a greater TTO-B score. Many authors have found similar results postulating that elevated ST per day over time correlates negatively with HRQoL (169-171). Our data showed that the highest HRQoL levels were reached by those subjects who were sitting less during the study time, followed by those that maintained the ST and the subjects that spent more time sitting in follow-up than at baseline reached the poorest HRQoL. Although reducing SB over time might lead to higher HRQoL, statistic significant differences were only found when comparing subjects who reduced the SB to those who increased the SB. No statistical differences were observed between the group that did not change the SB and the group that increased or reduced the SB. Individuals from the –P75 group presented statistical significant differences in HRQoL scores only between the groups that had reduced ST and had increased it. That could mean that subjects with lower fitness levels presented an increase in their perception of HRQoL when reducing the SB at follow-up. Due to SB is related to poor cardio-metabolic health outcomes, independently of participation in MVPA (143), reducing SB could have leaded this group to improve the cardio metabolic system and reach a greater perception of HRQoL. Breaking-up sedentary time is associated with better physical function in older adults (measured with the SFT); and, it may play an important role in future guidelines on preserving older adults' physical function to support activities of daily living.

Therefore, it is important, not only to spend short periods in a sitting position a day, but also to maintain this habit over time, not letting that age increases the ST and decreases the active time. Breaking up sedentary time and being physically active could help avoiding the negative metabolic effects that too much ST provokes in our bodies.

A review from Benatti and Ried-Larsen (183) in which 17 articles were included reviewing the effects of replacing ST by PA and analyzing the frequency, intensity and type of exercise necessary concluded that breaking up ST and replacing it with light-intensity ambulatory PA and standing may be a stimulus sufficient enough to induce acute favorable changes in the postprandial metabolic parameters in physically inactive and type 2 diabetic subjects, whereas a higher intensity or volume seems to be more effective in rendering such positive outcomes in young habitually physically active subjects.

Till the date, international institutions recommend to minimize the amount of time spent in prolonged sitting and break up long periods of sitting as often as possible (184).

In our study, results showed that individuals with very good fitness level (over the percentile 75) presented greater HRQoL. Therefore, fitness levels above average result in an improvement of HRQoL. Due to HRQoL is an individual's or a group's perceived physical and mental health over time, what reflects the subjective and multidimensional perception of health (173), encompassing physical and occupational function, psychological state, social interaction and somatic sensation (174), prolonged SB could induce cardio metabolic consequences but these effects do not have a negative influence in the HRQoL perceived by the individual if the person is able to engage in moderate to vigorous PA. That means, although these negative metabolic effects could be happening, if the person´s fitness level is high (which derives in no physical limitations) the perception of HRQoL would be also high. In our sample of individuals with very good fitness level, the HRQoL perceived was higher than in the group with normal fitness level even in those which ST per day were elevated.

In summary, replacing ST periods for PA time and achieving a very good fitness level could lead to greater perception of HRQoL in older adults.

# 10.CHAPTER 10. GENERAL CONCLUSIONS

**Comparation of handgrip strength**

- The most optimal correlation was found with the sum of both hands in a standing and sitting position in both sexes.
- When subjects are not able to perform the dynamometry test in a standing position, the data to be used should be the sum of both hands in sitting position.

**Study 1**

- Physical capacities evolution is dependent from sex and age. To remain active could help maintaining or reducing the decline in fitness level during a 4 year period of time in older adults.
- Females´ leg and arm strength increased after a 4 years period but arm flexibility, agility, speed and endurance decreased. Males´ agility and endurance presented lower values after the 4 years period.
- Balance and leg flexibility remained stable during the study follow-up.

**Study 2**

- ST is inversely related to HRQoL. Greater ST is related to poorer HRQoL in subjects with low physical capacity.
- Individuals that spend more than 4h/day sitted present a lower risk of suffering problems of mobility, self-care or daily activities when analyzing the 3 first domains of the EQ-5D-3L probably because they move less.
- No differences exist in the pain-discomfort domain between different ST or fitness levels. Pain might be experience by older adults as something for everyday life.
- Individuals with high fitness level present a bigger possibility of suffering anxiety-depression when they sit more than 4h/d while subjects with low or medium fitness level show less probability of suffering anxiety-depression when they sit more than 4h/d.

**Study 3**

- Independently from fitness, a reduction of the total ST in a 4year period could lead to greater HRQoL in older adults
- High fitness levels, independently from ST, may lead to greater HRQoL in older adults.
- The greatest HRQoL scores occur when both situations happened at the same time; a reduction of ST over time and high levels of fitness.

