Tesis Doctoral Internacional / International Doctoral Thesis

EFECTOS DE UN PROGRAMA DE EJERCICIO FÍSICO SOBRE COMPOSICIÓN CORPORAL, CONDICIÓN FÍSICA Y CALIDAD DE VIDA RELACIONADA CON LA SALUD EN MUJERES MAYORES

EFFECTS OF PHYSICAL EXERCISE PROGRAM IN BODY COMPOSITION, PHYSICAL FITNESS AND QUALITY OF LIFE RELATED TO HEALTH IN ELDERLY WOMEN

PROGRAMA DE DOCTORADO: ACTIVIDAD FÍSICA Y SALUD

DEPARTAMENTO DE EDUCACIÓN FÍSICA Y DEPORTIVA
FACULTAD DE CIENCIAS DEL DEPORTE
UNIVERSIDAD DE GRANADA

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2015

Editorial: Universidad de Granada. Tesis Doctorales
Autor: Pedro Jesús Ruiz Montero
ISBN: 978-84-9125-224-5
URI: http://hdl.handle.net/10481/40730

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Que la Tesis Doctoral titulada "Efectos de un programa de ejercicio físico sobre composición corporal, condición física y calidad de vida relacionada con la salud en mujeres mayores" que presenta D. **Pedro Jesús Ruiz Montero** al superior juicio del Tribunal que designe la Universidad de Granada, ha sido realizada bajo mi dirección durante los años 2012-2015, siendo expresión de la capacidad técnica e interpretativa de su autor en condiciones tan aventajadas que le hacen merecedor del Título de Doctor por la Universidad de Granada, siempre y cuando así lo considere el citado Tribunal.

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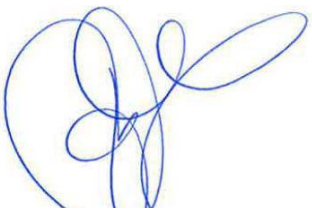

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CERTIFIES:

Mr. **PEDRO JESÚS RUIZ MONTERO**submits to opinion of PhD Commission designated by University of Granada the Doctoral Thesis entitled "Effects of a physical exercise program in body composition, physical fitness and quality of life related to health in elderly women", under my supervision from 2013 to 2015. The technical and interpretative capacity of the present PhD student makes him to deserve the designation of PhD whether the PhD Commission considers it equitable.

Prof. PhD Milena Mikalački

Novi Sad, 04/09/2015

El doctorando D. PEDRO JESÚS RUIZ MONTERO y los directores de la tesis D. MANUEL DELGADO FERNÁNDEZ, D. ALFONSO CASTILLO RODRÍGUEZ y Dña. MILENA MIKALACKI:

Garantizamos, al firmar esta tesis doctoral, que el trabajo ha sido realizado por el doctorando bajo la dirección de los directores de la tesis y hasta donde nuestro conocimiento alcanza, en la realización del trabajo, se han respetado los derechos de otros autores a ser citados, cuando se han utilizado sus resultados o publicaciones.

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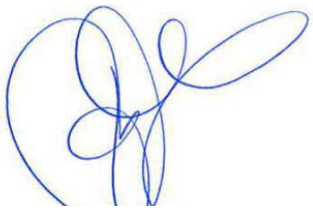

Fdo.: Alfonso Castillo Rodríguez

Fdo.: Milena Mikalacki

En Granada, 20 de Mayo de 2015

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PROYECTOS DE INVESTIGACIÓN (RESEARCH PROJECTS)

El trabajo desarrollado y los artículos que componen la presente memoria de Tesis Doctoral están basados en los siguientes convenios y proyectos de investigación:

- Influence of physical activity on risk factors in the working population. Provincial Secretariat for Science and Technological Development. Goverment of Novi Sad (Nº 114-451-2337/2011-01). Duración: 05/04/2011 hasta 31/03/2015.
- Relación entre niveles de Actividad Física, composición corporal y calidad de vida en personas mayores. Área de Deportes de la Diputación Provincial de Málaga. Duración: 01/10/2009 hasta la 13/05/2015 (revisable anualmente).

LISTA DE PUBLICACIONES [LIST OF PUBLICATIONS]

La presente memoria de Tesis Doctoral está compuesta por los siguientes artículos científicos:

I. **Ruiz-Montero PJ**, Castillo-Rodríguez A, Mikalački M, Čokorilo N, Korovljev D. Previous anthropometric measures in adult and elderly Serbian women to physical and educational program of Pilates and Aerobic. *International Journal of Morphology* 2013; 31(4): 1263-1268.

II. **Ruiz-Montero PJ**, Castillo-Rodríguez A, Mikalački M, Delgado-Fernández M. Physical fitness comparison and quality of life between Spanish-Serbian elderly women through a physical-educative program. *Coll Antropol. Accepted.*

III. **Ruiz-Montero PJ**, Castillo-Rodríguez A, Mikalački M, Čokorilo N, Korovljev D. 24-weeks Pilates-aerobic and educative training to improve body fat mass in elderly Serbian women. *Clinical Interventions in Aging* 2014; 9: 243-248.

RESUMEN

El envejecimiento es un proceso natural e inevitable con cambios degenerativos en la mayoría de las funciones físicas, fisiológicas, psicológicas y sociales. Además, el proceso de envejecimiento tiene un impacto en la composición corporal, capacidades físicas y calidad de vida relacionada con la salud de las personas mayores.

Los principales objetivos de esta Tesis Doctoral son: analizar los niveles de composición corporal de mujeres adultas y mayores serbias antes de comenzar un programa de ejercicio físico, comparar y relacionar la condición física y la calidad de vida relacionada con la salud de mujeres mayores participantes en programas de ejercicio físico de Serbia y España, y analizar los efectos de un programa de intervención de 24 semanas de Pilates y ejercicio aeróbico sobre la composición corporal de mujeres mayores serbias.

La muestra que ha participado en los estudios incluidos en la presente Tesis Doctoral se compone de 161 mujeres adultas (41 a 59 años) serbias, 303 mujeres mayores (60 a 76 años) serbias y 74 mujeres mayores (60 a 69 años) españolas.

La composición corporal ha sido evaluada mediante metodología de The International Society for the Advancement of Kinanthropometry (ISAK) y/o bioimpedancia. Las medidas analizadas han sido peso, talla, pliegues cutáneos (tricipital, bicipital, subescapular, abdominal, muslo, gemelar), perímetros (bíceps contraído, bíceps relajado, gemelo, antebrazo, muslo, abdomen, cintura) y diámetros (muñeca, fémur, húmero, tobillo). Las medidas calculadas han sido índice de masa corporal (IMC), porcentaje de masa grasa (% MG), masa magra (MG, Kg), índice de cintura/cadera, índice cintura/altura e índice cintura/muslo.

La condición física ha sido evaluada mediante la batería Fitness Senior Test. Las variables analizadas han sido: Fuerza de tren inferior (30-seconds chair stand test), fuerza de tren superior (arm curl test, 2.27Kg para mujeres), flexibilidad de tren inferior (chair sit and reach test), flexibilidad de tren superior (back scratch test),

agilidad/equilibrio dinámico (8-foot up-and-go test) y resistencia aeróbica (6-minute walk test). Además, se valoró la presión sanguínea (diastólica y sistólica).

La calidad de vida relacionada con la salud ha sido evaluada mediante el cuestionario SF-36. Este cuestionario ha permitido valorar las siguientes dimensiones: Función física, rol físico, dolor corporal, salud general, vitalidad, función social, rol emocional y salud mental.

El programa de ejercicio físico, consistente en una combinación de Pilates y ejercicio aeróbico, se realizó durante 24 semanas con una frecuencia semanal de 2 días a la semana. Las sesiones tenían una duración de 60 minutos, con estructura consistente en un calentamiento con ejercicios de desplazamientos y movilidad articular, una parte principal con los ejercicios de Pilates y/o aeróbicos, que fueron evolucionando de menor a mayor complejidad e intensidad, y una vuelta a la calma mediante ejercicios respiratorios y estiramientos. Las sesiones alternaban contenidos de Pilates y ejercicio aeróbico semanalmente.

Los principales resultados de la Tesis muestran que:

a) Las mujeres serbias mostraron valores de IMC entre 25.2$\pm$4.8 Kg/m^2 (41-50 años) y 30.3$\pm$4.1 Kg/m^2 (>71 años). A medida que aumenta la edad, la talla disminuye y MG aumenta (ambos, $P<0.05$). Además, la variable edad muestra correlaciones positivas, aunque débiles, con peso ($r=0.28$), IMC ($r=0.32$), % MG ($r=0.36$), MG (Kg) ($r=0.31$) y correlación inversa con la talla ($r=-0.23$) (todos, $P<0.01$). Además, las mujeres con un IMC mayor de 25 Kg/m^2, poseen valores mayores en las mediciones antropométricas y masa grasa.

b) Las mujeres serbias muestran mejor calidad de vida relacionada con la salud y mejor condición física que las mujeres españolas ($P<0.05$). La condición física de las mujeres, independientemente de su localización geográfica, está asociada directamente con la talla ($P<0.05$) e inversamente con el perímetro de cintura ($P<0.05$), IMC, edad (ambos, $P<0.01$) y con el peso ($P<0.05$). La condición física presenta mejores correlaciones con la dimensión función física de la calidad de vida relacionada con la salud que con el resto de dimensiones.

c) Un programa combinado de Pilates y ejercicio aeróbico, dos veces a la semana, redujo la masa grasa (en Kg y en %) ($P<0.001$) en las participantes.

SUMMARY

Ageing is a natural and inevitable process with degenerative changes in most of the physical, physiological, psychological and social functions. Furthermore, the ageing process has an impact on the body composition, physical fitness and quality of life related to health in elderly people.

The main aims of this Thesis have been to analyze the levels on the body composition of older adults and elderly Serbian women previous to following a physical exercise program, as well as to compare and relate physical fitness and quality of life related to health in Serbian and Spanish elderly women who participated in a physical exercise program and finally, to analyze the effects of a 24-week Pilates-aerobic training program on the body composition of Serbian elderly women.

The sample of the present Doctoral Thesis is composed of 161 Serbian older women (from 41 to 59 years), 303 Serbian elderly women (from 60 to 76 years) and 74 Spanish elderly women (from 60 to 69 years).

Body composition has been assessed by the methodology of The International Society for the Advancement of Kinanthropometry (ISAK) and/or bioimpedance. The measurements analyzed included weight, height, skinfold thickness measurements (subscapular, triceps, biceps, forearm, abdomen, front thigh and medial calf), muscular girths (upper arm relaxed, upper arm flexed and tensed, abdominal, waist circumference, thigh, maximum calf) and bone diameters (biepicondylar humerus breadth, wrist breadth, biepicondylar femur breadth, ankle breadth). The measurements calculated included body mass index (BMI), percentage fat mass (% FM), fat mass (Kg), waist-to-hip ratio, waist-to-height ratio and waist-to-thigh ratio.

Physical fitness has been assessed by the Senior Fitness test (SFT): lower body muscular strength (30-second chair stand test), upper body muscular strength (arm curl test, 2.27Kg for women), lower body flexibility (chair sit and reach test), upper body flexibility (back scratch test), agility/dynamic balance (8-foot up-and-go test) and aerobic endurance (6-minute walk test). In addition, both a diastolic blood pressure test and a systolic blood pressure test were carried out.

SF-36 health Survey was used to assess the quality of life related to the health of Serbian and Spanish participants of the present Doctoral Thesis. This questionnaire is composed of 8 scales assessing 8 dimensions: physical functioning, physical role, bodily pain, general health, vitality, social functioning, emotional role, mental health, and general health.

The 24-weeks Pilates-aerobic training program consisted of music-based aerobic and Pilates exercises. This program included one session of Pilates and one session of aerobics a week. The sessions took place twice a week and lasted 60 minutes per day-session. The structure of the session consisted of movements, with emphasis on joint movement warm-up exercises, Pilates and/or aerobic exercises with a progressive rise of intensity and, finally, a warm-down through breathing exercises and stretching.

The main findings were:

a) Serbian women showed BMI levels ranging from 25.2 ± 4.8 Kg/m^2 (41-50 years) to 30.3 ± 4.1 Kg/m^2 (>71 years). As age increases, height decreases and fat mass increases (both, $P<0.05$). Age shows a positive correlation with weight ($r=0.28$), BMI ($r=0.32$), % FM ($r=0.36$), FM (Kg) ($r=0.31$) and inverse correlation with height ($r=-0.23$) (all, $P<0.01$). Furthermore, women with a BMI over 25 Kg/m^2 have higher values in anthropometric measurements and fat mass.

b) Serbian women experience a better quality of life related to health and have better physical fitness than Spanish women ($P<0.05$). The physical fitness of elderly women, irrespective of geographic location, is directly associated with height ($P<0.05$) and inversely associated with waist circumference ($P<0.05$), BMI, age, (both, $P<0.01$) and the weight ($P<0.05$). The physical fitness aspect shows a better correlation to physical functioning dimension of quality of life in terms of health than the other dimensions.

c) Pilates-aerobic training program, twice a week, decreases the FM (Kg and %) ($P<0.001$) of the participants.

ABREVIATURAS [ABBREVIATIONS]

30´´AC	30s Arm Curl
ACSM	American College of Sport Medicine
AHA	American Heart Association
ANOVA	Analysis of Variance
BMI	Body Mass Index
BP	Bodily Pain
BS	Back Scratch
CSR	Chair Sit and Reach
EWGSOP	European Working Group on Sarcopenia in Older People
FFM	Fat-Free Mass
FM	Fat Mass
PA	Physical Activity
PF	Physical Fitness
QoL	Quality of Life
SF-36	Short-Form Health Survey 36
SFT	Senior Fitness Test
SMM	Skeletal Muscle Mass
SPSS	Statistical Package for the Social Sciences
VO_2	Oxygen Consumption
WC	Waist Circumference
WHO	World Health Organization
30´´CS	30s Chair Stand

INTRODUCCIÓN [INTRODUCTION]

1. Ageing: Definition and etiology

The definition of "elderly" is not yet a global term. Clinical and medical context often uses elderly when referring to people over the age of 65 (1), but all reports, documents, books and international meetings of The World Health Organization (WHO) employs elderly when the person in question is over the age of 60. Nonetheless, people over the age of 60-65 are a great achievement for humanity (2) because not long ago, most people did not live into old age.

