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ORIGINAL

PHYSICAL FUNCTION AMONG OLDER SUBGROUPS WHO ARE PHYSICALLY ACTIVE

FUNCIÓN FISICA ENTRE SUBGRUPOS DE MAYORES DE 55 AÑOS FISICAMENTE ACTIVOS

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ABSTRACT

Objective: To analyze how the neuromuscular ability to produce force (maximal isotonic and explosive force), by lower limb and back muscles, contributes to explain the balance capacity in healthy elders. The analysis considers the age and gender of the participants.

Material and Method: one hundred and thirteen healthy older participated in the present study were common physical test were instrumentalized (lumbar extension, functional reach test and get up and go test) to measure maximal force and balance. The analysis was developed considering gender and age of the participants.

Results: considering the age and gender of the participants, it could argue that older people show different responses to the same stimuli, providing higher performance by younger men and lower performance by older women. Furthermore, significant correlations were found between variables and the ability to perform functional task and neuromuscular force test between 0.497 and 0.811 for women subgroup and between 0.416 and 0.833 for men subgroup.

Conclusions: There are two negative conditions that affect the performance of functional tasks that analyze the strength or balance of people: Gender, the yield in less women than men, and age where older elderly showed lower performance on the tasks requested.

KEYWORDS: Cluster analysis, strength, balance, assessment, accidental fall

RESUMEN

Objetivo: analizar de qué manera la capacidad neuromuscular de producir fuerza explosiva e isotónica máxima, en los miembros inferiores y en la espalda, contribuyen al equilibrio en mayores diferenciando dicha respuesta a partir de la edad y del género de los sujetos.

Material y método: 113 mayores participaron en este estudio donde se instrumentalizaron pruebas comunes (extensión lumbar, salto con contramovimiento, test del alcance funcional y prueba de levántate y anda) para medir la capacidad neuromuscular de la fuerza y medición del equilibrio. Se distribuyeron los grupos por sexo y a partir de un análisis de subgrupos en función de la edad de los participantes.

Resultados: en función del sexo y de la edad, las personas mayores muestran respuestas diferentes ante los mismos estímulos, ofreciendo un mayor rendimiento los hombres más jóvenes, y un menor rendimiento las mujeres mayores. Además, se han comprobado correlaciones significativas entre variables funcionales y de la capacidad neuromuscular de la fuerza que oscila entre 0.497 y 0.811 en el subgrupo de mujeres y entre 0.416 y 0.833 en el subgrupo de hombres.

Conclusiones: la edad y el género en personas mayores actúan como un condicionante negativo del rendimiento durante la ejecución de tareas funcionales y pruebas para medir la capacidad neuromuscular de la fuerza.

PALABRAS CLAVE: análisis de subgrupos, fuerza, equilibrio, asesoramiento, caída.

1. INTRODUCTION

Beginning around age 60 there is a reduction of skeletal muscle mass (sarcopenia) and progressive atrophy of the muscle fibres, which are associated with muscle weakness (Aagaard, Magnusson, Larsson, Krustrup & Kjaer, 2007; Katsiaras et al., 2005). This loss of strength is the main cause of disability and loss of independence of older people (Kannus P, Sievänen H, Palvanen M, Järvinen T & Parkkari, 2005; Katsiaras et al., 2005). Neuromuscular response reduction has is prevalent in approximately 30% of individuals age 60 and older, increasing exponentially with each additional year of age (Doherty, 2003). Activities of daily living such as sitting, standing up from a chair, climbing stairs, walking smoothly or the ability to counteract unexpected perturbations in body position and postural balance, are negatively affected by reduced neuromuscular response (Kannus et al., 2005; Tinetti, Speechley & Ginter, 1988).

The ability to maintain balance is used as an indicator of overall health in older people (Studenski et al., 2011). Moreover, it has also been used as a predictor for determining the risk of falling (Verghese et al., 2009), dementia (Verghese, Wang, Lipton, Holtzer & Xue, 2007) and the possibility that the person is admitted into an institutionalised care structure (Abella Van Kan et al., 2009).