**General Conclusion**

Not all physical capacities evolve similar over time. Differences by age and sex were observed in a 4 year period. To have low levels of SB and maintaining these levels low over time, as well as presenting high fitness level and maintaining it high over time is related to higher HRQoL in older adults. Subjects with the highest SB and the lowest fitness level present the poorest HRQoL. More longitudinal studies that help clarifying the interaction between SB and fitness are needed, especially in older adults due to the tendency of this sector of the population to high levels of sedentary time and low fitness.

FUTURE RESEARCH LINES:

A third phase of the EXENET longitudinal study is currently being carried out. To continuous with the longitudinal study in the third point is the next step to investigate how time and changes in fitness and SB affect QoL.

An intervention with a fitness plan could be developed in order to deeply clarify the influence of measuring PA or fitness in relation to SB and HRQoL.

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**APPENDIX 1**

ANEXO II JULIO 08 V.2

EXERNET

Red de Investigación en ejercicio físico y salud para poblaciones especiales (EXERNET)

**ESTUDIO MULTI-CÉNTRICO PARA LA EVALUACIÓN DE LA CONDICIÓN FÍSICA EN PERSONAS MAYORES**

CONSENTIMIENTO INFORMADO

Ha sido usted invitado/a a participar en una investigación financiada por el IMSERSO (Ministerio de Trabajo y Asuntos Sociales) que incluye la realización de una serie de test para evaluar su condición física y su composición corporal. Su participación es totalmente voluntaria. Si usted accede a participar, se le pedirá que realice una serie de test diseñados para la evaluación de su fuerza (extremidades superiores e inferiores), resistencia aeróbica, flexibilidad, agilidad y composición corporal. Estas evaluaciones incluyen actividades como andar, permanecer de pie y estirarse. El riesgo de llevar a cabo estas actividades es similar al riesgo de desarrollar ejercicios moderados y por tanto podría llegar a provocar fatiga, agujetas, esguinces, lesión muscular, mareos o desvanecimientos. Así mismo, existe el riesgo de sufrir una parada cardiaca, infarto o muerte súbita. Si actualmente sufre alguno de los siguientes casos, usted no debería tomar parte en los test físicos a menos que un facultativo le autorizara por escrito a hacerlo: 1.- Su medico le ha desaconsejado la realización de ejercicio como consecuencia de alguna enfermedad. 2.- Ha sufrido recientemente un fallo cardiaco 3.- Actualmente cuando realiza ejercicio sufre dolor articular, dolor en el pecho, mareos o angina de pecho (incluyendo los siguientes síntomas: rigidez o presión en el pecho, dolor o sensación de pesadez) 4. Tiene presión arterial descontrolada (160/100 o superior)

Durante la realización de los test se le pedirá que los realice dentro de su "zona de confort" y nunca se le presionará hasta un punto de sobresolicitación o por encima de lo que usted crea es seguro. Comunique a la persona que le evalúa si tiene algún síntoma o sensación extraña como pérdida de aliento, mareo, dolor en el pecho, taquicardias, entumecimiento, pérdida de equilibrio, nauseas o visión borrosa.

Si como consecuencia de la realización de los test sufriera cualquier lesión, el personal que lleva a cabo los test únicamente está autorizado a darle los primeros auxilios y atenciones básicas. Posteriormente será usted mismo quien deberá buscar tratamiento en su propio medico si lo necesitara.

Recuerde que siempre puede dejar de realizar las pruebas en el momento que usted lo desee y así lo solicite. Mediante la firma de este consentimiento usted asume:

1.- Que ha leído el contenido completo de este documento. Que conoce el propósito de los test y los posibles riesgos que puede sufrir. 2.- Está de acuerdo en controlar su esfuerzo físico durante la realización de los test y está de acuerdo en parar y comunicar al instructor cualquier anomalía o síntoma inusual.

La información y datos recogidos en los diferentes cuestionarios realizados durante este estudio respetarán siempre lo establecido por la Ley Orgánica 15/1999 de Protección de Datos de Carácter Personal.

Mi firma abajo indica que he tenido la oportunidad de preguntar y recibir contestación a cualquier pregunta y que libremente decido dar consentimiento para realizar las pruebas anteriormente citadas.

Nombre y Firma del participante______________________________

Nombre y Firma del Investigador Principal del Proyecto:

(Dr. Ignacio Ara Royo)

Nota: Documento traducido y adaptado de Rickly & Jones (2001)

I

Red de Investigación en ejercicio físico y salud para poblaciones especiales (EXERNET)

**ESTUDIO MULTI-CÉNTRICO PARA LA EVALUACIÓN DE LA CONDICIÓN FÍSICA EN PERSONAS MAYORES**

Código: | | | | | |

Fecha de la encuesta:__________________

El presente documento constituye la primera parte de una serie de cuestionarios relacionados con la salud y la práctica de actividad física. Las preguntas redactadas a lo largo de las siguientes páginas hacen referencia a aspectos nutricionales, de educación, renta, historia deportiva, satisfacción personal...así como los datos personales. **No rellenar los cuadros sombreados.**

## DATOS PERSONALES

**Nombre y Apellidos**__________________________________________________________

**Fecha de Nacimiento** Día | | | Mes | | | Año | | | | |

Edad:____________años.