Ageing is a natural and inevitable process (3) associated with lack of adjustment in the immune system, "immunosenescence" (4-6), affecting all living organisms and representing progressive degenerative changes in most physical and physiological functions (7). Declination of cognitive capacity is also a characteristic of the ageing process (8) along with psychological disorders such as anxiety and depression (9, 10). Social relationships decline with ageing, often being associated with geriatric depression due to the lack of social interaction with other people (11, 12).

Similarly, cellular and molecular variations due to the ageing process produce an increase of infections and immune disorders (13). Chronic diseases are also related to the ageing process with a high incidence in the elderly population (14). Interactions of external environmental variables and genetic factors are essential for the understanding of chronic diseases (15). Genetic phenotype is not easy to express but may be commonly expressed in the elderly (14). The increase of diseases and chronic inflammations associated with the ageing process is determined by senescent phenotype (16). The tissue-residing senescent cells tend to accumulate and might produce a negative response in the secretory phenotype with pro-inflammatory characteristics. In addition, senescent cells abound in pathologies related to ageing such as degenerative or inflammatory disorders (17). Senescent cells are triggered by telomere attrition related to tissues and ageing (17, 18) or in response to diverse stress conditions (17, 19) and the accumulation of DNA damage (19).

The main characteristic of ageing is a gradual and inevitable deterioration of physical capacities and degenerative diseases (20), commonly seen in the elderly (21). Ageing process experiences cause the decrease of physiological reserves, commonly known as homeostenosis (22). The ageing process consists of two types of influences: negative (acceleration of ageing effects) or positive (delay of ageing effects). Therefore, knowledge of physical fitness evolution during the ageing process is necessary to guarantee a better understanding of elderly people and reduce their consequences (4). Disability, somatic diseases and depression are common characteristics that appear in the ageing process without any connection between them (23).

In conclusion, the evolution of aging is essentially understood as a gradual accumulation of damage which produces the functional declination of any organism (24). Finally, about 100.000 people die every day in the world due to age related causes. (25).

2. Body composition in elderly people

Changes in body composition are considered one of the major causes of chronic diseases of ageing people (26, 27) and have become a primary concern (28). During the ageing process, the body shows a decrease in physical capacities and other aspects such as fat mass (FM), skeletal muscle mass (SMM) or metabolic rates (29). Body composition is an important marker of health and predictor of comorbidities (30). Hence, from a clinical point of view, it is interesting to appreciate the changes through variations in body composition while linearly increasing age because the states of body composition are related to the ageing process and these are the reasons that are steadily changing (31). (PAPER I).

2.1. Fat mass, fat-free mass, skeletal muscle mass, overweight, obesity and sarcopenia in elderly people.

FM increases and FFM decreases during the period of 20-70 years of age (32, 33). Maximum levels FM are found between 60-70 years of age (34). However, maximum levels of FFM is at 20 years of age and up to 40% decrease until 70 years of

age, primarily skeletal muscle (35). Ageing is associated with the redistribution of FM and FFM in the body (3) and may be an important risk factor for metabolic disease (36). When there is an increase in FM, there is a reduction in SMM and physical capacity, along with a loss of FFM (37). The elderly, with more sedentary lifestyles, lose FFM faster than the elderly who are active. Consequently, there is prevention of weight loss and in maintaining functional capacity in people over the age of 70 (38).

The level of FM and FFM is best among the ageing population due to changes in body composition. This is the major drawback of body mass index (BMI) (3). However, BMI is a suitable method when it is necessary to classify medical risk by weight status (39), such as obesity (40).

Obesity is "an unhealthy excess of body fat, which increases the risk of medical diseases and premature mortality" (39). It is also considered a widespread health problem in developing countries, where it is accompanied by chronic morbidities, functional impairment and premature mortality (41). Obesity is classified into three categories (principal cut-off points): type I (30.00-34.99), type II (35.00-39.99) and type III ($\geq$ 40.00) (42). Excess of FM and a BMI of $\geq$30 in elderly people is associated with worse physical fitness, possible future disability (43) and excess body weight, (44) while obesity (45) is associated with the prevalence of diseases such as diabetes, hypertension, arthritis, cardiovascular risk, etc. Similarly, excess weight and obesity is strongly associated with T2 diabetes (46) and metabolic syndrome (46, 47) as was described in a Malaysian study on elderly women (48). It is, therefore, necessary to establish containment plans concerning potential risks of obesity and excess weight in elderly people with the main aim being to effectively tackle morbidity (49). A method of prevention could be a reduction in weight when people reach middle-age (50). However, weight loss in elderly people would be associated with risk of mortality if we compared this to elderly people maintaining a stable weight (51).

Body composition, FM and SMM are related to physical capacities (33). Obesity is observable with an increase of FM and sarcopenia with a loss of SMM (37, 52). European Working Group on Sarcopenia in Older people indicates important changes during the ageing process, emphasizing a decline in SMM, strength and functionality (53).

FFM is composed mainly of SMM. Vigorous physical activity maintains muscle strength in elderly people and muscle strength might be a reflection of SMM. Normally, SMM must always be measured because it may identify elderly people with a high level of mortality risk (50). For example, poor muscle strength is associated with a greater probability of mortality in patients with cardiovascular risks (54) and a stronger grip and quadriceps are associated with a lower mortality risk (55).

Prevalence of sarcopenia is exclusive in elderly people (56) but there is a different range of sarcopenia depending on the country (57) and the diagnostic criteria (58). Sarcopenia is a typical progressive process of ageing (59), where a loss of SMM and strength is observable (53, 60, 61). Early post-menopause negatively influences sarcopenia (62), specifically in feminine gender (63). Sarcopenia might appear in younger adults such as dementia or osteoporosis and be placed into two categories: "primary" when no other evident cause exists different from ageing and "secondary" if one or more cause is evident (53). According to some authors (35, 64-66), there is growing evidence that functional disability in elderly people is attributed to sarcopenia. Moreover, sarcopenia is a source of concern for public health systems due to the high cost this entails, especially in industrialized countries (67). There are authors who suggest recognizing sarcopenia as a geriatric syndrome because, by doing so, the identification of such would be faster and easier (68, 69).

2.2. Nutrition and diet

Diet should be taken into account with respect to longevity and healthier elderly people (70). The association of poor nutritional status and lack of strength is considered a risk factor for mortality (71, 72). Physiological factors produce intake deficiency in the diet and the common effects are higher rate of FFM, SMM loss and sarcopenia in elderly people. Alterations in taste and smell due to peripheral and central mechanisms decrease the desire to eat (73). Obesity and weight play an important part in health due to the influence that the diet has on the psycho-social aspects of life (74). Furthermore, adequate diet is essential in the treatment of obesity (3). The habits and frequency of family meals can influence the dietary behavior and body weight parameters of people (75).

Observational studies and clinical trials have highlighted the importance of nutrients and diet in the prevention of metabolic disorders in all populations (76, 77). The role of nutrients and food has been the main aim of nutrition and healthy aging researches. However, the interest of dietary pattern analysis is currently considered to be a determinant of chronic diseases (73, 74). The quality of the diet is related to depression and anxiety in elderly people (78) and a better quality diet brings about/suggests better quality of life in elderly women (79).

Several international dietary guidelines recommend consuming a variety of healthy foods such as vegetables, fruits, grains, meat and alternatives as the best option (79). The Mediterranean diet is considered an appropriate diet for elderly people as it has been associated with a decrease of cardiovascular diseases risks (80). A main aspect of the Mediterranean diet is a low intake of fat, sodium and processed foods whereas there is a high intake of fruit and vegetables (81). Other dietary patterns such as low carbohydrate intake or the vegetarian diet can be adapted to personal and cultural food preferences in order to prevent some cardiometabolic diseases (82). Thus, good knowledge regarding nutrition is necessary in order to get a better quality diet (83).

3. Physical fitness and exercise in elderly people

Physical fitness is a reliable predictor of life expectancy in elderly women (6, 84) . The association between physical fitness and physical activity and the benefits this provides for elderly people has been explained in great detail in several studies (85). Elderly people do not enjoy complete well-being due to the fact that they suffer from physical limitations which are commonly found in old age (86) and associated with the limitations of physical fitness (87). Physical inactivity and sedentary lifestyles are both causes of negative health consequences (88).

Consequently, The American College of Sport Medicine (ACSM), The American Heart Association (AHA) and WHO recommend regular practice of physical activity in order to produce health benefits in the elderly (89-91). This would, therefore, increase the quality of life (QoL) in these elderly people (92).

As a result, it would be of interest to compare the physical fitness and QoL related to the health of elderly people from two different countries, who participated in a physical exercise program with similar contents. (PAPER II).

3.1. Physical fitness and ageing

The relationship between health and physical fitness consists of various factors such as body composition, muscular strength and endurance, agility, balance and flexibility (93). It is common knowledge that ageing causes drastic reduction in physical fitness (3, 29, 93-95).

Loss of muscular strength ranges between 12%-14% per decade in people over the age of 50 (96). Overall strength decreases with the ageing process, however, lower body strength is often more affected than upper body strength (97, 98). This is one of the most common risk factors for falls in the elderly (99). Similarly, handgrip strength decreases at the same time as ageing (100). This phenomenon is important because some authors confirm a higher prediction of mortality in elderly people with low strength in lower body and hand-grip strength (55).

Hence, a moderate intensity level of effort in terms of muscle-strengthening exercises is generally recommended. The exercise might, also, be practiced at a higher level of intensity and under the supervision of a fitness specialist (101). Consequently, if an increase of upper body strength is combined with an improvement of lower body health, the physical fitness and QoL will be greater (102).

Aerobic exercise is a very important component of physical fitness and might improve other components through exercises with large muscle groups working dynamically (103). One of the most important physiological changes in the ageing process is the reduction of aerobic process (104). Several cross-sectional and control trial studies have demonstrated a decrease in the peak of oxygen consumption (VO_2) to between 5%-10% per decade (105-107). This reduction in VO_2 is not constant, although it is more apparent in men than it is in women (104). Furthermore, the decrease of VO_2 over the age of 60 is due to a reduction in maximum cardiac output and arterial-venous oxygen difference ($DavO_2$) reduction (108).

Aerobic capacity starts to decrease after the age of 40 and experiences a loss of 30% after the age of 65 (109). On the other hand, there is a reduction in maximal oxygen uptake of 0.5%–1.0% per year (110) and this, therefore, has an influence on the physical fitness of healthy and sick people (104). The oxygen uptake reserve level establishes a range between 50%-85% for aerobic exercises in elderly people, including moderate and vigorous exercises (20).

Ageing has a negative influence on the neuromuscular system (111), which increases the risk of falls in elderly people (112). Poor balance can be a common risk among elderly people and it is necessary to distinguish between static or dynamic balance. The first type of balance indicates body posture while standing still, while the second, dynamic balance, is the reaction speed of muscles when faced with different conditions of stability (113). Dynamic balance related to body posture decreases with the ageing process (114). If dynamic balance is associated with cognitive tasks the speed reaction will decrease further (115). There are more studies related to balance exercise than balance activities, which is why exercise is the only thing recommended (116).

Flexibility has often been treated as a physical fitness condition linked to the prevention of injuries and physical training (117). Flexibility allows people a range of movement through joints (118).The range of movement of each joint depends the degree of ageing (119). Flexibility decreases with age but this reduction is not lineal. Moreover, flexibility levels in women are always higher than in men, being 20%-40% more flexible than men after the age of 60, even in female childhood (120).

Health related to physical exercise consists of aerobic capacity, muscle strength, balance and flexibility (121) and each of these aspects of physical fitness may be improved through specific training and exercises (122). A combination of flexibility, balance and strength exercises with elderly people is associated with a reduction in the risk of falls (123). According to recommendations made by ACSM (20) and AHA (124), the elderly should do a minimum of 30 minutes of moderate intensity aerobic exercise five days a week or a minimum of 20 minutes of high intensity aerobic activity three days a week.

A muscle-strengthening activity for an elderly person should have a frequency of a minimum of two days a week with 8-10 exercises involving most muscle groups. Flexibility and balance exercises might be performed for a minimum of two days per week.

3.2. Exercise, physical fitness and body composition

The main objective of exercise is the improvement or maintenance of physical fitness (125). Exercise produces benefits in the mobility of elderly people (126) and is effective in the treatment and prevention causes of morbidity and mortality (6). Exercise capacity is a high predictor of overall mortality rates in both blacks and whites (127). Previous studies have shown the connection between active lifestyle habits and regular exercise and improved physical fitness in elderly people (90). Exercise carried out frequently improves independent lifestyle in elderly people due to a reduction of FM and obesity (128, 129). Similarly, exercise produces a reduction in inflammation and chronic diseases (130) such as pressure levels (131) and arterial hypertension (129).

According to Castillo-Garzón et al. (6), physical fitness is an integrated measurement of skeletomuscular, cardiorespiratory, hematocirculatory, psychoneurological, and endocrine-metabolic functions. The same authors confirm that the assessment of physical fitness might be considered as an important indicator of health and life expectancy. Physical fitness is used as an important predictor of the causes of mortality and the possibility of independent life in elderly people (84), even in overweight and obese people (132). Most physical fitness evaluations carried out on the elderly are characterized by a measurement of muscular strength and body composition (133, 134).

Body composition is a component of good health and disease prevention associated with physical fitness (6). Body composition, physical fitness and sarcopenia are related to neuromuscular fatigue (59). It is also important to highlight that sarcopenia is impaired muscle strength and physical performance (53).Changes in body composition in sedentary elderly people can be reversed, at least partly, by exercise programs. The levels of FM, FFM and SMM can be healthier with the regular practice

of exercise (135). Thus, moderate to high-intensity resistance exercise training is necessary in order to decrease the percentage of total FM (21, 136, 137).