The deterioration of peripheral sensory systems is another normal process during aging (Daubney & Culham, 1999; Fried Bandeen-Roche, Chaves & Johnson 2000; Hardy, Perera, Roumani, Chandler & Studenski, 2007; Lezzoni, McCarthy, Davis & Siebens, 2000, Tinetti et al., 1988) which adversely affects the ability to perform the activities of daily living (ADLs) (Fried et al., 2000). However, it was found that a rehabilitation program could improve dexterity neurogeriátrica in ADL impairments (Lord, Sherrington & Menz, 2001). Such programs can be integrated as part of a program evaluation, intervention and control developed by a multidisciplinary team to promote physical fitness to practice healthy exercise, sports and therapy in community structures of health promotion (Cuesta -Vargas, 2008).

For simplicity, validity and reliability, the Functional Reach Test (FRT) (Duncan, Weiner, Chandler, & Studenski, 1990) and Time Up and Go test (TUG) (Podsiadlo & Richardson, 1991) were used because of their widespread use for estimating static and dynamic balance. The loss of the ability to generate force favours neuromuscular processes directly and indirectly, namely by influencing loss of balance on the part of the person (Daubney & Culham 1999, Liu et al., 2006). On the other hand, by gender, older people offer different responses and performance during the development of the same activities. (Komi & Bosco 1978; Kuh, Bassey, Butterworth, Hardy & Wadsworth, 2005). Several studies have demonstrated that with advancing age the older person losses the ability to produce neuromuscular explosive force (Izquierdo, Aguado, Gonzalez, Lopez & Hakkinen, 1999, Liu et al., 2006).

2. OBJECTIVES

The main objective of this study is to analyse how neuromuscular ability in older adults produces explosive and maximal isotonic strength in the legs and back, thereby contributing to greater balance (results grouped by age and gender). The secondary objective of this study is to assess the degree of interaction of these capabilities while executing neuromuscular functional tasks.

3. MATERIAL AND METHODS

3.1. Participants: Of the 126 older adults enrolled in a sports centre and two primary care centres, 113 agreed to participate in the present study. Four clusters based on sex and age of the participants where created. All study participants performed a minimum of 30 minutes of moderate physical activity at least 5 times a week, so that they could be classified as physically active. Exclusion criteria for the volunteers included: unable to walk, have a diagnosis of severe dementia (as this would make it difficult from them to understand and follow verbal instructions given), having suffered a heart attack, hip fracture, have implanted a prosthesis knee or hip in the last 6 months and/or have had a stroke.

Following the guidelines of the Helsinki Declaration of 1964 which sets out ethical principles for all human research and has been upgraded in successive assemblies of the World Medical Association (Helsinki Declaration), all participants gave voluntarily expressed informed consent, Furthermore, this study was approved by the ethics committee of the University of Málaga.

3.2 Procedure

The same investigator performed all measurements; an assistant was always present to ensure the safety of the tests. All tests were performed under the same conditions. In addition, the researchers gave all participants the same instructions and directions for the execution of each test. As indicated previously, participants were divided into clusters based on age and gender.

Basic anthropometrics were measured for each participant allowing a description of each sample group. Making a modification to the protocol proposed by Ito (Müller, Strässle & Wirth, 2010) (Figure 1), to measure the neuromuscular capacity of isotonic maximum strength during trunk extension, a digital dynamometer was used (PowerTrack ® JtechMedical). Subjects performed a maximal isotonic trunk extension from a prone position and the peak force was automatically recorded. This test has a reliability (calculated through interclass correlation) between 0.93 to 0.97 (Müller et al., 2010). Each subject performed three repetitions. The highest record was used for analysis of data.

Neuromuscular capacity of explosive strength was measured on a jump platform (Globus Thesys Ergojump 3000 ®) where volunteers performed three maximum countermovement jumps (CMJ) (Bosco, Luhtanen & Komi, 1983). Rest between sets was 10 seconds. This test intends to evaluate the explosive force of the muscles of the lower limbs after conducting a series of stretch –

shortening cicles, using flight time and the maximum height of the jump measures for data analysis (Bosco et al., 1983; Moreland, Finch, Stradford, Balsor & Gill, 1997; Ries, Echternach & Nof, 2009). This test has a reliability (calculated by interclass correlation) of 0.88 (Moreland et al., 1997).