**Sexo**: Hombre [ ] (1) Mujer [ ] (2)

**Edad de Menopausia**:_______________años.

**Domicilio**:__________________________________________________________________

**Localidad**: ________________________________ Provincia:__________

**Teléfono/s**:_________________________________________________________________

**Estado civil**: Soltero/a [ ] (1) Casado/a [ ] (2)
Divorciado/a [ ] (3) Viudo/a [ ] (4)

**Lugar de residencia habitual hasta los 15 años**:

## INFORMACIÓN GENERAL

**1. Actualmente, ¿realiza actividad física de manera organizada (gimnasio, actividades del ayuntamiento, club deportivo...)?**

S

N

**2. ¿Qué tipo de actividad?**

Natación ☐ (1) Acuagym ☐ (2) gimnasia de mantenimiento ☐ (3)

Yoga ☐ (4) Otra ☐ (5) indique cuál:______

**3A - ¿Cuántas horas a la semana**?_______________ horas

**3B- ¿Ha variado su actividad física desde la última vez que le hicieron las pruebas?**

No, hago la misma actividad física ☐ (0)

Sí, ahora hago más actividad física que antes ☐ (1)

Sí, ahora hago menos actividad física que antes ☐ (2)

Sí, ya no hago nada de actividad física ☐ (3)

**4. En su juventud, ¿practicó algún tipo deporte o hizo ejercicio físico de manera regular?** Sí ☐ (1) No ☐ (0)

**5. ¿Qué tipo de actividad?**

Natación ☐ (1)

Gimnasia Mantenimiento ☐ (2)

Fútbol ☐ (3)

Otro ☐ Indique cuál:___________

**6. ¿A qué nivel?**

| | | |
|---|---|---|
| Élite | | (1) |
| Competición | | (2) |
| Recreación | | (3) |
| Otro | | (4) |

Indique cuál:______________

**7. Respecto a su vida laboral, ¿trabajó fuera del** Sí (1) No (0)

**8. ¿A qué se dedicaba?**

| | | |
|---|---|---|
| *Dirección de empresas y administraciones públicas | | (1) |
| *Técnicos y profesionales científicos e intelectuales | | (2) |
| *Técnicos y profesionales de apoyo | | (3) |
| *Empleados de tipo administrativo | | (4) |
| *Trabajadores de servicio de restauración, personales, protección y *Vendedores de comercio | | (5) |
| *Trabajadores cualificados en agricultura y en la pesca | | (6) |
| *Artesanos y trabajadores cualificados de industrias manufactureras, Construcción, y minería, excepto operadores de instalación y Maquinaria | | (7) |
| *Operadores instalaciones y maquinaria, y montadores | | (8) |
| *Trabajadores no cualificados | | (9) |
| *Fuerzas armadas | | (10) |
| *Trabajo en el hogar | | (11) |
| *Desempleado | | (12) |
| *Otra (indicar): ______________ | | (13) |

**8A El desempeño de su trabajo profesional implicaba ser:**

| | | |
|---|---|---|
| Nada activo | | (0) |
| Ligeramente Activo | | (1) |
| Activo | | (2) |
| Bastante activo | | (3) |
| Muy activo | | (4) |

**8B En su tiempo libre durante su vida laboral, antes de jubilarse, se consideraría:**

| | |
|---|---|
| Nada activo | |
| Ligeramente Activo | |
| Activo | |
| Bastante activo | |
| Muy activo | |

**9. Indique cuánto tiempo dedica al día a cada una de las siguientes actividades:**

| | **Caminar** | **Estar sentado** | **Tareas del hogar** |
|---|---|---|---|
| Menos de 1 hora (1) | | | |
| Entre 1 y 2horas (2) | | | |
| Entre 2 y 3 horas (3) | | | |
| Entre 3 y 4 horas (4) | | | |
| Entre 4 y 5 horas (5) | | | |
| Más de 5 horas (6) | | | |

**10. ¿Toma medicación de manera habitual?** Sí ☐ (1) No ☐ (0)

En caso afirmativo, por favor, indique cuál:

| Nombre del medicamento | Laboratorio fabricante | Nombre del principio activo | Cantidad (g,mg,ml) | Dosis que toma | Frecuencia de consumo (diario, semanal, mensual) |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