Moreover, resistance training is helpful when wanting to lose specific subcutaneous adipose tissue in elderly women such as Hunter et al. study (136), where there was a 12% reduction after a 25-week interventional program of strength and resistance exercises. The combination of strength and aerobic exercise may be more effective on the cardiovascular system and SMM than separately (90).

3.3. Exercise and ageing: Pilates

Aerobic and resistance exercise (89, 138), Pilates (139) or a mixture of aerobic exercise and Pilates (128, 140), prevent a reduction and maintain strength in the elderly. There are relatively few studies related to muscle strengthening activities compared with other aerobic activities (141). Some of them provide beneficial effects, while others do not offer any significant changes (142) in terms of intensity, duration, frequency (143), or activity (142).

The importance of the Pilates method exercises have undergone improvement and innovation since Joseph Pilates first began with his two books: *Your Health (144)* and *Pilates' Return to Life Through Contrology* (145). The Pilates method mixes a philosophy of health and well-being by means of brain cells activation, in turn, stimulating a positive impact on the mind and the body (145). This method was ranked seventh place by the ACSM as an emerging physical activity in 2008 and 2009, and in the US alone, the number of users reached 10.5 million in 2004 (146). The Pilates method coincides with the modern principles of fitness, personal training, and mental happiness through exercises that maintain a neutral spine position and the use of the floor and equipment to develop strength and balance (139). Therefore, exercise programs used in Pilates can be seen as a physical activity with proven physical and clinical benefits through several studies on the aging process (139, 140, 147-150). Similarly, Pilates helps to maintain SMSS in elderly people as well as aerobic-endurance exercises (128). A systematic review based on seventeen experimental studies of the Pilates method presented contradictory results of body composition (151).

However, not many studies combine Pilates and other exercise such as strength or aerobic capacity. Therefore, a combined program of Pilates and aerobic exercise might produce benefits in the body composition of elderly people. (PAPER III).

4. Evolution of the ageing process and quality of life

Most western countries are aware that ageing is going to increase more and more among their population in the coming decades (152). However, the low-and-middle income countries will experience the fastest demographic change in terms of the elderly population (153). This may be alleviated with the increase of knowledge related to gerontology, as well as supporting and helping issues of well-being in elderly people (154). The ageing of society represents a socio-demographic change which has been increasing in recent decades. Life expectancy of developed countries is currently over the age of 70 (155). The elderly population rate is currently experiencing the fastest demographic growth (156, 157). Moreover, the Second World Assembly on Ageing (158) concluded that from 2008 to 2050, there will be an increase of 10% to almost 21% in the number of people over the age of 60. Specifically, 2 billion people in the world are going to be over the age of 60, and 400 million will be over the age of 80 and over (153). Similarly, life expectancy in European countries is 79.2 years and 82.2 years for females (159). This data is the source of growing interest in the well-being of elderly people around the world (160), regardless of geographic location or types of societies.

Global estimations by international institutions indicate that over 600 million people are over the age of 65 (161). Therefore, the aging phenomenon needs to be addressed using suitable strategies that maintain the health and QoL of elderly people for as long as possible (162). The QoL has shown a negative correlation with age (163). Physiological changes that appear during the ageing process may affect the QoL and functionality of elderly people (164). However, the connection between mental components of QoL and ageing is not still clear (165, 166).

QoL related to health is often used to evaluate the the health status of people (163, 167). Predictors of QoL are necessary in order to recognise whether elderly people

enjoy well-being in their daily lives. Health status, physical fitness and social interaction with other people are the predictors (168) which improve the ageing process . The scores obtained in physical functioning (163), physical role, general health and social functioning have shown a decline with age in adults and elderly women (165). Similarly, poor self-perceived QoL is related to lack of exercise adherence (169). According to the mental component of QoL, some studies do not indicate any correlation with age. On the other hand, some of the elderly population will experience an increase of mental components of QoL with ageing (166).

Scientific studies on Serbian elderly people are extremely hard to find in Serbian (170) and international medical journals. This might, therefore, cause a lack of interest in physicians regarding the medical problems of the elderly population (170). Serbia has a population of 23% over the age of 60 (171) and there are not many studies related to health problems in the Balkan countries (172). However, in Spain, 22.4% of the population is over the age of 60 and this demographic group has been the object of research studies such as the one carried out for 20 years on the Spanish population and their health issues (173).

Several studies on diverse types of societies and cultures have evaluated the impact of different factors relating to QoL (174). QoL questionnaires as predictive value have been used to report on mortality (175). QoL does not determine longevity. One example could be people who live long lives but who also experience diseases, social problems or functional disability for a long time. They would be considered people with low QoL. Thus, it is necessary to introduce a healthy life year's indicator or "disability-free life expectancy" related to QoL. This would greatly help people to distinguish between years lived with or without limitations in physical functions. If elderly people manage to increase their health status, they will also live with more economic prosperity. However, various trends in longevity between genders are the reason why life expectancy, healthy life years and QoL as mean health indicators in Europe are included (176). Factors such as QoL and well-being must be linked to social interactions with other people (177).

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OBJETIVOS

General:

El objetivo general de esta Tesis ha sido valorar y comparar parámetros morfológicos, condición física y calidad de vida relacionada con la salud de mujeres mayores serbias y españolas, así como analizar los efectos de un programa de intervención basado en Pilates y ejercicio aeróbico sobre la composición corporal de mujeres mayores serbias.

Específicos:

- Analizar parámetros morfológicos y composición corporal de mujeres adultas y mayores serbias, previo a un programa de Pilates y ejercicio aeróbico.
- Comparar y relacionar la condición física y la calidad de vida relacionada con la salud de mujeres mayores de España y Serbia, participantes en un programa de ejercicio físico (fuerza, agilidad, ejercicio aeróbico y Pilates).
- Analizar los efectos de un programa de intervención de 24 semanas de Pilates y ejercicio aeróbico sobre la composición corporal de mujeres mayores serbias.

AIMS

Overall:

The overall objective of this Doctoral Thesis has been to value and compare morphological parameters, physical fitness and quality of life related to the health of Serbian and Spanish elderly women, as well as to analyze the effects of a Pilates and aerobic training program in the body composition of Serbian elderly women.

Specifics:

- To analyze the morphologic parameters and body composition of Serbian adult and elderly women, previous to Pilates-aerobic training program.
- To compare and relate the physical fitness and quality of life related to health of Spanish and Serbian elderly women participants of a physical exercise program (strength, agility, aerobic exercise and Pilates).
- To analyze the effects of a 24-weeks Pilates-aerobic training program on the body composition of Serbian elderly women

MATERIAL Y MÉTODOS [MATERIAL AND METHODS]

The section of material and methods of the present Doctoral Thesis is summarized in the next table which includes the most relevant methodological information of the articles from this Doctoral Thesis.

Table 1. Summary table of the methodology used in the current Thesis.

Paper	Study Desing	Participants	Intervention	Main variables studied	Methods
Previous Anthropometric Measures in Adult and Elderly Serbian Women to Physical and Educational Program Of Pilates And Aerobic	Cross-sectional	102 adult and 103 elderly women	Not applicable	Height, weight, BMI, FM(%), FM(Kg), subcutaneous skinfold thickness (subscapularis, triceps, forearm, abdominal, front thigh, and medial calf), muscular girths (upper arm relaxed, upper arm tensed, forearm, omphalion (abdominal), waist, mid-thigh and maximum calf), and four diameters (wrist, biepicondylar femur, biepicondylar humeral, and ankle).	Electronic scales, anthropometric measurement, corporal density equation (Durnin and Womersley, 1974) and FM equation (Brozek et al., 1963)
Physical fitness comparison and quality of life between Spanish-Serbian elderly women through a physical-educative program	Cross-sectional	127 elderly women -74 Spanish participants -53 Serbian participants	Adult and elderly female participants in multidisciplinary program (Pilates and Aerobic)/ 2 times per week	Height, weight , BMI, WC, fat mass, physical fitness, quality of life related to health	BIA, anthropometric measurement, SF-36, 30-s chair stand, dumbbell-5 lb hand strength, chair sit and reach test, back scratch test, 8-ft up and go test and 6-min walk test
24-weeks Pilates-aerobic and educative training to improve body fat mass in elderly Serbian women	Control trial	303 elderly women	6-months multidiscliplinary program (Pilates and Aerobic)/ 2 times per week	subcutaneous skinfold thickness (subscapularis, triceps, biceps, forearm, abdominal, front thigh, and medial calf), muscular girths (upper arm relaxed, upper arm tensed, forearm, omphalion (abdominal), waist, waist-to-hip, waist-to-height, mid-thigh, waist-to-thigh, and maximum calf), and four diameters (wrist, biepicondylar femur, biepicondylar humeral, and ankle).	Electronic scale, anthropometric measurement, corporal density equation (Durnin and Womersley, 1974) and FM equation (Brozek et al., 1963)

BIA: Bioelectrical Impedance Analysis, BMI: Body Mass Index, FM: Fat mass, SF-36: Short-Form Health Survey 36, WC: waist circumference

RESULTADOS Y DISCUSIÓN [RESULTS AND DISCUSSION]

The results and discussion are shown in the same form that they have been published/ submitted in scientific journals.

I

Previous anthropometric measures in adult and elderly Serbian women to physical and educational program of Pilates and Aerobic

Ruiz-Montero PJ, Castillo-Rodríguez A, Mikalački M, Čokorilo N, Korovljev D

International Journal of Morphology

2013; 31(4): 1263-1268

Int. J. Morphol.,
31(4):1263-1268, 2013.

Mediciones Antropométricas en Mujeres Serbias Adultas y Mayores Previo a un Programa Físico y Educativo de Pilates y Aeróbica

Previous Anthropometric Measures in Adult and Elderly Serbian Women to Physical and Educational Program Of Pilates And Aerobic

Pedro Jesús Ruiz-Montero[*]; Alfonso Castillo-Rodríguez[**]; Milena Mikalacki[***]; Cokorilo Nebojsa[***] & Darinka Korovljev[***]

RUIZ-MONTERO, P. J.; CASTILLO-RODRÍGUEZ, A.; MIKALACKI, M.; NEBOJSA, C. & KOROVLJEV, D. Mediciones antropométricas en mujeres serbias adultas y mayores previo a un programa físico y educativo de pilates y aerobic. ***Int. J. Morphol., 31(4)***:1263-1268, 2013.

RESUMEN: Las personas adultas y mayores deben mejorar su bienestar físico para evitar enfermedades derivadas del envejecimiento. La edad está íntimamente relacionada directamente con el aumento de la masa grasa y peso e inversamente con la talla de las personas. Este estudio muestra las características antropométricas previas a un programa educativo de Pilates y Aeróbica. Doscientas cinco mujeres de la ciudad de Novi Sad (Serbia) con edades comprendidas entre los 40 y 76 años han participado voluntariamente. Los resultados obtenidos muestran que la edad se relaciona con el peso, masa grasa, IMC y talla ($p<0,01$). Además, las mujeres con un IMC mayor de 25 kg/m^2, poseen valores mayores en las mediciones antropométricas, masa grasa y talla ($p<0,01$). Por último, a medida que aumenta la edad (en intervalos de 10 años), la talla disminuye y la masa grasa aumenta ($p<0,05$).

PALABRAS CLAVE: Antropometría; Personas adultas; Mayores; Grasa; Pilates.

INTRODUCCIÓN

La actividad física en general, así como diversas especialidades que resultan más motivantes, como el Pilates (Ruiz-Montero & Petrovic, 2013; Palop Montoro, 2009), en personas mayores puede evitar y/o mejorar posibles limitaciones y discapacidad funcional-motriz que van apareciendo con la edad (Tercedor, 2001). El límite máximo de capacidad funcional es el que inicia la vida adulta. A partir de ahí, comienza un descenso de esta capacidad que es característico del envejecimiento (Castillo, 2009). Además, se puede encontrar mayores activos que tienen mejores registros antropométricos y fisiológicos que mayores sedentarios, confirmando esto las teorías sobre un envejecimiento activo y éxitos (Díaz *et al*., 2011).

Existen, por tanto, diversos beneficios de la actividad física regular y evidencia científica en relación a éstos. A nivel individual, entre los beneficios que pueden mejorar, se encuentran, la resistencia cardiorrespiratoria, la fuerza muscular, la densidad ósea, la composición corporal y los biomarcadores metabólicos y cardiovasculares (WHO, 2010).

En los países desarrollados, el número de personas mayores ha aumentado considerablemente en los últimos años. El proceso de envejecimiento lleva consigo diversos cambios, que la actividad física puede ralentizar. Estos cambios pueden producir el desarrollo de enfermedades como la obesidad, sarcopenia y osteoporosis, que se encuentran íntimamente relacionadas con la pérdida de pérdida de masa muscular y ósea, así como la cantidad de fuerza (González *et al*., 2003). Éstas y otras enfermedades están relacionadas a una disminución de la calidad de vida y como consecuencia, mayor probabilidad de dependencia y aumento de la mortalidad (Gómez-Cabello *et al*., 2012).

Una variación en las mediciones antropométricas (mayor perímetro muscular y/o menor pliegue subcutáneo) supone el primer escalón de la mejora de la calidad de vida de la persona. De ahí que, las personas mayores entrenadas posean valores inferiores de masa grasa que, personas no entrenadas, de una misma edad (González *et al*.).

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El objetivo de este estudio ha sido analizar el estado de salud mediante el nivel de composición corporal, en general, y mediciones antropométricas, en particular, de mujeres con edades comprendidas entre los 40 y 76 años. Para ello, se ha realizado una evaluación previa a un programa de intervención física y educativa a través de ejercicios de Pilates para la pérdida de masa grasa y mejora de la fuerza. También se pretendía fomentar una educación saludable en la misma intervención, mediante asimilación de adecuados hábitos posturales y corrección de malas posiciones tanto en la propia intervención de Pilates como en la vida cotidiana de cada participante.

MATERIAL Y MÉTODO

El presente trabajo se centra en una investigación con un diseño descriptivo y correlacional, de corte transversal y seleccionando aleatoriamente la muestra a evaluar.