Duncan's test or Functional Reach Test (FRT) (Duncan et al., 1990) aims to measure the semi-static balance of a person (Duncan et al., 1990). Each participant, without changing the position of the feet, with outstretched arms and shoulders flexed 90 degrees, leans forward as much as possible without losing balance (loss of balance is interpreted as the time which the subject must give a step to avoid falling) and return to the starting position. Measurement is the difference between the starting point and the maximum point that the person can reach without falling. Each participant completed three attempts, taking the highest record for analysis. This test has a reliability (calculated through interclass correlation) of 0.81 (Bogduk, Pearcy & Macintosh 1992).

For the dynamic balance test, Time Up and Go (TUG) was performed. For this test, each participant must stand up from a chair whose support is 45 cm high, walk 10 meters ahead at full speed (without running) turn, return to the chair and sit down again. The time taken by each participant to move from sitting to standing was recorded. (stand-up time) and the total test time in seconds. This test has a reliability (calculated through interclass correlation) of 0.985 (Bogduk, Pearcy, Macintosh & 1992).

3.3 Statistical analysis

Descriptive analysis was performed with a separation of the groups based on the gender of the participants. From this first division, there was a cluster analysis by k-means method based on the age distribution of the participants. Prior to any analysis, a study of normal outcomes using the Kolmogorov-Smirnov test was performed. Descriptive analyses were conducted (mean and standard deviation) of the responses within each cluster. Subsequently, differences between the variables of each cluster were calculated using the Student t-test or Wilcoxon depending on whether the distribution of the sample was parametric or nonparametric respectively. Finally, the relationship between the different neuromuscular capacities of force variables recorded in this study were analysed to determine which could act as predictors of FRT and TUG tests in both genders and different age groups. Differences and correlations were considered significant at p values from ≤ 0.05. The computer statistical program SPSS 19.0 version was used to perform data analysis.

4. RESULTS

The sample consisted of 113 active older volunteers; 50 men and 63 women with an age range from 55 to 89 years old(mean age of 71.49 years, with a median of 72.02 years, the first quartile at age 66 years and the third quartile at age 75 years).

Figure 1 and 2 show the division performed in groups based on the age of the participants from the same gender. To perform the division into subgroups based on gender, the distance between the centre of each clusters was taken into account. In the group consisting of 63 women, distribution groups were 27 - 36 participants (GW_Y and GW_O respectively) with a distance between the centres of the groups of 3.5. In the group composed of men, the distribution of 50 participants was 20-30 (GM_Y and GM_O respectively) with a distance between the centres of each cluster equal to 3.2.

The results for the cluster analysis by k-means on a 95% range (55-89 years) showed groups had a mean age of 70.18 years to 71.3 years and median first quartile to third quartile 65 and 75 years. Table 1 shows, divided by cluster, age, anthropometric measurements and the mean values of each variable according to the test performed**.**

Table 1: Descriptive characteristics of the four groups from cluster division.

	WOMEN		MEN	
	GW_Y Mean (SD)	GW_O Mean (SD)	GM_Y Mean (SD)	GM_O Mean (SD)
Age (year)	**63.58** (±4.39)	**76.48** (±4.36)	**65.15** (±4.48)	**75.73** (±3.48)
Weight (kg)	**71.84** (±14.82)	**68.61** (±13.72)	**77.41** (±12.82)	**74.55** (±12.72)
Height (m)	**1.59** (±0.08)	**1.55** (±0.08)	**1.66** (±0.06)	**1.64** (±0.10)
BMI (kg/m^2)	**30.78** (±4.66)	**30.66** (±3.18)	**28.88** (±5.61)	**29.40** (±4.11)
Jump Fly Time (s)	**0.29** (±0.12)	**0.25** (±0.13)	**0.37** (±0.07)	**0.28** (±0.07)
Jump Height (m)	**0.20** (±0.12)	**0.17** (±0.11)	**0.23** (±0.07)	**0.19** (±0.07)
Trunk Extension (N)	**33.72** (±29.13)	**30.99** (±27.36)	**62.54** (±35.82)	**53.89** (±46.97)
FRT (cm)	**26.15** (±7.23)	**23.04** (±6.41)	**20.37** (±6.59)	**19.04** (±5.88)
TUG_Stand (s)	**1.27** (±1.29)	**1.58** (±3.22)	**0.67** (±0.37)	**0.96** (±0.80)
TUG_Total (s)	**15.46** (±4.54)	**21.09** (±4.43)	**15.01** (±3.90)	**18.73** (±4.75)
N	**27**	**36**	**20**	**30**

GW_Y: Group of young women (younger); GW_O: Group of older women (older).; GM_Y: Group of young men (younger). GM_O: Group of older men (older), BMI: body mass index; FRT: Functional Reach Test, TUG: time up and go test.