**11. ¿Fuma?** Sí ☐ (1) No ☐ (0)

**12. ¿Cuántos cigarrillos al día?**

Menos de 5 cigarrillos ☐ (1)
Entre 5 y 10 cigarrillos ☐ (2)
Entre 10 y 15 cigarrillos ☐ (3)
Entre 15 y 20 cigarrillos ☐ (4)
Más de una cajetilla diaria ☐ (5)

**13. ¿Toma bebidas alcohólicas de manera habitual? (Incluye cerveza y vino)**

Sí ☐ (1) No ☐ (0)

**14. ¿Cuánta cantidad?**____________________

**15. ¿Vive sólo?** Sí ☐ (1) No ☐ (0)

**16. ¿Con quién?**

Cónyuge ☐ (1) Hijo/a ☐ (2)

Hermano/a ☐ (3) Otro ☐ (4) Indique cuál:______________________

**17. ¿En su casa tiene ascensor?** Sí ☐ (1) No ☐ (0)

**18. ¿En qué piso vive?**___________________

**19. ¿Qué estudios tiene?**

- No sabe leer ni escribir ☐ (1)
- Estudios primarios ☐ (2)
- Estudios secundarios ☐ (3)
- Estudios universitarios ☐ (4)

**20. ¿Cuál es su nivel de renta actual?**

- Menos de 600 €/mes ☐ (1)
- Entre 600 y 900 €/mes ☐ (2)
- Más de 900 €/mes ☐ (3)

## <u>CUESTIONARIO DE SALUD EUROQOL-5D (EQ-5D)</u>

Marque con una cruz la respuesta de cada apartado que mejor describa su estado de salud en el día de hoy.

**21. MOVILIDAD:**

No tengo problemas para caminar. ☐ (1)
Tengo algunos problemas para caminar. ☐ (2)
Tengo que estar en la cama. ☐ (3)

**22. CUIDADO PERSONAL:**

No tengo problemas con el cuidado personal. ☐ (1)
Tengo algunos problemas para lavarme o vestirme. ☐ (2)
Soy incapaz de lavarme o vestirme. ☐ (3)

**23. ACTIVIDADES COTIDIANAS:** (p.ej. trabajar, estudiar, hacer las tareas domésticas, actividades familiares o durante el tiempo libre).

No tengo problemas para realizar mis actividades cotidianas. ☐ (1)
Tengo algunos problemas para realizar mis actividades cotidianas. ☐ (2)
Soy incapaz de realizar mis actividades cotidianas. ☐ (3)

**24. DOLOR/ MALESTAR:**

No tengo dolor ni malestar. ☐ (1)
Tengo moderado dolor o malestar. ☐ (2)
Tengo mucho dolor o malestar. ☐ (3)

**25. ANSIEDAD/ DEPRESIÓN:**

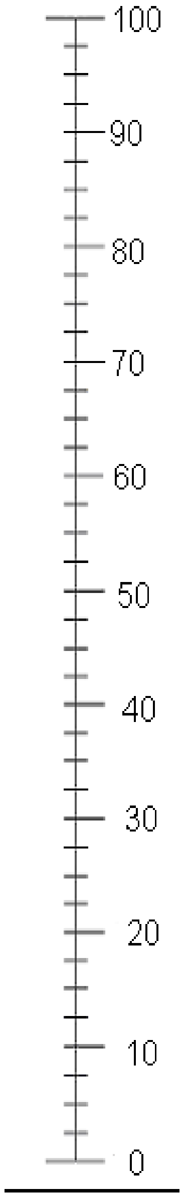
No estoy ansioso o deprimido. ☐ (1)
Estoy moderadamente ansioso o deprimido. ☐ (2)
Estoy muy ansioso o deprimido. ☐ (3)

**26. Comparado con mi estado general de salud durante los últimos 12 meses, mi estado de salud hoy es:**

Mejor. ☐ (1)
Igual. ☐ (2)
Peor. ☐ (3)

**27.** Para ayudar a la gente a describir lo bueno o malo que es su estado de salud hemos dibujado una escala parecida a un termómetro en la cual se marca con un 100 el mejor estado de salud que se pueda imaginar y con un 0 el peor estado de salud que se pueda imaginar.
Nos gustaría que nos indicara en esta escala, en su opinión, lo bueno o lo malo que es su estado de salud en el día de hoy.
Por favor, dibuje una línea desde el casillero donde dice “Su estado de salud hoy” hasta el punto del termómetro que en su opinión indique lo bueno o lo malo que es su estado de salud en el día de hoy.

El mejor estado de salud imaginable




El peor estado de salud imaginable

**<u>STAGES OF CHANGE QUESTIONNARIE</u>**

<u>"Cuestionario de los estados de cambio"</u>

La **Actividad Física moderada** se refiere a aquellas actividades físicas tales como andar deprisa, subir escaleras, practicar algún deporte, realizar las tareas domésticas, etc. en las que nuestra temperatura corporal se eleva y nuestro ritmo respiratorio se acelera. Resumiendo, al realizar dichas actividades *podemos hablar al mismo tiempo pero nos cuesta*.