Participantes. Se evaluaron a 205 mujeres serbias de un universo de 300 posibles participantes, con edades entre 40 y 76 años (1= 41-50 años; 2= 51-60 años; 3= 61-70 años; 4= >71). Todas ellas fueron las participantes del presente estudio, no habiendo realizado anteriormente ninguna práctica física controlada por especialistas y accediendo de manera voluntaria y bajo un consentimiento informado. Las características específicas se presentan en la Tabla I. El Comité de ética de la Facultad del Deporte y Educación Física de la Universidad de Novi Sad (Serbia) aprobó la realización de este estudio (Tabla I).

Instrumentos. Se utilizó diversos instrumentos para la evaluación y recogida de datos antropométricos como plicómetro (precisión 0,2 mm y apertura de 50 mm), cinta antropométrica (precisión 1 mm) y paquímetro (precisión 1 mm y rango de medición de 0-140 mm), todos ellos de la marca Holtain. Las mediciones antropométricas llevadas a cabo se encuentran en la Tabla II. Para determinar el peso y talla se utilizó báscula con tallímetro incorporado modelo Seca 714 (rango 60-200 cm) (Tabla II).

Procedimiento. El presente estudio de investigación fue iniciado con el propósito de establecer la influencia de la actividad física (mediante un programa de actividad física y educativa basado en Pilates y Aerobica) en personas tanto adultas como mayores (dependiendo del rango de edad en el que se encuentren), con diferentes pesos corporales y masa grasa. Se tomaron medidas antropométricas así como un cuestionario sociodemográfico para recoger variables tanto sociales como demográficas.

Tabla I. Características de talla, peso y masa grasa en función del IMC.

	IMC < 24,99 (n= 93)	**IMC > 25 (n= 112)**	*p*
Talla (cm)	165,4±5,3	162,3±6,20	0,001
Peso (kg)	60,82±7,12	76,71±10,99	0,001
MG (%)	28,72±4,82	39,80±7,28	0,001
MG (kg)	17,75±3,99	30,98±9,41	0,001

IMC: Índice de Masa Corporal; MG: Masa Grasa.

El programa de intervención llevado a cabo, estaba compuesto por contenidos de ejercicios aeróbicos con base musical y del método Pilates, nivel iniciación y medio. Las sesiones del presente programa tuvieron una frecuencia de 2 días a la semana, con una duración de una hora y tiempo útil de actividad de 45 minutos, siguiendo las indicaciones del American College of Sports Medicine (2005). Esta intervención tuvo una duración de 16 semanas y se comprobó en la siguiente fase de la investigación, el grado de influencia.

La evaluación antropométrica fue llevada a cabo una semana antes del inicio de la actividad, a primera hora de la mañana, con pantalones cortos y parte superior de bikinis o top como única ropa por parte de las participantes.

Análisis estadístico. En primer lugar se realizaron análisis de normalidad (prueba de Kolmogórov-Smirnov), resultando todas las variables dependientes normales. Posteriormente, se realizaron análisis descriptivos y comparativos en función del IMC y de la edad (prueba T de Student y ANOVA de una vía, respectivamente). Para el factor o variable independiente IMC, se estructuró en 2 grupos, uno para menores o iguales de 24,99 kg x m^2, y otro para mayores o iguales de 25,00 kg x m-2. En el caso del factor o variable independiente de la edad, se dividió en 4 grupos con rangos de 10 años cada uno. Finalmente, se analizó la correlación de las variables a través del coeficiente de Pearson. El nivel de significación establecido fue de $p<0,05$.

RESULTADOS

Los participantes con un IMC superior a 25 kg x m^2 poseen mayores valores de perímetros musculares, pliegues cutáneos y diámetros óseos ($p<0,05$). Estas diferencias significativas se encuentran detalladas en la Tabla II.

Sin embargo, la comparación de variables como talla, peso, IMC y MG en función de la edad, se determinó diversas diferencias significativas entre el grupo de edad 1, de 41 a 50 años, frente a los grupos 3 y 4, de 61 a 70 y mayores de 71, respectivamente ($p<0,05$), en las variables específicas de talla y MG (Tabla III).

Por último, en la Tabla IV, existen diversas relaciones entre variables de edad, peso, talla, IMC y MG. Destacar que la edad de las mujeres se relaciona inversamente con la talla y directamente con el peso, IMC y MG ($p<0,01$) (Tabla V).

Tabla II. Variables antropométricas realizadas.

Perímetros	Pliegues	Diámetros
Brazo relajado (PBrR)	Subescapular (PlSE)	Bihumeral (DCod)
Brazo contraído (PBrC)	Tríceps (PlTri)	Muñeca (DMuñ)
Antebrazo (PAn)	Antebrazo frontal (PlAnF)	Fémur (DFém)
Cintura (PCintura)	Antebrazo externo (PlAnE)	Tobillo (Dtob)
Cadera (PCadera)	Abdominal (PlAbd)	
Muslo (PMuslo)	Muslo (PlMus)	
Pirna posterior (P PostP)	Pierna posterior (P PostP)	

Tabla III. Comparación de variables antropométricas en función del IMC.

		IMC<24.99 (n= 93)	IMC>25 (n= 112)	*p*
Perímetros	PBrR	26.43±2.25	31.01±2.86	0.001
	PBrC	27.98±2.05	31.43±4.73	0.001
	PAn	22.88±3.48	26.32±9.88	0.020
	PCintura	74,92±5,45	89,07±9,55	0,001
	PCadera	97,86±4,99	109,2±8,05	0,001
	PMuslo	52,92±4,05	58,93±7,52	0,001
	PPost P	35.96±2.66	37.92±2.79	0.001
Pliegues	PlSE	13.88±4.77	23.32±7.99	0.001
	PlTri	18,67±4,15	26,82±6,06	0,001
	PlAnF	8,72±2,31	12,97±5,06	0,001
	PlAnE	9,21±2,48	12,85±4,35	0,001
	PlAbd	18,96±6,65	31,98±7,51	0,001
	PlMus	31.17±6.81	36.84±8.27	0.001
	PPost P	20.78±5.18	23.63±8.35	0.036
Diámetros	DCod	6,01±0,69	6,45±0,60	0,001
	DMuñ	5,11±0,42	5,34±0,41	0,004
	DFem	10,59±12,9	9,22±0,97	0,388
	Dtob	6,51±0,45	6,79±0,57	0,005

Tabla IV. ANOVA de talla, peso, IMC y MG en función de la edad.

	41-50 años (n= 102)	51-60 (n= 59)	61-70 (n= 27)	> 71 años (n= 4)	*p*
Talla (cm)	164,6±5,39[3,4]	162,9±6,91	161,6±4,97[1]	160,63±5,70[1]	*
Peso (kg)	68,36±13,13	72,3±11,89	69,50±9,99	78,73±14,84	ns
IMC (kg/m^2)	25,26±4,84	26,77±5,31	25,64±6,24	30,35±4,04	ns
MG (%)	33,48±8,16[3,4]	36,27±8,54	37,94±8,15[1]	42,25±4,26[1]	*
MG (kg)	23,91±10,46	26,85±9,59	26,71±8,90	33,78±9,59	ns

*p<0,05; ns: no significativo; IMC: Índice de Masa Corporal; MG: Masa grasa. Pos hoc Bonferroni: 1: 41-50 años; 2: 51-60 años; 3: 61-70 años; 4: >71 años.

Tabla V. Correlaciones de las variables demográficas.

	Talla (cm)	Peso (kg)	IMC	MG (%)	MG (Kg)
Edad (años)	-0,23**	0,28**	0,32**	0,36**	0,31**
Talla (cm)		0,24**	-0,14*	-0,15**	-0,01
Peso (kg)			0,92**	0,76**	0,88**
IMC (kg/m^2)				0,80**	0,87**
MG (%)					0,94**

*p<0,05; **p<0,01

DISCUSIÓN

El objetivo de este estudio de investigación fue evaluar las mediciones antropométricas previas a un programa de entrenamiento de 16 semanas específico de Pilates para la pérdida de masa grasa y aumento de la fuerza.

Las características de los sujetos como talla y peso, varía en función de la edad (Palop Montoro), de modo que la talla disminuye mientras que el peso aumenta. En la misma línea, Rossi *et al*. (2008) evidenciaron una disminución de la altura y de masa libre de grasa con el avance en edad, no siendo así con la masa grasa, la cual aumenta con el avance de los años (Coin *et al*., 2008). En los resultados obtenidos en el presente estudio, se aprecia un aumento de la masa grasa en relación con la edad de forma lineal (p<0,05; Tabla IV).

En este estudio preliminar, los participantes de diferentes edades poseían medias similares a estas afirmaciones (Tabla IV). Además, las mediciones antropométricas son superiores en personas con obesidad (IMC>25 kg x m-2; Tabla III). Existen relaciones entre edad y el IMC con la masa grasa de las participantes (p<0,05). Estos resultados se encuentran en la línea de lo establecido por Raab *et al*. (1988) y Rikli & Edwards (1991), haciendo alusión a la existencia de limitaciones funcionales en función de valores elevados de IMC (Zoico *et al*., 2004). Valores de IMC>25 kg x m^2 pueden producir también limitaciones funcionales futuras. Ejemplo de esto es el estudio de Davison *et al*. (2002), donde los resultados obtenidos mostraban como las mujeres de avanzada edad, con un valor IMC>30 kg x m^2 o más en la clasificación de sobrepeso y obesidad de IMC podían llegar a tener hasta el doble de limitaciones funcionales que las mujeres con rangos normales.

Diversos programas de actividad física con objetivos similares afirman no conseguir una mejora de todas las capacidades físicas, en referencia a la resistencia cardiovascular (Domínguez Pachón *et al*., 2009), aunque otros estudios analíticos demuestran que es posible mejorar la fuerza y resistencia de forma conjunta (Toraman & Ayceman, 2005). Esta capacidad aeróbica, planteada desde un entrenamiento adecuado puede ser también beneficiosa en la mejora de la fuerza si se aplica con una intensidad de trabajo mayor del 60% en cada RM (Fatouros *et al*., 2006).

En un estudio de Domínguez Pachón *et al*., las mujeres españolas, similares al grupo 3 de edad del presente estudio (60-70 años), poseían un peso corporal (67,58±12,43 kg) similar a las mujeres serbias halladas en nuestro estudio (69,5± 9,99 kg), previo a un programa de actividad física. Además, en otra muestra similar de mujeres japonesas poseen un peso corporal medio y masa grasa de 67,65 y 33,48 kg, respectivamente (Nakamura *et al*., 2007).

Las mediciones antropométricas también se encuentran en la media mundial, ya que en estudios similares poseen mujeres tailandesas unos pliegues del tríceps y subescapular de 17,4 y 13,2 mm, respectivamente, frente a 18,67 y 13,88 mm, respectivamente, de nuestro estudio en mujeres de la misma edad (Henry *et al*., 2001).

Como conclusión, las participantes del presente estudio piloto, muestran unas medidas antropométricas, como son perímetros, diámetros y pliegues, mayores cuando superan el nivel IMC>25 kgxm-^{2}, índice que indica el comienzo del rango denominado sobrepeso según la Sociedad Española para el Estudio de la Obesidad (SEEDO) (2007). Los diámetros no distan mucha diferencia unos de otro, cuando el IMC es mayor o menor a 25 kg x m-^{2}. Las características de composición corporal también presentan niveles superiores a medida que la edad aumenta y se presenta de forma lineal, así como en personas con un IMC superior a 25 kg x m-^{2} en este estudio transversal de primera fase.

AGRADECIMIENTOS. A todas las mujeres participantes en este proyecto, con todas las molestias ocasionadas hacia ellas. También a los estudiantes de último curso de la Facul-

tad del Deporte y Educación Física de la Universidad de Novi Sad (Serbia), colaborando y organizando parte de las actividades y contenidos de las sesiones de Pilates y Aerobica, así como ayuda en las evaluaciones.

Estudio subvencionado por la Secretaría Provincial para Ciencia y Desarrollo Tecnológico en Novi Sad, bajo el título "The influence of physical activity on risk factors in the working population" (número: 114-451-2337/2011-01).

RUIZ-MONTERO, P. J.; CASTILLO-RODRÍGUEZ, A.; MIKALACKI, M.; NEBOJSA, C. & KOROVLJEV, D. Previous anthropometric measures in adult and elderly Serbian women to physical and educational program of pilates and aerobic. ***Int. J. Morphol., 31(4)***:1263-1268, 2013.

SUMMARY: Adult and elderly must improve their physical well-being to avoid illness caused by aging. The age is directly related with increasing of body fat and body weight but inversely related with body height. This study shows previous anthropometric characteristics of educational program of Pilates and Aerobic. 205 women from Novi Sad (Serbia) aged between 40 and 76 years participated voluntarily. The results obtained indicate that age is related with body weight, body fat, BMI and body height ($p<0.01$). In addition, women with BMI over 25 kgxm2 have higher values in anthropometric measures, body fat and body height ($p<0.01$). Finally, as age is increasing (intervals 10 years) the body height decreases and body fat increases ($p<0.05$).

KEY WORDS: Anthropometry; Adult; Elderly; Body fat; Pilates.