Table 2 shows the differences between each cluster for all functional and neuromuscular capacity of force variables measured in this study. In this table it can be seen that all differences are significant when comparing the results in terms of age, older youth (men (75.73 ±3.48 years) or women (76.48 ±4.36) and gender from the participants.

Table 2: Mean differences of each variable depending on the cluster analysis.

	$GW_Y – GW_O$	$GW_Y – GM_O$	$GW_Y – GM_O$	$GW_Y – GM_O$	$GW_Y – GM_O$	$GM_Y – GM_O$
Jump Flight Time (s)	**0.04**** (±0..02)	**-0.08**** (±0.03)	**0.01*** (±0.00)	**-0.12**** (±0.07)	**-0.03*** (±0.02)	**0.09**** (±0.03)
Jump Height (m)	**0.03***** (±0.01)	**-0.03**** (±0.01)	**0.01*** (±0.00)	**-0.06***** (±0.02)	**-0.02**** (±0.01)	**0.04**** (±0.02)
Lumbar Extension (N)	**2.73***** (±0.92)	**-28.82***** (±9.83)	**-20.17***** (±9.86)	**-31.55***** (±15.59)	**-22.9***** (±8.23)	**8.65***** (±3.01)
FRT (cm)	**3.11*** (±1.45)	**5.78**** (±2.49)	**7.11***** (±3.07)	**2.67**** (±1.09)	**4.02***** (±2.23)	**1.33***** (±0.68)
TUG_Stand (s)	**-0.31***** (±0.11)	**0.6***** (±0.19)	**0.31***** (±0.14)	**0.91**** (±0.42)	**0.62***** (±0.26)	**-0.29**** (±0.16)
TUG_Total (s)	**-5.63**** (±2.06)	**0.45**** (±0.28)	**-3.27**** (±1.77)	**6.08***** (±2.88)	**2.36**** (±1.38)	**-3.72***** (±1.76)

GW_Y: Group women (younger).
GW_O: Group women (Older).
GM_Y: Group men (younger).
GM_O: Group men (Older).
BMI: Body mass index.
FRT: Functional Reach Test.
TUG: Time up and go.

Signification Level:
* ≤ 0.05
** ≤ 0.01
*** ≤ 0.001

In the group of young women (63.58 ±4.39 years), the variable "flight time" shows only a significant correlation with the other variable taken from the same test (flying height). In the group of older women, the same result occurs with the variable TUG_{Total}; this shows a significant correlation only with the variable Time Up and Go. The remaining correlations between the different variables for the group of women can be seen in Table 3.

Table 3: Correlations of the variables in the group of women according to age.

	Jump Flight Time		Jump Height		Lumbar Extension		FRT		TUG Stand		TUG Total	
	GW_Y	GW_O	GW_Y	GW_O	GW_Y	GW_O	GW_Y	GW_O	GW_Y	GW_O	GW_Y	GW_O
Jump Flight Time (s)	1	1										
Jump Height (m)	**-0.562****	0.068	1	1								
Lumbar Extension (N)	0.553	**0.831****	-0.440	0.243	1	1						
FRT (cm)	0.347	**0.594****	-0.249	0.011	0.097	**0.811****	1	1				
TUG_Stand (s)	0.123	**0.497****	-0.206	0.195	-0.043	0.456	**0.530****	-0.065	1	1		
TUG_Total (s)	-0.003	0.242	-0.320	-0.061	-0.149	-0.418	-0.193	-0.228	0.036	**0.769****	1	1

GW$_J$: Group women (younger).
GW$_O$: Group women (Older).
BMI: Body mass index.
FRT: Functional Reach Test.
TUG: Time up and go.