SU ESTADO DE SALUD HOY

Por favor marca un Sí o NO para cada respuesta.

28.Actualmente participo en actividades físicas moderadas Sí ☐ (1) No ☐ (0)

29.Pretendo incrementar mi participación en actividades físicas moderadas durante los próximos 6 meses Sí ☐ (1) No ☐ (0)

Para que la actividad física moderada sea **regular** debe realizarse al menos 5 días por semana y llegar a acumular 30 minutos al día.

30. Actualmente participo en actividad física moderada regular. Sí ☐ (1) No ☐ (0)

31. Llevo participando en actividad física moderada regular desde hace 6 meses o más. Sí ☐ (1) No ☐ (0)

32. En el pasado, fui regular en mi práctica de actividad física moderada por un periodo de al menos 3 meses. Sí ☐ (1) No ☐ (0)

Este es el final de los cuestionarios, **gracias por su participación.**

Firma del encuestador:

EXERNET

Red de Investigación en ejercicio físico y salud para poblaciones especiales (EXERNET)

**ESTUDIO MULTI-CÉNTRICO PARA LA EVALUACIÓN DE LA CONDICIÓN FÍSICA EN PERSONAS MAYORES**

| | |
|---|---|
| EXERNET | Red de Investigación en ejercicio físico y salud para poblaciones especiales (EXERNET)<br><br>**ESTUDIO MULTI-CÉNTRICO PARA LA EVALUACIÓN DE LA CONDICIÓN FÍSICA EN PERSONAS MAYORES** |

HOJA DE REGISTRO BATERIA DE PRUEBAS FISICAS EXERNET LONGITUDINAL

Nombre y apellidos: ______________________________

Fecha de la encuesta: ______________

Localidad: ____________

Código: ____________

Investigador responsable: ____________

| | SI | NO |
|---|---|---|
| **Firma consentimiento informado:** | | |
| **Rellena cuestionario** | | |

| **Tensión arterial** | Toma 1 | Toma 2 | Toma 3 | Valor final |
|---|---|---|---|---|
| | | | | |

| **Genética recogida** | SI | NO |
|---|---|---|
| | | |

| **Perímetros (cm)** | Toma 1 | Toma 2 | Toma 3 |
|---|---|---|---|
| Cintura | | | |
| Cadera | | | |

| **Talla (cm)** | Toma 1 | Toma 2 |
|---|---|---|
| | | |

| Tanita realizada | SI | NO |
|---|---|---|
| | | |

## BATERÍA DE TEST DE CONDICIÓN FÍSICA

| *Equilibrio* | 1ª Evaluación | | 2ª Evaluación | |
|---|---|---|---|---|
| | Derecha | Izquierda | Derecha | Izquierda |
| Equilibro sobre una pierna | | | | |

| *Fuerza manual de pie* | 1ª Evaluación | | 2ª Evaluación | |
|---|---|---|---|---|
| | Derecha | Izquierda | Derecha | Izquierda |
| Dinamometría manual (kg) | | | | |

| *Fuerza manual sentado* | 1ª Evaluación | | 2ª Evaluación | |
|---|---|---|---|---|
| | Derecha | Izquierda | Derecha | Izquierda |
| Dinamometría manual (kg) | | | | |

| *Fuerza miembro inferior* | Evaluación |
|---|---|
| Sentarse y levantarse (30 seg) | |

| **Fuerza miembro superior** | Evaluación |
|---|---|
| Flexiones de codo con mancuernas (30 seg) | |

| **Tests de Flexibilidad de piernas** | 1ª Evaluación | 2ª Evaluación |
|---|---|---|
| Inclinación sobre la pierna (cm) | | |

| **Tests de Flexibilidad de brazos** | 1ª Evaluación | 2ª Evaluación |
|---|---|---|
| Rascarse la espalda (cm) | | |

| **Tests de agilidad** | 1ª Evaluación | 2ª Evaluación |
|---|---|---|
| Rodear un cono (seg) | | |

| **Velocidad** | 1ª Evaluación | 2ª Evaluación |
|---|---|---|
| Test velocidad 30m | | |

| **Resistencia** | Evaluación |
|---|---|

| | |
|---|---|
| Test de los 6 min | |

Firma del encuestador:

INVENTARIO DE MATERIAL TOMA DE DATOS EXERNET

- ☐ Tallímetro
- ☐ Tanita y rollos de tanita + la mochila del tanita + manual de instrucciones
- ☐ Torre de la CPU + ratón + monitor + teclado + cables
- ☐ Cajón
- ☐ 9 conos
- ☐ 4 mancuernas. 2x2,5kg 2x4kg
- ☐ 2 cintras métricas
- ☐ 5 cronómetros
- ☐ 2 reglas de medida de flexibilidad
- ☐ Cintra métrica de perímetros
- ☐ 2 dinamómetros
- ☐ 3 tensiómetros
- ☐ Bolígrafos
- ☐ Tijeras
- ☐ Grapadora con grapas
- ☐ Celo y cinta adesiva
- ☐ Cable alargador
- ☐ Tizas
- ☐ Material de enfermería
    - lancetas
    - guantes
    - empapadores
    - gasas
    - alcohol
    - esparadrapo
    - tiritas
    - bidón de residuos orgánicos
- ☐ Documentación:
    - cuestionarios
    - hojas de registro
    - consentimiento informado
    - listado de participantes con los códigos
    - protocolo de realización de pruebas de condición física
    - protocolo de mediciones antropométricas

# INFORME TIPO

## VALORACIÓN DE LA CONDICIÓN FÍSICA

Nombre

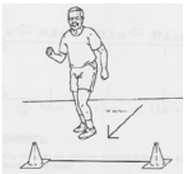
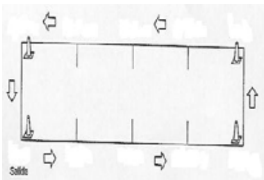
Edad:

Presión Arterial: (sistólica) (diastólica).

Frecuencia Cardiaca:

Fuerza Manos: Mano derecha: Mano izquierda:

| TEST | PUNTUACIÓN | CLASIFICACIÓN SEGÚN PERCENTIL | | | PERCENTIL |
|---|---|---|---|---|---|
| | | **Inferior a la media** ☹ Percentil < 25 | **Rango Normal** ☺ Percentil 25 - 75 | **Superior a la media** ☺☺ Percentil > 75 | |
| **Equilibrio**  | 16,46 seg. | -- | -- | -- | |
| **Fuerza Piernas**  | 11 | | X | | 30 – 35 |
| **Fuerza Brazos** | 19 *Derecho* | | | X | 85 |

| | | | | | |
|---|---|---|---|---|---|
|  | 16 *Izquierdo* | | X | | 65 – 70 |
| **TEST** | **PUNTUACIÓN** | **CLASIFICACIÓN SEGÚN PERCENTIL** | | | **PERCENTIL** |
| | | **Inferior a la media** ☹ Percentil < 25 | **Rango Normal** ☺ Percentil 25 - 75 | **Superior a la media** ☺☺ Percentil > 75 | |
| **Flexibilidad Piernas**  | -19,1 cm. *Derecha* | X | | | 5 |
| | -19,3 cm. *Izquierda* | X | | | 5 |
| **Flexibilidad Brazos**  | -4 cm. *Derecho* | | X | | 30 |
| | -5,5 cm. *Izquierdo* | X | | | 20 |
| **Agilidad**  | 5,82 seg. | | X | | 60 |
| **Velocidad**  | 15,9 seg. | -- | -- | -- | |
| **Resistencia**  | 483 metros | | X | | 40 |

Studies data:
Título del proyecto: Evaluación de los Niveles de Condición Física y su relación con Estilos de Vida Saludables en población mayor española no institucionalizada. Estudio Multi-céntrico (104/2007). Entidad financiadora: Ministerio de Trabajo y Asuntos Sociales-IMSERSO. Duración, desde: 2007 hasta: 2008 Cuantía de la subvención: 35.000 €. Investigador responsable: Ignacio Ara Royo. Tipo de convocatoria: Nacional.

## SUMMARIZED CV/CURRÍCULUM VITAE ABREVIADO

### Olga Lopez Torres

Surname(s): Lopez Torres
Name: Olga
Spanish ID number: 11833728K
Date of birth: 17/08/1976
Sex: Woman
Nationality: Spain
Land line phone: 913364027
Fax: 630654771
Email address: olga.lopez@upm.es
Asociated teacher at departamneto de salud y rendimiento humano, FACULTAD DE CIENCIAS DE LA ACTIVIDAD FÍSICA Y DEL DEPORTE. INEF-MADRID
Category / Title of position or responsibility: profesora asociada 6+6
Start date: 01/09/2014
Modality of the contract: Temporary
Tertiary (UNESCO code): 332199 - Other
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### University education

#### Diplomas, degrees and engineering degrees

Official University Qualification: Higher degree
Name of qualification: Licenciado en Educación Física
City of qualification: Madrid, Community of Madrid, Spain
Entity issuing the qualification: Universidad
Politécnica de Madrid
Type of body: University
Date of qualification: 22/01/2002
Average marks: Pass