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Recibido: 06-05-2013
Aceptado: 28-08-2013

II

Physical fitness comparison and quality of life between Spanish-Serbian elderly women through a physical fitness program

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Collegium Antropologicum

Accepted

Physical fitness comparison and quality of life between Spanish and Serbian elderly women through a physical fitness program

Original scientific paper

Comparison between elderly from Spain and Serbia

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Abstract

The aim of this study was to compare the physical fitness and quality of life related to the health of a sample population of older adult women from Spain and Serbia (60-69 years). A total of 127 female participants of physical fitness programs from Spain (64.33±3.26) and Serbia (63.00±2.88) have participated. Physical fitness (PF), quality of life (QoL) and socio-demographic characteristics were evaluated by Senior Fitness Test, SF-36 Health Survey and socio-demographic questionnaire, respectively. The anthropometric characteristic was measured by corporal measurement. The physical fitness program comprised exercise of strength, agility and aerobic capacity, centering on the Pilates' program and Aerobic. Mean body mass index was 33.6±7.4 $kg \cdot m^{-2}$ in the Spanish participants and 25.1±2.6 $kg \cdot m^{-2}$ from the Serbian participants ($P<0.001$). Similarly, mean waist circumference and body weight of Spanish women was higher than Serbian ($P<0.001$; $P<0.05$, respectively). Spanish women perceived lower quality of life dimensions than Serbian women, such as physical functioning, social functioning and general health ($P<0.001$), general health ($P<0.01$) and vitality ($P<0.05$). Serbian participants experienced higher physical fitness, such as upper body flexibility ($P<0.05$), lower body flexibility, agility and aerobic endurance ($P<0.001$). In conclusion, Serbian women were found to have better levels of physical fitness and quality of life than Spanish women. Furthermore, endurance fitness has 73% of explained variance with age, body mass index and fat mass.

Key words : Physical fitness, socio-cultural difference, quality of life, aging, economic development

Introduction

The ageing of society represents a socio-demographic change which has been increasing in recent decades. Moreover, the Second World Assembly on Ageing[1] concluded that from the present day to 2050, we will see an increase of 10% to nearly 21% in the number of people over the age of 60. Similarly, life expectancy in 27 of the UE countries is 79.2 years and 82.2 years for females[2].

Serbia has a percentage of people over 60 years with 23% of total population[3] and there are not many studies related to health problems in the Balkan countries[4]. However, in Spain 22.4% of the population is over 60 and this demographic group has been the object of research studies such as the one carried out for 20 years with Spanish population and their health issues[5].

This sector of the population does not enjoy full well-being due to the fact that they suffer from physical limitations or chronic cardiovascular diseases which are commonly found in old age[6], both being associated with limitations in functionality[7]. Physical inactivity and sedentary lifestyles are both causes of negative health consequences[8]. The low level of PA in the elderly[9] might be explained by the fact that only 21% of people worldwide over the age of 65 regularly do physical exercise. The physical limitations and chronic diseases caused by sedentary lifestyles can be lessened and reduced in developed countries thanks to physical exercise, and this can produce an increase in QoL[10]. The importance of Pilates method exercises have experienced a improvement and innovation since first steps of Joseph Pilates. The present method prevents sarcopenia and maintains the strength in elderly people[11]. Similarly, Pilates method might influence in the reduction of body composition parameters and flexibility of sedentary women with obesity[12].Therefore, regular practice of physical activity is recommended in order to produce health benefits in the elderly[13].

The aim of the present study was to compare the PF and the QoL related to health in two samples of women ranged between 60 to 69 years from Serbia and Spain through a fitness program.

Methods

Participants

Participants of present study were recruited from different fitness programs via e-mail, letter or telephone in both countries. Spanish female participants were recruited from a fitness program of "Diputación de Málaga" (Spain) and Serbian female participants belonged to a fitness intervention of Faculty of Sport of Novi Sad (Serbia). One hundred twenty seven participants (74 Spanish and 53 Serbian) were volunteered for this study. They are women and their ages are ranged between 60 and 69 years. The characteristics of participants are detailed in Table 1. Participants were informed of the purpose of this study and voluntarily agreed to participate by signing the informed consent. The inclusion criterions of participants were: i) not to have acute or terminal illness, ii) not have functional mobility limited.

The study was conducted according to the Declaration of Helsinki. The study protocol was approved by the local ethics committee – institutional board.

<<Please, insert Table 1>>

Measurements

A cross-sectional study was used to assess anthropometric characteristics, physical fitness and quality of life of participants.

We measured weight (Kg) by bioelectrical impedance analysis with a Tanita SC 330s. Waist circumference (cm) was measured with the participant standing at the middle point between the ribs and ileac crest (Harpenden anthropometric tape, Holtain Ltd., Crymych, UK). Height (cm) was measured using a stadiometer (Seca 22, Hamburg, Germany). Body mass index (BMI) was calculated as weight (in kilograms) divided by height (in meters) squared and categorized using international criteria as underweight (BMI < 18.5 kg/m2), normal weight (BMI 18.5–24.9 kg/m2), overweight (BMI 25.0–29.9 kg/m2), and obese (BMI ≥30.0 kg/m2).

To assess physical fitness we used the Senior Fitness Test[9] (SFT) because 1) it is relatively easy to administer; 2) requires minimal equipment and space; 3) the tests are safe. The fitness test battery was administered by sport scientists.

Lower body muscular strength: It was assessed by the 30-second chair stand test (30´´CS). We counted the number of times that the participant could raise to a full stand from a seated position with back straight and feet flat on the floor, within 30 seconds and pushing off the arms[9]. *Upper body muscular strength:* This test was conducted with a dumbbell-5 lb for women. The participants were seated the entire test. Each participant performed (alternately with both hands) the test twice allowing a 1-minute rest period between measures (30´´AC). The best value of two trials for each hand and mean of both arms was chosen for analysis. *Lower body flexibility:* It was assessed by the "chair sit and reach test" (CSR). The participant is seated with one leg extended, slowly bends forward sliding the hands down the extended leg in an attempt to touch (or pass) the toes. The number of centimeters short of reaching the toe (minus score) or reaching beyond it (plus score) was recorded[9]. Two trials with each leg were measured and the best value of each leg was registered, being the mean score of both legs used in the analysis. *Upper body flexibility:* It was assessed by the "back scratch test" (BS). This test gives an overall measure of shoulder range of motion. It measures the distance between (or overlap of) the middle fingers behind the back[9]. We measured both hands twice and the best value was registered, being the mean score of both hands computed for analysis. *Agility/dynamic balance:* It was assessed by the 8-ft up and go test. The participant stood up from a chair, walk 8 ft to and around a cone, and return to the chair as fast as possible. We recorded the best time of two trials. *Aerobic endurance:* It was assessed by the 6-minute walk test. We measured the maximum distance (meters) walked by the patients in 6 minutes along a 45.7-m rectangular course.

The Spanish version[14] and Serbian translation[15] of the SF-36 Health Survey were used to assess QoL. This questionnaire is composed of 36 items, grouped into 8 scales assessing 8 dimensions: physical functioning, physical role, bodily pain, general health, vitality, social functioning, emotional role, mental health, and general health. Each

subscale score is standardized and ranges from 0 to 100, where 0 indicates the worst possible health status and 100 the best possible one.

Procedures

Contents were treated as upper and lower body strength exercises, agility and specially, Aerobic Capacity and Pilates. The frequency of sessions was twice a week in the afternoon and lasting 45 minutes per session. Each exercise was performed in both Spain and Serbia of the same way by supervision of specialists. The cross-sectional study was carried out with samples homogeneous of the 2 European countries and similar weather but one of them is non-included within UE (Serbia).

When the participants agreed to collaborate, they were given socio-demographic and clinical questionnaires to verify if they were eligible under the criteria of inclusion and exclusion. This way allows ensuring that participants were not taking any medications and had no functional mobility problems. Subsequently, we assessed the height, weight and proceeded to take the test SF -36 Health Survey, before to performer any physical activity in order to avoid fatigue or excessive motivation can influence the responses of the participants.

SFT test tests were conducted during the same week to all participants. We need two sessions to complete the battery. We have carried out in both countries in a covered room with temperature ranging between 17-22°C. Before the tests, were conducted formal and non-exhausted warm.

Statistical Analyzes

Firstly, we analyzed the Kolmogorov-Smirnov test to check the normal distribution of the sample. The descriptive analyzes were carried out to check the characteristics of the participants and comparison of means for independent samples (nationality). Secondly, we have assessed a correlation coefficient Spearman's Rho test to determine the relationships between variables of fitness and quality of life. Finally, linear regression test of stepwise model was run between variables. The significance level was of $p < 0.05$.

SPSS for Windows v.17.0 program (Chicago, SPSS Inc.) was used to perform statistical analysis.

Results

Clinical characteristics of the present study are specified by nationalities in Table 1. The clinical characteristics such as height, waist circumference, body mass index ($p < 0.001$) and weight ($p < 0.05$) showed differences, except for age and fat mass.

Table 2 shows the results of each performed SFT test from the Serbian and Spanish population in two types of units. Firstly, the record is shown in absolute values of each of the tests, and then, the value is shown in ‘years’, in line with the protocol for variable calculations. In this table, we have found significant differences between the types of population.

<<Please, insert Table 2>>

Serbian women have better physical function, general health, vitality, social function and mental health than that found in Spanish women ($p < 0.05$, Table 2). In the remaining variables of the SF-36 Health Survey test, Serbian women also have higher values than Spanish women, although these are non- significant (role physical, bodily pain, emotional role, and health development).

Below, Table 3 shows various correlations between SFT and the variables of QoL (SF-36). In this regard, it is worth pointing out a strong relationship between physical function and the tests carried out by 'CSR mean', "6minut_totalmeter" and "8 feet up & go" (Rho = 0.64, 0.65, 0.59, $p < 0.01$, respectively.)
However, with respect to the relationship between body characteristics and QoL variables we should point out a strong relationship between skeletal muscle mass (SMM) and vitality (Rho: 0.55, $p < 0.01$). In addition, the participant's bodily pain and fat mass have an inverse (Rho: 0.37, $p < 0.05$). Finally, body weight and BMI have similar inverse relationships with physical function, physical role and mental health states (Rho: -0.39 and -0.55, -0.40 and -0.39, -0.44 and -0.58, $p < 0.05$; respectively).

We can see different correlation coefficients. It should be highlighted that age, WC and BMI are inversely related to all physical fitness tests, though they are more significant with the CSR and BS tests ($p < 0.01$). However, height is positively related to the tests from the set of SFT ($p < 0.01$, Table 3).

<<Please, insert Table 3>>

Lastly, two different models have been found through linear regression tests with the dependent variable of "CF_6minut_totalmeter" (a: R2 adjust = 0.67, SEE = 64.27, $p < 0.05$, b: adjust R2 = 0.73, SEE = 58.70 , $p < 0.05$), carried out with the step by step method (stepwise) between the 6 minute test (m) and body characteristics. The calculations are as follows: a) CF_6minut_totalmeter = 812784 + (9.998 * Height) - (7.491 * Weight) + (8.227 * FM) and b) CF_6minut_totalmeter = 1035,717 - (4.721 * Age) - (1.16 * BMI) + (6.722 * FM).

Discussion

The present study shows differences in a physical fitness program whose content were based on Pilates and aerobic exercises which was carried out twice a week. These disparities were observed between variables related to physical fitness, perceived health of participants and body parameters, both in the Spanish and Serbian samples. Serbian women showed higher levels of physical fitness and quality of life than Spanish women.

An explanation might be due to the lifestyle lead by Serbian population which differs somewhat with respect to the Spanish. In the first, the use of a personal vehicle may not be as marked as in the second. This might be due to the fact that the Serbian sample lives in a city where their day-to-day lives take place (work, family, daily needs, etc...).

The less economically developed countries tend to have a higher concentration of employment in the cities[16]. Whereas, the Spanish sample resides in small, restricted towns. According with other studies[17], they must use a vehicle as a form of transport in order to acquire certain resources or other social demands, among other things, to spend more time at home watching television[18], making them less active on the whole. But most important aspect is that Serbia's economic resources differ greatly from those found in Spain. Serbia's GDP per capita places its economy in 78th position in the world ranking. In contrast, the Spain's GDP is in 14th position[19]. Serbian participants might use public transport more or walk to places instead of using personal transport as it is more attractive economically speaking. Moreover, using public transport implies more energy expenditure than travelling by car[20]. Consequently, the Serbian samples commute implies more physical activity, which suggests that there is more exertion of physical fitness throughout their day-to-day lives, being able to be more active in their leisure time, resulting in maintaining their body weight[21].

The PF evaluation, including through primary care, is always problematic due to the relationship between health, socioeconomic, demographic and cultural factors[22]. As regards to QoL, it must be noted that it has a subjective value when it can be modified by cultural context. The health benefits of Spanish participants score lower than the Serbian participants in all SF-36 domains. There is a great difference between the two samples in the domain of mental Health as an integral part of the mental component. Although it is worth mentioning that the largest differences can be observed in the domains related to the physical component, specifically in physical function, physical role and general health. Given that the average age is slightly higher in the Spanish sample, this may be associated with the increase in the physical component domain in the SF-36 scores, according to literature[23]. Despite this, Spanish women also have a suitable QoL since the domains are all above average, with the exception of mental health and general health. Samples of both countries perform PF in a structured manner, through a physical education program, being related to an improved QoL as well as physical, social and emotion perception[24].

The level of daily activities performed and a low level of QoL is related to obesity[25]. However, the rate of overweight (Serbian) or obese (Spanish) does not prevent them doing exercise or having an active lifestyle. A study conducted on older Caucasians concluded that obese men with a high fitness levels had less mortality risks[27] than those who did not do exercise. This fact can also be found in our study, where women have high levels of BMI ($P < 0.001$) and waist circumference ($P < 0.001$) but also adequate values of certain physical capacities (Table 2), thereby causing confusion[28].

The Spanish participants present higher rates of obesity than the Serbian participants, but this does not mean they fare worse physically. Studies in Germany and the United States have shown a higher prevalence of obesity rates in people living in rural villages and towns compared to those living in cities[29]. Similarly, the Spanish participants reside in villages >10,000 inhabitants of Malaga. However, the Serbian participants reside in Novi Sad (Serbia), <250.000 inhabitants[30]. Therefore, the results of the body characteristics of Spanish participants corroborate the studies of the authors mentioned above. Besides this, it is worth highlighting the peculiarity of the geographical location of the two samples analyzed in this study. One of them belongs to Spain, placed in twenty-third position in the ranking of Human Development Index with a value of 0.89

compared to the first position, Norway 0.96. Serbia is in the position 64th with a value of 0.77.

These data may further substantiate body values obtained by the Spanish sample, considerably worse than the Serbian sample in terms of health markers. And a study carried out on countries in Central and South America, obtained as a result an increase in the prevalence of obesity in countries that were less developed than others, due to rapid changes in the structure of the diet and a decrease in the physical activity levels of its inhabitants[31].