Signification Level:
* ≤ 0.05
** ≤ 0.01
*** ≤ 0.001

On the other hand, Table 4 shows the correlations obtained in the group of men. To promote an understanding of the results and, therefore, better interpretation thereof, both tables are presented in pairs (including both clusters analysed). In the analysis of the correlations between the different variables, it is possible to observe how the variable TUG_{Stand} is correlated significantly with the variable TUG_{Total} extracted from the same test, but only in the group of older men. Additionally, FRT is significantly correlated with height and flight time, for the group of older men. On the other hand, in the group of young men, there are significant correlations between the flight time and lumbar extension. Also within the group of young men there is a significant correlation between lumbar extension and flight time and transition time sitting to standing. The remaining correlations between the different variables for the group of men are presented in Table 4.

Table 4: Correlations of the variables in the group of men according to age.

	Jump Flight Time		**Jump Height**		**Lumbar Extension**		**FRT**		**TUG Stand**		**TUG Total**	
	GM_Y	**GM_O**	**GM_Y**	**GM_O**	**GM_Y**	**GM_O**	**GM_Y**	**GM_O**	**GM_Y**	**GM_O**	**GM_Y**	**GM_O**
Jump Fly Flight (s)	1	1										
Jump Height (m)	0.016	0.303	1	1								
Lumbar Extension (N)	**0.576****	-0.134	-0.327	-0.165	1	1						
FRT (cm)	0.331	**0.499****	-0.054	**0.416***	0.347	-0.307	1	1				
TUG_Stand (s)	0.034	0.270	-0.243	-0.073	**0.833****	0.146	-0.133	-0.213	1	1		
TUG_Total (s)	-0.386	-0.313	-0.296	-0.188	0.183	0.365	-0.092	-0.280	0.260	**0.647****	1	1

GM_J: Group men (younger).
GM_O: Group men (Older).
BMI: Body mass index.
FRT: Functional Reach Test.
TUG: Time up and go.

Signification Level:
* ≤ 0.05
** ≤ 0.01
*** ≤ 0.001

5. DISCUSSION

The aim of this study was to analyse how neuromuscular ability to produce maximum explosive and isotonic strength, in the legs and back, contribute to balance in older respondents (groups divided by age and gender of subjects). The analysis of all the variables measured in this study indicate that mean correlations and interactions between the analysed variables behave differently depending on the age and gender of participants; there is lower performance by older people (women and men) compared to the youth group. Moreover, there is less difference between genders, although the group of men showed a slightly higher performance on each test compared to the women. Given these results, one could argue that the objective of the present study was achieved and the hypothesis confirmed.

Analysing the data reveals how the subject group can be divided into four clusters (based on age and gender of participants). If the results are analysed from cluster subdivision according to the age of participants, there is a lower performance by older subjects, regardless of gender (Table 2).

The use of the TUG test to measure functional abilities in older adults is very common (Schoene et al., 2013) and it is particularly used to measure semi-static and dynamic balance of the people (Schoene et al., 2013; Takahashi et al., 2006). Analysing the results observed in this study, indicate how the components of the two older groups (GW_O and GM_O) offer a lower yield than the young group (GW_Y and GM_J) (Table 2).

Specifically, in the two variables (TUG_Stand and TUG Total), TUG tests show an average time of 1.27 seconds (±1.29) and 15.46 seconds (± 4.54) in the GW_Y group compared to 1.58 seconds (± 3.22) and 21.09 seconds (±4.43) in the GW_O group to TUG_{Stand} and TUG_{Total} performance respectively. The same trend is observed in the group of men, where the times are 0.67 seconds (± 0.37) and 15.01 seconds (± 3.90) in the GM_Y group versus 0.96 seconds (±

0.80) and 18.73 seconds (± 4.75) in the GM_O group (Table 1). These results are consistent with two recently published systematic reviews stating that physical performance is negatively influenced by the age and structural morphological changes occuring in the later years of life (McPhee et al., 2013; Vidoni et al., 2012).

In addition, Table 1 and 2 highlight the lower performance on tests used to measure the functional capabilities of force when comparing older (GW_O and GM_Y) and youth (GW_Y and GM_Y) groups. There is high evidence that lower strength, poor balance, increased fear of falling and less skill to perform activities of daily life, are associated with an increased risk of falling (Janssen, Samson, Meeuwsen, & Werhaar Duursma, 2004; Podsiadlo & Richardson, 1991; Schoene et al., 2013; Takahashi et al., 2006; Tinetti & Kumar, 2010).