#### Other postgraduate university training

1 Type of Training: Master
Postgraduate qualification: magister en nutrición y dietetica aplicada
City: Madrid, Community of Madrid, Spain
University: Universidad Complutense de Madrid Type of body: University
Date of qualification: 18/06/2015
Mark: apta
2 Type of Training: Specialism
Postgraduate qualification: experto en nutrición y dietética humana
City: Madrid, Community of Madrid, Spain
University: Universidad Complutense de Madrid Type of body: University

Date of qualification: 30/05/2014
Mark: apta

## Teaching work

Type of teaching: Official teaching
Name of subject/ name of course: nuevas perspectivas en nutrición y salud pública
Type of programme: Master's degree Type of teaching: In person theory
Type of subject: Optional
Title: máster Salina
Hours/credits: Hours
Number of hours/credits: 2
Body where project took place: Universidad Politécnica de Madrid
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Department: Adscripción temporal al centro

## Participation in research, development or innovation groups / teams

Name (if applicable): Grupo de Investigación en nutrición, ejercicio y estilo de vida saludable. ImFINE
Name of the head researcher of the group (HR): Maria Marcela Gonzalez Gross
City: Madrid, Community of Madrid, Spain
Body the group belongs to: Universidad Politécnica de Madrid
Start date: 01/03/2011

## Scientific or technological activity

### Participation in R&D&I projects funded in competitive tenders by public or private bodies

1 Name of the project: FLUID INTAKE IN ELDERLY. DIFFERENCES IN HYDRATATION HABITS BETWEEN AN ACTIVE AND A NON-ACTIVE SPANISH POPULATION
City: Unknown
Head(s) researcher(s): Maria Marcela Gonzalez Gross
Number of participating researchers: 5
Funding body or bodies: European Hydration Institute
Code according to the funding body: E131115081
Start date: 14/03/2013
Total amount: 0

2 Name of the project: FLUID INTAKE IN ELDERLY. DIFFERENCES IN HYDRATATION HABITS BETWEEN AN ACTIVE AND A NON-ACTIVE SPANISH POPULATION
City: Unknown
Head(s) researcher(s): Maria Marcela Gonzalez Gross
Number of participating researchers: 5
Funding body or bodies: European Hydration Institute
Code according to the funding body: E131115081
Start date: 14/03/2013
Total amount: 5.000

3 Name of the project: ACTIVEAGE ¿ Capacity Building for Physical Activity Programs for Aging People
Head(s) researcher(s): Maria Marcela Gonzalez Gross
Number of participating researchers: 10
Funding body or bodies: Comisión Europea/DG Education and Culture
Code according to the funding body: EAC/S06/2012/029
Start date: 31/10/2012
Total amount: 84.000
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4 Name of the project: ACTIVEAGE ¿ Capacity Building for Physical Activity Programs for Aging People
City: Unknown

Head(s) researcher(s): Maria Marcela Gonzalez Gross
Number of participating researchers: 8
Funding body or bodies: Comisión Europea/DG Education and Culture
Code according to the funding body: EAC/S06/2012/029
Start date: 31/10/2012
Total amount: 84
5 Name of the project: ACTIVEAGE ¿ Capacity Building for Physical Activity Programs for Aging People
Head(s) researcher(s): Maria Marcela Gonzalez Gross
Number of participating researchers: 8
Funding body or bodies: Comisión Europea/DG Education and Culture
Code according to the funding body: EAC/S06/2012/029
Start date: 31/10/2012
Total amount: 84.000
6 Name of the project: Estudio Longitudinal EXERNET: Genética y su relación con el deterioro de la composición corporal y la condición física en personas mayores de 65 años no institucionalizadas
Head(s) researcher(s): Maria Marcela Gonzalez Gross
Number of participating researchers: 8
Funding body or bodies: Ministerio de Sanidad, Política Social e Igualdad-Instituto de Mayores y Servicios Sociales (IMSERSO)
Code according to the funding body: 147/2011
Start date: 02/01/2012
Total amount: 30.000
7 Name of the project: Determinantes de riesgo de primeros eventos cardiovasculares. Un estudio coordinado de casos y controles anidado de la cohorte PREDIMED. Antioxidantes y estrés oxidativo.
Head(s) researcher(s): Maria Marcela Gonzalez Gross
Number of participating researchers: 11
Funding body or bodies: Instituto de Salud Carlos III
Code according to the funding body: PI11/01791
Start date: 15/12/2011
Total amount: 98.312,5
8 Name of the project: Determinantes de riesgo de primeros eventos cardiovasculares. Un estudio coordinado de casos y controles anidado de la cohorte PREDIMED. Antioxidantes y estrés oxidativo.
Number of participating researchers: 11
Funding body or bodies: Instituto de Salud Carlos III
Code according to the funding body: PI11/01791
Start date: 15/12/2011
Total amount: 98.312,5
9 Name of the project: Estudio Longitudinal EXERNET: Genética y su relación con el deterioro de la composición corporal y la condición física en personas mayores de 65 años no institucionalizadas
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Number of participating researchers: 14
Funding body or bodies: Ministerio de Sanidad, Política Social e Igualdad-Instituto de Mayores y Servicios Sociales (IMSERSO).
Code according to the funding body: 147/2011
Start date: 18/11/2011
Total amount: 45.000
10 Name of the project: DEVELOPMENT OF A HEALTHY LIFESTYLE GUIDE P YRAMID FOR CHILDREN AND ADOLESCENTS.
Head(s) researcher(s): Maria Marcela Gonzalez Gross
Number of participating researchers: 14
Funding body or bodies: Coca Cola Iberia