Despite this, an overweight value cannot be considered a negative or risk factor. The results of a study carried out on a sample of four thousand Chinese residents of Hong Kong over the age of 65 years, with a higher average of body mass and percentage of fat-free fat mass were associated with lower mortality risks[32]. These results are also consistent with the study carried out on 13,000 elderly men and women from the Cooper Clinic[33] in which obese individuals or people with cardiovascular risk factors but high fitness levels correlated with reduced mortality and cardiovascular risks.

In the present study, a link has been observed between different physical capacities and body composition and the age of participants. This relationship confirms that ageing is associated with significant changes in body composition and obesity is associated with a deterioration of physical fitness in the upper and lower body.

Moreover, age is inversely associated with the physical capacities assessed by the SFT based upon a coefficient force of rho = -0.44 to 0.75 ($p < 0.01$). These results confirm the reduced levels of AF as the ageing process progresses. The physical capacity levels of the Serbian sample levels correspond to the link established between the level of physical activity and improvement of physical capacity, but the same could not be said for the Spanish sample. Finally, the muscle strength and aerobic capacity, evaluated in the SFT, decreases from 32% to 44% between the ages of 60 to 90[34].

Conclusion

This study concludes that the sample of Spanish participants has a lower QoL and PF than that found in Serbian participants of the same age range and similar characteristics. The variables of PF are associated with the participants' physical characteristics in this study. The strength of upper and lower body is appropriate for the age range of each sample and causes the level of agility, balance and motor ability (test "eight feet up & go") to be different from other existing associations. Therefore, this suggests the need to work specific strength in upper and lower limbs to improve agility and dynamic balance not associated with body composition, weight and WC in women with the same characteristics as those of the present study. At the same time, it has been established that resistance capacity is determined by a 73% of explained variance in age and BMI.

Several limitations of this study need to be mentioned. First, the study was conducted just with women and thus, quality of life and physical fitness with male patients would be needed. Second, our participants were volunteers, which could have affected the representativeness of the study sample and unequal distribution among age status categories. Moreover, the mean age of both samples is very similar and they are in the

range 60-69 years. Further research on elderly female participants with larger range of age is required to discuss the present findings between these both countries.

Disclosure of interest

The authors report no potential conflicts of interest in this research and/or publication of this article.

Acknowledgments

Present research is an agreement between Sport Area of Malaga County Council and Research Group CTS-545 "Physical Activity, Sport and Ergonomics for Quality of Life" from University of Granada (Spain).
A special thanks to all the women from Fitness Program of Malaga County Council (Diputación Provincial de Málaga; Programa de Condición Física de Mayores) and Novi Sad (Faculty of Sport and Physical Education) who participated in this study, and to any inconvenience it may have caused them. Also, to the final year students at the Faculty of Sport and Physical Education, University of Novi (Serbia) and the colleagues from this Faculty who provided participants, material and space for this research.

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FIZIČKA FITNESS USPOREDBU I KVALITETE ŽIVOTA IZMEĐU ŠPANJOLSKIH I SRPSKIH STARIJIH ŽENA KROZ FIZIČKE FITNESS PROGRAMA

Sažetak

Cilj ovog istraživanja bio je usporediti fizičke kondicije i kvalitete života vezane za zdravlje uzorku populacije starijih odraslih žena iz Španjolske i Srbije (60 - 69 godina).Ukupno 127 ženskih sudionika fizičke fitness programa iz Španjolske (64.33 ± 3,26) i Srbije (63.00 ± 2.88) sudjelovali. Fizička fitness, kvaliteta života i socio-demografskih obilježja su ocijenjeni od strane višeg testa vježbanja, SF-36 Health Survey i socio-demografskih upitnika, respektivno.Antropometrijski karakteristična je mjerena tjelesnog mjerenja.Tjelesna kondicija programa čine vježbe snage, agilnosti i aerobnog kapaciteta, usredotočujući se na pilates 'programa i aerobna plesa. Srednji indeks tjelesne mase bio je 33,6 ± 7,4 kg • m-2 u španjolskim sudionika i 25,1 ± 2,6 kg • m-2 od srpskih sudionika (P <0.001). Isto tako, znači opseg struka i tjelesne težine španjolskih žena bila viša od srpske (P <0,001, P <0,05, respektivno). Španjolske žene percipiraju manju kvalitetu dimenzije života nego srpskih žena, kao što je fizičko funkcioniranje, socijalizacija i opće zdravlje (p <0.001), opće zdravlje (p <0,01) i vitalnosti (P <0,05). Srpski sudionici imali su veću fizičku kondiciju, kao što je gornji fleksibilnost tijela (P <0,05), donje fleksibilnost tijela, agilnosti i aerobne izdržljivosti (P <0.001). U zaključku, Srpkinje su otkrili da imaju bolje razine fizičke kondicije i kvalitete života od španjolske žene. Nadalje, izdržljivost fitness ima 73% objašnjene varijance s dobi, indeksa tjelesne mase i masnog tkiva.

TABLE 1

CLINICAL CHARACTERISTICS OF STUDY PARTICIPANTS

		Spanish (n=74)	Serbian (n=53)	p-value[a]
Age	(year)	64.33 ± 3.26	63.00 ± 2.88	0.301
Weight	(kg)	78.44 ± 18.99	65.96 ± 8.16	<0.05
Height	(cm)	152.6 ± 4.76	162.1 ± 5.59	<0.001
WC	(cm)	105.7 ± 14.23	90.38 ± 11.36	<0.001
BMI	($kg \cdot m^{-2}$)	33.57 ± 7.39	25.08 ± 2.63	<0.001
FM	(%)	37.12 ± 12.75	36.90 ± 5.17	0.948

WC- Waist circumference, BMI- Body Mass Index, FM- Fat mass
[a] P values calculated by U Mann Whitney Test

TABLE 2

SENIOR FITNESS TEST (SFT) AND QUALITY OF LIFE (SF-36 HEALTH SURVEY) IN SERBIAN AND SPANISH WOMEN

		Spanish (n=74)	Serbian (n=53)	p-value[a]
30´´CS	(nº repetitions)	12.76 ± 2.97	14.00 ± 3.12	0.351
30´´AC right	(nº repetitions)	18.40 ± 3.55	21.25 ± 3.96	0.102
30´´AC left	(nº repetitions)	18.90 ± 3.97	21.13 ± 4.19	0.220
30´´AC mean	(nº repetitions)	18.90 ± 3.34	21.19 ± 3.94	0.175
BS Right	(cm)	-6.21 ± 9.26	1.21 ± 5.14	<0.05
BS Left	(cm)	-10.81 ± 9.61	-1.05 ± 5.56	<0.05
BS mean	(cm)	-8.51 ± 9.01	0.08 ± 4.90	<0.05
CSR Right	(cm)	-0.167 ± 16.53	51.66 ± 6.35	<0.001
CSR Left	(cm)	-0.143 ± 16.35	52.40 ± 6.49	<0.001
CSR mean	(cm)	-0.155 ± 16.31	52.03 ± 6.36	<0.001
"8 feet up & go"	(seconds)	6.37 ± 1.40	5.07 ± 0.54	0.149
6min walk test	(m)	436.5 ± 68.32	598.01 ± 58.47	0.466
		Quality of life (SF-36 Health Survey)		
Physical functioning		60.00±23.45	86.25±7.44	<0.001
Physical role		58.33+44.95	84.38+35.20	0.120
Bodily pain		52.71+19.94	58.50+12.98	0.371
General health		49.19+18.26	73.50+11.70	<0.01
Vitality		50.24+38.49	55.00+8.45	<0.05
Social Functioning		57.74+12.17	81.25+16.37	<0.001
Emotional role		66.67+44.72	79.17+35.36	0.442
Mental health		39.24+21.45	66.50+8.54	<0.001

30´´CS- 30s chair stand (lower body), 30´´AC- 30s arm curl (upper body), BS- back scratch test, CSR- chair sit and reach

[a] Significant difference between nationalities, Senior Fitness Test (SFT) and quality of life (SF-36 Health Survey) (U Mann Whitney Test)

TABLE 3

RHO OF SPEARMAN CORRELATION COEFFICIENT BETWEEN SENIOR FITNESS TEST (SFT[a]) WITH BODY COMPOSITION[b] AND QUALITY OF LIFE (SF-36 HEALTH SURVEY)

	CSR right	CSR left	BS right	BS left	30´CS	30´´AC right	30´´AC left	Test "8 feet up & go"	6min-walking
Weight (Kg)	-0.16	-0.15	-0.30*	-0.29*	-0.23	-0.09	-0.02	0.18	-0.22
Height (cm)	0.72**	0.73**	0.54**	0.39**	0.20	0.30*	0.26*	-0.45**	0.64**
Waist circumference	-0.55**	-0.57**	-0.71**	-0.57**	-0.34**	-0.31*	-0.26*	0.53**	-0.59**
BMI	-0.63**	-0.62**	-0.67**	-0.56**	-0.36**	-0.24	-0.16	0.45**	-064**
Fat mass	.0.01	0.03	-0.15	-0.08	-0.13	0.18	0.19	-0.18	0.03
Age	-0.75**	-0.75**	-0.69**	-0.55**	-0.44**	-0.56**	-0.53**	0.71**	-0.77**
Physical functioning	0.64**	-0.57**	0.55**	-0.50**	0.29**	0.12	0.15	-0.59**	0.65**
Physical role	0.49**	-0.58**	0.29**	-0.18**	0.13**	0.01	0.03	-0.30**	0.21**
Bodily pain	0.45**	-0.34**	0.50**	-0.43**	0.34**	-0.14	0.06	-0.39**	0.35**
General Health	0.21	0.05	0.12	-0.05	-0.04	0.23	0.14	-0.06	0.12
Vitality	0.34*	-0.24*	0.38*	-0.27*	-0.14*	-0.01	0.06	-0.14*	0.13*
Social Functioning	0.46*	-0.18*	0.34*	-0.37*	-0.01*	0.31	0.21	-0.39*	0.34*
Emotional role	0.21	-0.35	0.13	-0.16	0.01	0.27	0.29	0.01	0.11
Mental health	0.30**	-0.04**	0.04**	-0.04**	0.34**	0.15	0.14	-0.54**	0.46**

*p<0.05, **p<0.01

[a] 30´´CS- 30s chair stand (lower body), 30´´AC- 30s arm curl (upper body), CSR- chair sit and reach, BS- back scratch

[b] BMI- body mass index

III

24-weeks Pilates-aerobic and educative training to improve body fat mass in elderly Serbian women

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Clinical Interventions in Aging

2014; 9: 243-248

Clinical Interventions in Aging

Dovepress

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ORIGINAL RESEARCH

24-weeks Pilates-aerobic and educative training to improve body fat mass in elderly Serbian women

This article was published in the following Dove Press journal:
Clinical Interventions in Aging
31 January 2014
Number of times this article has been viewed

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Background: The purpose of this study was to examine the differences in anthropometric measurements using an aerobic and Pilates exercise program which lasted 24 weeks.

Method: This was a clinical intervention study of 303 women over the age of 60 living in Novi Sad, Serbia. Changes in body mass index and skinfold thickness were estimated through height, weight, and anthropometric measurements. The program comprised Pilates exercises for upper- and lower-body strength, agility, and aerobic capacity.

Results: Fat mass (FM) improved significantly (pre-test, 32.89%, 8.65; post-test, 28.25%, 6.58; $P<0.01$). Bone diameters and muscle perimeters showed no significant changes pre- and post-test ($P>0.05$), but there was a higher correlation between FM (%) and waist–hip ratio (rho, 0.80; $P<0.01$).

Conclusion: A mixed program of aerobics and Pilates, controls and improves baseline muscle mass and decreases FM values, without causing deterioration during practice and follow-up exercises.

Keywords: lean body mass, anthropometric measures, educative program

Introduction

Changes in body composition can very often cause chronic diseases, and as a result have become a primary concern.[1] Lean body mass (LBM) and fat mass (FM) are body composition states that change continuously and are closely related to the aging process when compared with other factors.[2,3] Moreover, a strong link has been established between decreased muscle strength, physical capacity, quality of life, and the loss of fat-free mass.[4]

These changes can be seen in variations in body composition after middle age,[5] through the increase of FM, reduction in LBM,[6,7] and through the loss of height due to compression of the vertebrae and progressive curvature of the back.[8] Consequently, another deterioration has been identified from the age of approximately 65 to 75–80,[9] where the loss of muscle mass becomes 25%.[10]

Physical activity (PA) is considered to be one of the most important health indicators which produces benefits for all age groups,[11–13] is used as an effective intervention to prevent functional loss related to age,[14–17] and promotes an improved quality of life and, as a result, greater longevity, coupled with appropriate eating patterns.[18–21] Physical exercise also improves quality of life due to the reduction of FM and obesity,[22,23] and prevents a rapid reduction in the size and number of muscle fibers.[24]

The practice of exercise should be consistent and controlled by specific programs. If the subject chose to do the opposite, ie, not follow a specific exercise program,

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body composition might not be affected.[25] Thanks to a progressive strength program which lasted 12 months, improvements in the health of elderly women with metabolic diseases were reflected in their body composition.[26] According to Sims et al there are studies that do not show clear links between PA programs and changes in FM in women aged between 50 and 79, and which do not show prevention of loss of LBM in aerobic activities, regardless of the level.[27]

However, PA in the elderly is a widely studied and corroborated factor that improves quality of life.[28] In turn, it helps to reduce the loss of functionality and the implications of such during the aging process.[29] The American College of Sports Medicine (ACSM)[30] recommends, as part of a guide on basic exercises, that the elderly use training programs that focus on resistance, strength, aerobic capacity, and flexibility exercises. Part of its content focuses on the Pilates method through the activation of brain cells, stimulation of the mind, and the positive impact on the body.[31] The ACSM ranked this method in seventh place as an emerging PA in 2008 and 2009,[32] and in the US alone, the number of users reached 10.5 million in 2004. The Pilates method coincides with the modern principles of fitness, personal training, and mental happiness through exercises that maintain a neutral spine position and appropriate use of the floor and equipment to develop strength and balance.[33]

Aerobic capacity and endurance can also help to maintain muscle mass and strength in the elderly as well as the Pilates method.[22] According to De Cocker et al, there are relatively few studies related to muscle strengthening activities compared with other aerobic activities.[34] Some of the studies provide beneficial effects, while others do not offer any significant changes[35] in terms of intensity, duration, frequency,[36] or activity.[35]

This research project aimed to assess the differences in body composition and anthropometric measurements of a sample of Serbian women over the age of 60, in a 24-week clinical intervention study, through a guided program that combined aerobics and Pilates.