On the other hand, holding age constant and considering gender, men had better performance in all tests than did women. Men had more flight time during the jump (0.08 seconds and 0.03 seconds), greater height in the same test (0.03 meters and 0.02 meters), greater strength in the trunk extension (28.82 N and 22.90 N), a faster in the sitting-standing transition (0.6 seconds and 0.62 seconds) and increased speed in performing the full TUG test (0.45 seconds and 2.36 seconds) when comparing men and women, young and old respectively. The FRT is the only test that women had a better performance than men, with differences ranging from 5.78 cm (when comparing the young groups) and 4.00 cm (when comparing older groups) (Table 2). These results are in line with a meta-analysis published where, after analysing different physical tests for men and women of comparable age, the authors indicated that better performance was observed in the case of men (Courtright, McCormick, Postlethwaite, Reeves & Mount, 2013). The authors conclude by proposing strategies to reduce gender differences, such as specific training (Courtright et al., 2013).

Observing the correlations between the two age groups (in the group of women) only the youngest group shows a significant correlation between jump height and flight time, although the correlation is negative. Moreover, the group of men (regardless of age cluster) achieved a significant correlation between these two variables.

To maintain posture, both standing as sitting, paravertebral musculature plays an important role (Bogduk et al., 1992). Thus, performing a test on maximum isometric forces participants to attempt to quantify this variable (Figure 1). In the results, the lumbar extension variable could predict the outcome of functional reach test in the oldest women's group, showing a correlation index of 0.811; for the rest of the groups the correlations were significant. An index of correlation in the same group of women higher than in the FRT (r = 0.831 against 0.811) where found. Also, significant differences were found between flight time and lumbar extension in GM_Y (r = 0.576).

It has been shown that the TUG is a test with high validity and reliability in identifying shortcomings in older peoples balance (Podsiadlo & Richardson, 1991). If the correlation between the two variables of the TUG (standing and total) within each cluster is analysed, TUG_{Stand} in the women's group shows significant results when correlated with flight time (r= 0.497), FRT (r=0.530) and TUG_{Total} (r=0.769). However, these correlations do not hover over the same group; the first two are associated with the smallest group (GW_Y) and the correlation between the variables of the TUG is associated with the larger group (GW_O). This point is the only significant variable between TUG_{Total} and the other variables, which means that any variable could be a predictor as the dynamic equilibrium in the group of women, except one in which a woman changes her sitting position to standing.

On the other hand, in the male group, it seems that there is a high correlation between the variables and lumbar extension TUG_{Stand} in GM_Y, and moderate correlation with TUG_{Total} in GM_O. It seems that those participants who achieved a higher registration isotonic strength back extension, have less skill at the transfer from sitting to standing. However, those who were able to perform more quickly, seem to have a greater dynamic balance confirmed by the lower time involved in completing the TUG_{Total} performance.

There is a modified of the TUG (MTUG), which has demonstrated validity and reliability in identifying different functional levels in older adults (Giné-Garriga, Guerra, Marí-Dell'Olmo, Martin & Unnithan, 2009). The results of this study could deepen the relationship between the ability to go from sitting to standing and dynamic balance assessment of the person through performing TUG fully as modifications and thereby considering other subjective aspects of the elderly.

Inclusion of both types of tests to measure functional neuromuscular capacity of force, such as those used in this study, let a dual study focused on analytical activities subsequently integrated in functional activities develop. In the future this could help in planning strategies for older intervention to minimise the effects of age and focus on the ways in which therapeutic activity is analytically being integrating it into everyday activities and gestures.

Among the strengths of this study, one might note that this is the first trial that studies the behaviour of basic physical skills in analytical and global functioning of older adults extracting the results from the creation of clusters according to gender and age of the participants. However, the age variable was developed not through the chronological data of the volunteer's life but the answers given in the different tests. The main weakness that could be attributed to this study is the small sample size, which thereby limits the ability to reinforce the results, and allowing, in turn, a deepening of the causes of the observed responses in the different clusters studied.

6. CONCLUSIÓN

The main conclusion that could be reached in this study is that depending on age and gender, older people show different responses to the same stimuli. Observing how differences in some functional capabilities are greater in terms of age and others in terms of gender of the participants. This could be a stimulus to identify those variables that are most depleted in the elderly by selection criteria based on the gender and age of participants. These findings, together with other studies, could help plan future intervention strategies in this population group helping to minimise the negative effects on the physical conditions in later life.

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