Code according to the funding body: P0611001003
Start date: 20/11/2006
Total amount: 0
11 Name of the project: Determinantes de riesgo de primeros eventos cardiovasculares. Un estudio coordinado de casos y controles anidado de la cohorte PREDIMED. Antioxidantes y estrés oxidativo.
Head(s) researcher(s): Maria Marcela Gonzalez Gross
Number of participating researchers: 9
Funding body or bodies: Instituto de Salud Carlos III
Code according to the funding body: PI11/01791
Total amount: 80.000
12 Name of the project: Estudio Longitudinal EXERNET: Genética y su relación con el deterioro de la composición corporal y la condición física en personas mayores de 65 años no institucionalizadas
Number of participating researchers: 9
Funding body or bodies: Ministerio de Sanidad, Política Social e Igualdad-Instituto de Mayores y Servicios Sociales (IMSERSO).
Code according to the funding body: 147/2011
Total amount: 2
13 Name of the project: HELLP: Health as a lifelong learning process (III)
City: Unknown
Head(s) researcher(s): Maria Marcela Gonzalez Gross
Number of participating researchers: 7
Funding body or bodies: Programa Erasmus. Comunidad Europea
Code according to the funding body: DE-2010-ERA-MOBIP-ZuV-29975-1-28
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## Participation in R&D&I contracts, agreements or projects, not the result of competitive bidding, with companies (or internally in them) and/or governments

Name of the project: MISSION X: Train like an astronaut
City: Unknown
Head researcher: Maria Marcela Gonzalez Gross
Number of participating researchers: 12
Funding body: NASA, ESA, empresas varias Type of body: Body, others

## Scientific production

### Publications, Scientific and Technical Documents and any other publication

1 Olga Lopez Torres. nutrición para el deportista. LIBSA, 2017. ISBN 978-84-662-3457-3
Type of production: Book
2 Olga Lopez Torres. What do we know about homocysteine and exercise? A review from the literature.Clin Chem Lab Med. 54(10):156 - 14, pp. 156 - 77. 2016. ISSN 1434-6621
Type of production: Article. Index measuring impact: 3,017
3 Olga Lopez Torres. la alimentación sana para el deportista. LIBSA, 2012. ISBN 978-84-662-2450-5
Type of production: Book
4 Olga Lopez Torres. Ejercicio físico y salud en poblaciones especiales: EXERNET. Ejercicio físico y salud en poblaciones especiales: EXERNET. pp. 101 - 122. 2011. ISBN 978-84-7949-216-8
Type of production: Chapters of books

### Work presented in conferences at the national or international level

Title: MISSION X: TRAIN LIKE AN ASTRONAUT. A- HEALTHY ¿LIFESTYLE- PROMOTING PROGRAMME FOR PRIMARY SCHOOLS.

Name of the conference: 2011 Annual Meeting of the International Society for Behavioral Nutrition and Physical Activity. Speaker
Date of the event: 15/06/2011
City: Melbourne,
Olga Lopez Torres. "MISSION X: TRAIN LIKE AN ASTRONAUT. A- HEALTHY ¿LIFESTYLE-PROMOTING PROGRAMME FOR PRIMARY SCHOOLS.".pp. 330 - 335. ISBN 135612 401302447b8891a542b28691fb9f9f468

## Work presented in Seminars, Workshops and/or Courses at the national or international level.

1 Title: diploma teórico práctico en nutrición deportiva
Type of event: Course
Date of the event: 10/06/2015
Organising body: Universidad Complutense de Madrid
2 Title: diploma teórico práctico en nutrición deportiva
Type of event: Course
Date of the event: 10/06/2015
Organising body: Universidad Complutense de Madrid
3 Title: diploma teórico práctico en nutrición deportiva
Type of event: Course
Date of the event: 10/07/2014
Organising body: Universidad Complutense de Madrid
4 Title: diploma teórico práctico en nutrición deportiva
Type of event: Course
Date of the event: 10/08/2013
Organising body: Universidad Complutense de Madrid