Methods

Participants

A total of 303 elderly Serbian females and eight males over the age of 60 voluntarily participated in this study. It was decided to exclude the men due to their small number. Subjects were informed about the experimental procedures, completed a medical history form, and signed an informed consent statement. The inclusion criteria were that the participants were women aged greater than 60 and less than 70 years. The exclusion criteria included having any chronic disease, limited functional mobility and taking medications. Thirty participants were smokers. A blood test was carried out to check that the participants had no problems related to the following biological parameters: glucose (4.68 g/L), triglycerides (1.29 mmol/L), high density lipoprotein (1.48 mmol/L), and low density lipoprotein (3.78 mmol/L). The average age for the onset of menopause was 48.86 years. The average number of pregnancies was 1.92. No participants were medicated during the training process, and none of the participants performed any other PA.

Measurements obtained were: height, weight, body mass index, subcutaneous skinfold thickness (triceps, subscapularis, suprailiac, abdomen, front thigh, and medial calf), muscular girths (upper arm relaxed, upper arm flexed and tensed, abdominal, thigh, and maximum calf), and four diameters (wrist, femur, humeral, and ankle).

Instruments

Bodyweight was measured to ±0.1 kg on an electronic scale (Seca GmbH & Co, KG, Hamburg, Germany), with participants wearing light indoor clothing and no shoes. Measurements were performed following the standardized techniques adopted by the International Society for the Advancement of Kinanthropometry.[37] The technical error of measurement was lower than 5% for skinfold thickness and lower than 1% for the other measurements. Skinfold thickness was taken using a caliper with a precision of 0.2 mm (Holtain Ltd, Crymych, UK). Girths were performed with a flexible metallic tape measure with a precision of 0.1 mm. Body mass index was calculated as weight (kg) × height^2 (m). The equation used to determine FM was: corporal density of Durnin–Womersley[38] $=1.1567-0.0717\times\log$ (subscapularis skinfold + triceps skinfold + forearm skinfold + biceps skinfold) and FM equation[39] (%) = [4.57/corporal density − 4.142] × 100.

Procedure

This present study was initiated in order to establish the influence of PA (through a program of educational activity and PA based on Pilates and aerobics) on the elderly, with different bodyweights and FM. A medical and sociodemographic questionnaire was completed to collect social, demographic, and medical variables. Consequently, the collection of anthropometric measurements was carried out.

Data were collected twice. On the first occasion, a pre-test was evaluated during the month of May 2011. Then, a post-test was performed in November of 2011. The Pilates-gym

training process lasted for 24 weeks. The program had an 80% attendance rate during this period.

The training program consisted of music-based aerobics and Pilates, basic to intermediate level. Following these sessions, concepts of health education were given to orientate participants towards a more healthy posture and the practice of food hygiene in their daily lives. The diet regime was established according to the recommendations of ACSM[13] and was followed by 91% of the participants. The sessions included in this program took place twice per week and lasted 55–60 minutes per day-session, with an effective PA time of 45 minutes, in line with the requirements laid out by the ACSM.[23] The program comprised Pilates exercises for upper- and lower-body strength, agility, and aerobic capacity. During the first session of the intervention process, participants were asked their perceived level of exertion on a scale of 0–10 (Borg scale) to establish the initial level and then gradually increase exercise intensity. This course lasted 24 weeks and was based initially on a pilot study in which changes in behavior and body composition of the participants were expected.[40] This study was approved by the Ethical Committee of the University of Novi Sad.

Statistical analyses

Data were analyzed using the SPSS (SPSS, Chicago, IL, USA) statistical program, version 17.0. Normality of distribution was tested by means of the Kolmogorov–Smirnov test, which suggested that the variables were not distributed normally. Descriptive statistical methods were used for the calculations of the means and standard deviations. Repeated-measurement tests were used to determine the differences between times (Wilcoxon test; repeated-measures test). For all analyses, significance was accepted at $P<0.05$.

Results

Characteristics of the subjects are shown in Table 1. Participants had a lower height and had gained more weight after the training period, although these data were not significant. However, the FM was lower after the Pilates-gym program ($P<0.01$). Blood pressure, both systolic and diastolic, increased ($P<0.05$).

Muscle perimeters were all lower, apart from in the waist. These data show no significant differences between pre- and post-test (Table 2). Waist-to-thigh ratio was higher post-test than pre-test.

As for skinfold thickness, various results were obtained ($P<0.05$). In some participants, they were higher such as skinfold thickness of triceps, inner forearm, and the abdomen, and in others, the results were lower, such as in skinfold thickness in the subscapularis, outer forearm, mid-thigh, and calf (Table 3).

Lastly, bone diameters were similar in the pre- and post-tests ($P>0.05$) (Table 4). Regarding correlations, there was a strong relationship between FM (%) and waist-to-hip ratio (rho, 0.80; $P<0.01$).

Table 1 Descriptive characteristic of participants

	Pre-test	Post-test	*P*-value
Height (cm)	165.1±5.11	164.7±4.90	0.84
Weight (kg)	62.63±9.92	64.38±13.20	0.64
BMI ($kg \cdot m^{-2}$)	22.94±3.26	23.75±4.88	0.57
FM (%)	32.89±8.65	28.25±6.58	0.00
FM (kg)	23.02±9.45	18.96±8.15	0.00
SYS	111.8±16.9	122.7±14.4	0.05
DIAS	71.82±8.74	77.27±8.76	0.01

Abbreviations: BMI, body mass index; DIAS, diastolic blood pressure; FM, fat mass; SYS, systolic blood pressure.

Discussion

This is the first study assessing the effects of 24 weeks of Pilates-aerobic exercise on older, Serbian women. The aim of this study was to examine body composition (FM and LBM) at the beginning and end of an aerobic-Pilates program. To ensure a full collaboration of participants over the period of 24 weeks, it was especially important that they were motivated in these longitudinal studies so that the practice of PA was done on a daily basis.[41]

When there is an increase in FM, there is a reduction in muscle strength, physical capacity, and quality of life, along with a loss of fat-free mass.[4] The elderly, with more sedentary lifestyles, lose fat-free mass faster than people who perform PAs through a combination of strength training[42] and force balance training,[43] the latter being the reason for the prevention of weight loss and in maintaining functional capacity in

Table 2 Wilcoxon paired-samples test (muscle perimeters)

Girth	Pre-test	Post-test	*P*-value
ARg	26.33±2.99	25.86±5.04	0.71
AFTg	27.75±1.21	26.43±5.24	0.54
FORg	23.25±1.21	22.40±2.93	0.48
OMPg	88.50±8.10	87.88±10.22	0.83
WAISTg	74.38±6.63	75.58±12.92	0.71
WHtR	0.45±0.04	0.46±0.08	0.67
WHR	0.76±0.55	0.77±0.68	0.96
MTHIg	56.08±4.03	52.70±6.60	0.36
WTR	0.67±0.70	1.40±0.14	0.01
CALFg	37.33±1.72	34.12±3.18	0.12

Abbreviations: AFTg, arm girth (flexed and tensed); ARg, arm girth (relaxed); CALFg, calf girth; FORg, forearm girth; MTHIg, mid-thigh girth; OMPg, omphalion girth (abdominal); WAISTg, waist girth; WHR, waist-to-hip ratio; WHtR, waist-to-height ratio; WTR, waist-to-thigh ratio.

Table 3 Wilcoxon test for repeated measures (skinfold thickness)

Skin	Pre-test	Post-test	*P*-value
SEs	16.74±8.64	14.60±5.73	0.38
TRIs	18.70±5.28	19.43±5.59	0.67
BIs	9.88±4.07	10.00±3.67	0.96
FOs	11.17±3.94	10.94±3.45	0.91
ABDs	18.86±7.70	21.40±8.03	0.40
MTs	36.93±7.60	34.28±7.11	0.59
MCs	25.41±4.26	19.99±5.84	0.17

Abbreviations: ABDs, abdominal skinfold; BIs, biceps skinfold; FOs, forearm skinfold; MCs, medial-calf skinfold; MTs, mid-thigh skinfold; SEs, subscapularis skinfold; TRIs, triceps skinfold.

people above the age of 70.[44] Low mortality values and less muscle fat have even been linked to an increase in aerobic exercise through walking speed.[44] This body fat (%) is related to the waist-to-hip ratio, as in the study by Bae et al[1] with a sample of the elderly. However, the correlation between the two that we have obtained is stronger (r=0.80; P<0.01) due to the homogeneity of the study sample.

Joseph Pilates developed a system of exercises which is defined as "a unique method of physical fitness that uses a combination of muscle strengthening, lengthening and breathing to develop trunk muscles and restore muscle balance."[45] The Pilates method is considered by European practice guidelines as an adequate treatment for correct modification of posture,[46,47] but it is not effective in the diminution of disability.[48] Despite there being no clear evidence of improved functionality in elderly people through the practice of Pilates, except balance,[49,50] an improvement in body composition in healthy people has been found,[51] as observed in the present study, as well as a reduction in risk situations and cardiovascular mortality.[52] Various aerobic exercise programs have shown improvements in functional capacity and particularly cardiovascular type exercises in women during the aging process.[53] The participants had an improved FM level of 32.89%±8.65% and at the end of the Pilates-aerobic program (24 weeks), the FM levels had decreased to 28.25%±6.58%. Skinfold thickness variations were very small (P>0.05); however, Table 3 shows that in all cases it decreases. Therefore, the sum of these skinfolds is a major difference. This is the reason why FM is highly significant (P<0.01). This decline in FM is linked to the completion of PA controlled and planned,[41] in addition to following a balanced diet. However, other authors such as Dias et al[54] and Lim et al[55] have not found any improvements in their participants who took part in a Pilates program. The reason for this is thought to be due to the short duration of the course (6 weeks).

Table 4 Wilcoxon test of bone diameters

Bone diameter	Pre-test	Post-test	*P*-value
BHUMb	6.18±0.13	6.20±0.59	0.95
WRb	5.23±0.23	5.10±0.17	0.21
BFEMb	9.75±0.59	10.12±1.26	0.56
ANKb	6.67±0.26	6.35±0.38	0.06

Abbreviations: ANKb, ankle breadth; BFEMb, biepicondylar femur breadth; BHUMb, biepicondylar humerus breadth; WRb, wrist breadth.

FM in the elderly does not only remain stable through the practice of the Pilates-aerobic program, but it can also decrease significantly (Table 1). Hence, as a result of the human aging process, there is a considerable loss of skeletal muscle mass over time, especially in women.[53] However, our results are similar pre-post after 24 weeks of PA (P>0.05), although Pereira et al report an increase in skeletal muscle mass, thanks to the Pilates programs.

Conclusion

In conclusion, a combined program of aerobic and Pilates, carried out under the supervision of an instructor, at least twice a week, produces health benefits in functionally independent women over the age of 60. Furthermore, initial muscular mass values remained stable, whereas FM decreased, without causing deterioration of health during the practice of exercises. For the level of balance and functional performance, physical capacity was not evaluated. We need to conduct further research, using fitness tests and comparing benefits of physical programs, especially Pilates and aerobic activity. Finally, it is important to note that the present study has its limitations with this population. According to some authors, data of the Serbian elderly sample is limited[56] because there are not many studies related to this area of Europe and in particular regarding the elderly.

Acknowledgments

A special thanks to all the women who participated in this study, and to any inconvenience it may have caused them. The authors also thank the final-year students at the Faculty of Sport and Physical Education, University of Novi Sad (Serbia), who collaborated with the project and organized some of the activities and content of the Pilates and aerobics sessions, as well as helped with the assessments. Thanks also to the physical intervention group al-Andalus and research group CTS-545 (Department of Physical Education and Sport, University of Granada) for their various forms of collaboration.

Funding

This study was funded by the Provincial Secretariat for Science and Technological Development in Novi Sad, and

was entitled "The Influence of physical activity on risk factors in the working population" (number: 114-451-2337/2011-01).

Disclosure

The authors report no potential conflicts of interest in this research and/or publication of this article.

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LIMITACIONES

Ciertas limitaciones en la presente memoria de Tesis Doctoral han de ser mencionada

i) Selección no aleatoria de la muestra (muestra por conveniencia: participantes voluntarias);
ii) Muestra no representativa de las poblaciones de estudio;
iii) Inexistencia de muestra de hombres;
iv) En varios de los estudios mostrados, falta grupo control poblacional sin practicar ejercicio físico o con otros síntomas y enfermedades relacionadas con el envejecimiento como sarcopenia, problemas de movilidad, trastornos psicológicos, etc.
v) La medicación tomada por cada participante puede haber afectado en los resultados de capacidad funcional, composición corporal, antropometría y calidad de vida relacionada con la salud.
vi) Falta de evaluación con métodos objetivos del nivel de actividad física.
vii) Ausencia de evaluación rigurosa de determinadas variables de la composición corporal mediante técnicas de referencia como DEXA.
viii) Falta de control dietético en la muestra participante aunque si se indicaron pautas alimenticias al inicio del programa combinado de Pilates y ejercicio aeróbico.

La principal fortaleza de la presente memoria de Tesis Doctoral es la singularidad y característica de las dos muestras estudiadas, principalmente una de ellas: Serbia. Además, son escasos los estudios y referencias que abordan un programa combinado de Pilates y ejercicio aeróbico en personas mayores y sus efectos en la composición corporal.

LIMITATIONS

Several limitations of the present Doctoral Thesis must be mentioned:

i) The selection of the sample studied was not randomized (volunteer participants sample)
ii) None representative sample from countries studied
iii) Absence of male participants
iv) Part of the study shown does not have a control group of participants who do not practice physical exercise or with other symptoms and illness related to the ageing process such as sarcopenia, mobility problems, psychological disorder, etc.
v) The medication of participants might have affected to results of physical fitness, body composition and quality of life related to health.
vi) Lack of assessment of physical activity level with objective methods.
vii) Absence of rigorous measurement of some BMI variables through references techniques as DEXA.
viii) Lack of dietetic supervision on sample studied although nutrition guidelines were indicated previous to Pilates-aerobic training program.

The main strength of this Doctoral Thesis is the singularity and characteristics of both samples studied, primarily Serbia. In addition, studies and references regarding the Pilates-aerobic training program in elderly people and the effects on their body composition are scant.

CONCLUSIONES

- Las mujeres serbias mostraron valores de IMC entre 25.2±4.8 Kg/m^2 (41-50 años) y 30.3±4.1 Kg/m^2 (>71 años). A medida que aumenta la edad, la talla disminuye y MG aumenta (ambos, P<0.05). Además, la variable edad muestra correlaciones positivas, aunque débiles, con peso (r=0.28), IMC (r=0.32), % MG (r=0.36), MG (Kg) (r=0.31) y correlación inversa con la talla (r=-0.23) (todos, P<0.01). Además, las mujeres con un IMC mayor de 25 Kg/m^2, poseen valores mayores en las mediciones antropométricas y masa grasa.

- Las mujeres serbias muestran mejor calidad de vida relacionada con la salud y mejor condición física que las mujeres españolas (P<0.05). La condición física de las mujeres, independientemente de su localización geográfica, está asociada directamente con la talla (P<0.05) e inversamente con el perímetro de cintura (P<0.05), IMC, edad (ambos, P<0.01) y con el peso (P<0.05). La condición física presenta mejores correlaciones con la dimensión función física de la calidad de vida relacionada con la salud que con el resto de dimensiones.

- Un programa combinado de Pilates y ejercicio aeróbico, dos veces a la semana, redujo la masa grasa (en Kg y en %) (P<0.001) en las participantes.

Conclusión general:

Con la edad, las personas mayores empeoran su composición corporal. La condición física se relaciona positivamente con la calidad de vida relacionada con la salud. Un programa combinado de Pilates y ejercicio aeróbico, dos veces a la semana, contribuye a un envejecimiento más saludable.

CONCLUSIONS

- Serbian women showed BMI levels ranging from 25.2±4.8 Kg/m^2 (41-50 years) to 30.3±4.1 Kg/m^2 (>71 years). As age increases, height decreases and fat mass increases (both, $P<0.05$). Age shows a positive correlation with weight ($r=0.28$), BMI ($r=0.32$), % FM ($r=0.36$), FM (Kg) ($r=0.31$) and inverse correlation with height ($r=-0.23$) (all, $P<0.01$). Furthermore, women with a BMI over 25 Kg/m^2 have higher values in anthropometric measurements and fat mass.

- Serbian women experience a better quality of life related to health and have better physical fitness than Spanish women ($P<0.05$). The physical fitness of elderly women, irrespective of geographic location, is directly associated with height ($P<0.05$) and inversely associated with waist circumference ($P<0.05$), BMI, age, (both, $P<0.01$) and the weight ($P<0.05$). The physical fitness aspect shows a better correlation to physical functioning dimension of quality of life in terms of health than the other dimensions.

- Pilates-aerobic training program, twice a week, decreases the FM (Kg and %) ($P<0.001$) of the participants.

Overall conclusion:

Body composition worsens in elderly people with the age. Physical fitness is positively related with quality of life related to health. A Pilates-aerobic training program, two sessions a week, contributes to healthier ageing.

CURRICULUM VITAE abreviado [Short CV]

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AGRADECIMIENTOS [ACKNOWLEDGEMENTS]

A mi **madre**, por transmitirme los valores más grandes que puede haber en este mundo: el amor, la humildad y la abnegación. Siempre me has dado todo tu cariño y me has hecho ver la importancia de decir "te quiero" cuando lo sienta. Gracias por anteponerme a tus necesidades y darlo todo para que siempre fuese feliz. He tenido la infancia más bonita que un niño pueda desear. Gracias por ir conmigo al fin del mundo y caminar cogida de mi mano a todos los rincones donde podíamos llegar. Eso me ha hecho vivir cientos de experiencias. Todo ello ha dado lugar a que sea una persona con inquietudes y que ponga todo mi cariño en las cosas que hago, entre ellas mi Tesis Doctoral.

A mi **padre**, por haber sido un claro ejemplo de lucha constante a lo largo de toda su vida, por preocuparte por mis estudios, tesis y vida en el mundo de la Universidad aunque no lo entiendas en diversas ocasiones, pero sobre todo por enseñarme lo que significa el esfuerzo y su correspondiente resultado. Me trajiste a Granada para hacer las pruebas de INEF y sufrimos juntos ese día junto a mama, estabais orgullosos de mí. Lo siento mucho pero decidiste comenzar esta larga andadura conmigo y ahora tienes que acabarla.

"…don´t you worry child, see heaven´s got a plan for you…"[1]

Kiitos **Eeva-Marialle** tämän haasteen alusta asti antamastasi tuesta. Tutustuin sinuun, kun väitöskirjani oli vasta alussa. Siitä lähtien olet ollut erottamaton kumppanini, jollaisen kuka tahansa tahtoisi rinnalleen näin pitkälle ja haastavalle matkalle. Olet aina uskonut minuun, ja olet ollut tukenani, kun olen eniten sitä tarvinnut ja auttanut pyyteettömästi minä tahansa päivänä tai kellonaikana. Lukemattomat kerrat olen saanut voimaa jatkaa eteenpäin myötätuntosi ja ymmärryksesi ansiosta. Olisi epäreilua sanoa, ettei iso osa tätä urakkaa olisi sinun ansiotasi, ja toivonkin, että tiedät olevasi siinä tärkeässä osassa. Olen sinulle ikuisesti kiitollinen.

"…I follow you, dark boom honey, I follow you…"[2]

A mi **hermano** y **hermana**, por ser las personas que más han confiado en mí desde que era pequeño. **Nena,** gracias por construir en mí una sensación de seguridad tan grande. Gracias por motivarme y hacerme ver que las cosas más difíciles de alcanzar pero más deseadas, son las que más merecen la pena. Gracias por motivarme e insistir cuando era adolescente en la importancia de estudiar, por intentar que alcanzase todas mis metas incluso por delante de las tuyas. Siempre has sentido mis logros como si fuesen los tuyos y eso me ha hecho sentirme orgulloso, pero también con el compromiso de tener que seguir luchando y trabajando sin que decaiga la ilusión por todo lo que hago. Gracias por ser mi confidente, mi amiga, mi psicóloga, mi almohada donde ahogar las penas pero sobre todo, mi seguidora más incondicional. **Emi**, gracias por tu espíritu insuperable y ganas de vivir a pesar de las adversidades. He copiado de ti las ansias de disfrutar y aprovechar cada minuto de vida de la mejor manera posible. Gracias por transmitirme una actitud alegre y cercana a los demás, ser cortés y afable pero sobre todo, gracias por estar orgulloso siempre de mí y presumir de todos mis logros, eso también se traduce en confianza.

"...we´re gonna sabe the world tonight"[3]

A **Emilito** y **Noa**, por ser esos pequeños diablillos que me han sacado una sonrisa en muchos momentos y a los que no les he podido dedicar muchas veces el tiempo que se merecen. Por esto último, os pido perdón y espero que lo podáis entender cuando seáis grandes.

A mis directores de tesis, Manuel, Alfonso y Milena. En cuanto a **Manuel**, todavía recuerdo el día que fui a hablar con él para contarle mis ideas de la tesina y tesis (hace 6 años). La temática de las personas mayores fue algo que te llamó la atención y desde entonces siempre ha estado ahí para todo. Gracias por aceptarme ese día como doctorando, me hiciste muy feliz y desde entonces he estado orgulloso de tener un director como tú. Me has enseñado cosas que jamás nadie podrá hacer y contemplar la Educación Física/ Salud desde una perspectiva diferente. Además, haces que la gente se sienta útil y sepa trabajar de forma autónoma. Tus conocimientos y sacrificio por tu trabajo me abruman, pero lo que más admiro de ti es tu *humildad*.

A **Alfonso**, por tu predisposición y esfuerzo en cualquier momento, incluso domingos o festivos. Pocos como tú hacen eso y te estoy muy agradecido. Comenzaste a ayudarme incluso antes de que te propusiese como director de tesis. Lo diste todo para que nuestros estudios y trabajos saliesen para adelante y gran parte de esta tesis te la debo a ti. Sin tus consejos de cómo escribir un artículo científico o el tratamiento estadístico entre otros, todo hubiese sido más difícil. Espero algún día poder tener la fuerza que tú tienes para afrontar la vida y desafiar a los retos.

Zahvaljujem se Mileni Mikalacki zato sto je bila osoba koja mi je pružila priliku da bliže upoznam realnost jednog društva koje uprkos svojim manama, mnogo toga moze da pruži. Verovali ste u mene i omogućili ste mi da nastavim vaše istraživanje u oblasti odraslih i starijih žena u Srbiji. Na neki način, pomogli ste mi da obogatim svoju radnu biografiju.

"…and we will never be afraid again…"[4]

A mis ex directores de Tesis Doctoral. A la persona que la puedo considerar como mi director espiritual de tesis, **Antonio Baena**. A ti y solamente a ti, te debo la ilusión y el afán por este difícil mundo que es la Universidad. Siempre me he sentido a gusto contigo porque has depositado tu confianza en mi forma de trabajar. Comencé a "escribir" junto a ti y me diste la oportunidad de adentrarme en este mundo de tu mano. Gracias. A **Julia Wärnberg**, gracias por ayudarme en mis primeros momentos de esta larga carrera y facilitarme el contacto de gente de holandesa. Me aconsejaste con quién contactar durante mi periodo en Groningen (Holanda) y poder investigar con pacientes con fibromialgia.

Aan **Paul Van Wilgen** and **Miriam Van Ittersum**, voor mijn acceptatie binnen jullie onderzoeksteam en jullie geloof in mij. Jullie hebben mij de kans gegeven een groter begrip te verkrijgen van de wereld van fibromyalgia tijdens mijn verblijf in Groningen. Ik zal mijn tijd daar nooit vergeten. In addition, thanks to the people who shared their time and worked with me during my stay in Novi Sad (Serbia), in particular **Dara Korovljev, Nebojsa Cokorilo, Marko Stojanovic, Sergej Ostojic, Jelena Obradovic**, etc.

"…In a feeling that I never never, knew I, Knew I had before…"[5]

A compañeros del programa de condición física de mayores (Diputación Provincial de Málaga). A **Antonio Merino**, gracias por abrirme las puertas y aceptarme dentro de ese gran programa provincial. Tus ánimos, consejos y ayuda me han servido en muchos momentos para "venirme arriba" y continuar investigando en el apasionante mundo del envejecimiento y su relación con la práctica del ejercicio físico. A **Eva, Inma** y **Antonio**, porque nunca me habéis dado un *NO* por respuesta ante las miles de preguntas, documentos necesarios y consultas que os he realizado a cerca de ese genial programa que mantenéis día a día con gran esfuerzo. Vuestra ayuda me ha servido de mucho. A los compañeros del programa de mayores, **Antonio** de Tapia**, Mario** de Archidona**,** equipo de Coín **(Robles, Juan, Sergio), Serón** de cártama**, Alberto** de Almachar**, Rafa** de Vv Trabuco**, Felipe** de Vv Concepción, **Baltasar** de Colmenar, **Salva de** El Borge; **Ali** de Manilva, **Luis** y **Manuel Carmona** de Estepona; que me abrieron sus grupos de personas mayores e instalaciones cuando les propuse evaluar a sus participantes.

A **Pedro Montiel**, por siempre haber estado dispuesto a trabajar conmigo, decir que si a mis ideas cuando te las he propuesto y sobre todo, proporcionarme siempre todos los recursos que te he pedido.

A **Enrique** y **Carmen**, por vuestra ayuda en los momentos previos al depósito de esta Tesis Doctoral, los más tensos. Me habéis aconsejado de la mejor manera que se podía hacer, habéis estado encima de mí en todo momento, os habéis preocupado de mi tesis como si fuerais mis directores y sobre todo, habéis velado por mi situación personal desde el primer momento que llegué a vuestro departamento. Me habéis tratado como si me conocieseis de toda la vida y habéis confiado en mi trabajo, cosa que me ha facilitado mi labor docente desde mi llegada. Por todo ello, os considero personas muy importantes y os debo muchísimo. Sin duda alguna, mi gratitud hacia vosotros será para siempre.

"…el paseo de los tristes alegrar, si te pones a bailar, las estrellas nos Alhambran al pasar…"[6]

A todos los miembros del grupo de investigación **CTS-545**, me ayudasteis en los comienzos de mi tesis, ya hace unos años, y siempre he podido contar con vosotros para cualquier tipo de duda o ayuda hasta el día de hoy.

A **mis amigos**, absolutamente todos/as, gracias por comprenderme en multitud de ocasiones y nunca cuestionarme cuando he declinado vuestra invitación a viajar, salir a tomar algo o vernos un rato para charlar. De verdad que no soy un bicho raro, pero cuando se me mete algo en la cabeza no me lo puedo quitar y mi Tesis era una de ellas.

A todas las participantes de este estudio, gracias por vuestra amabilidad, comprensión y paciencia a la hora de ser evaluadas. Me habéis dado todo lo que teníais de forma altruista. Sin vosotras, por supuesto que nada de esto hubiese sido posible.

[1]John Martin Lindström, Michel Zitron, Swedish House Mafia-Don´t you worry child
[2]Lykke Li - I follow rivers
[3]Swedish House Mafia- Save The World (Tonight)
[4]Florence + The Machine - Spectrum (Say My Name)
[5]Avicii -Levels
[6]Supersubmarina- LN Granada