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Trabajo Original

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Daily physical activity impact in old women bone density and grip strength

Impacto de la actividad física diaria en la densidad ósea y la prensión manual de mujeres mayores

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Abstract

Introduction: Being physically active is related to a better physical functioning in older people, but daily physical activity impact in specific outcomes such as osteoporosis or sarcopenia is still not clear.

Objective: The main objective of this study is to determine the impact of daily physical activity (DPA) in the bone mineral density and grip strength of old women. The secondary objective is to distinguish between weekday and weekend day scores.

Methods: Forty-two women between 65 and 79 years participated. DPA was monitored with the accelerometer ActiGraph GT3X (Pensacola, FL, USA) placed on the dominant hand wrist. Bone mineral density was measured with dual-energy X-ray absorptiometry (AccuDEXA, SHICK, USA) in the central finger of the dominant hand; and grip strength, with a Takei dynamometer (TKK 5001).

Results: There were statistical differences between moderate and vigorous DPA in age, T-score, physical activity counts/min and min/day, and grip strength. Weekend minutes correlated significantly with all the variables. Age was a confounding factor.

Conclusions: Higher DPA intensities accomplished by our old women sample preserve T-score (bone standard deviations respect to young, healthy people) and grip strength in a normal range. These results are strongly influenced by weekend scores. Age should be controlled by shorter ranks.

Key words:

Accelerometry. Wrist. Motor activity. Aged women. Bones. Hand strength.

Resumen

Introducción: mantenerse físicamente activo se relaciona con la funcionalidad en las personas mayores, pero el impacto de la actividad física diaria en alteraciones como la osteoporosis o la sarcopenia no está claro.

Objetivo: el principal objetivo es determinar el impacto de la actividad física diaria (AFD) en la densidad ósea y la fuerza de prensión manual de mujeres mayores. El objetivo secundario es distinguir entre los datos de los días de diario y los fines de semana.

Métodos: participaron 42 mujeres de entre 65 y 79 años. La AFD se monitorizó con el acelerómetro ActiGraph GT3X (Pensacola, FL, USA) situado en la muñeca de la mano dominante. La densidad de masa ósea se midió mediante absorciometría dual de rayos X (AccuDEXA, SHICK, USA) en el dedo central de la mano dominante; y la fuerza de prensión manual, con el dinamómetro Takei (TKK 5001).

Resultados: se encontraron diferencias significativas entre los grupos AFD de intensidad moderada y vigorosa en la edad, el T-score, los counts/min y los min/día de AFD, y la fuerza de prensión manual. Los minutos de AFD realizados los fines de semana correlacionaron significativamente con todas las variables. La edad es un factor de confusión.

Conclusiones: una mayor intensidad de AFD alcanzada por nuestra muestra de mujeres mayores preserva los valores de T-score (desviaciones estándar óseas respecto a personas jóvenes y sanas) y fuerza manual en un rango normal. Estos resultados están fuertemente influenciados por los valores alcanzados los fines de semana. La edad debería ser controlada.

Palabras clave:

Acelerometría. Muñeca. Actividad motora. Mujeres mayores. Huesos. Fuerza de la mano.

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ABBREVIATIONS

Counts: total intensity registered by the accelerometer in counts/min.

WCounts: weekday intensity registered by the accelerometer in counts/min.

WndCounts: weekend day intensity registered by the accelerometer in counts/min.

PA: minutes of physical activity registered by the accelerometer.

WPA: weekday minutes of physical activity registered by the accelerometer.

WndPA: weekend day minutes of physical activity registered by the accelerometer.

DXA: dual-energy X-ray absorptiometry.

T-score: bone standard deviations respect to young, healthy people.

INTRODUCTION

Spain is one of the oldest countries of the European Union with a major proportion of women among the old people group. The rapid aging of this population has influenced government spending and health care systems in the devising strategies for the prevention of common multiple chronic health conditions, disability and mental health issues (1). Osteoporosis and sarcopenia are important public health problems with devastating consequences for functional impairment, health and quality of life in older people. Structured and planned exercise has become an effective strategy for preventing or even controlling the decline in these physiological structures (2,3).

On the other hand, activities in which older women tend to involve more frequently are leisurely walking, housework, or gardening. These activities are not considered exercise but physical activity, treated as bodily movement produced by skeletal muscles that result in energy expenditure (4), and are usually developed in a light-to-moderate intensity (5). There is cross-sectional and empirical evidence that being physically active is related to a better physical functioning in old people (6).

Older physical activity and sedentary time are frequently assessed using self-report questionnaires (7,8). However, some caution is required in the interpretation of these measures since these tools are potentially influenced by social and mental factors that difficult the physical activity assessment reliability, furthermore when it is of a light-to-moderate intensity. That is the reason why accelerometers have recently been used to objectively describe activity patterns in old people with acceptable reproducibility (5,9).

With respect to daily physical activity impact in specific outcomes such as osteoporosis or sarcopenia in older people, previous investigations have highlighted an association between habitual physical activity and the lower extremity muscle power (10-12) and handgrip strength (11,13). In contrast, the relationship between dual-energy X-ray absorptiometry and daily physical activity accelerometry brings clear inverse correlation between intensity and adiposity (12,14) but associations regarding bone density markers are still not clear. In these studies daily physical activity assessment is usually accomplished placing the accelerometer on the hip, however, to our knowledge, there is not accelerometry data registry when it is placed in another body region, closer to strength and bone density measures. Moreover week days and weekend day data are rarely registered separately.

In this context, the aim of this study was 1) to report the prevalence of a non-exercisers old women sample attaining physical activity guidelines objectively assessed using accelerometers placed on the wrist, 2) to determine the impact of the daily physical activity intensity and quantity achieved on bone mineral density and grip strength, 3) to distinguish weekday and weekend day data influence regarding the results.

METHODS

SAMPLE

The study was performed with 42 women from 65 to 79 years. They were recruited from a local medical center and were screened to ensure that they fulfilled the selection criteria: women aged between 65 and 80 years, having no neurological, cardiovascular, metabolic, inflammatory or musculoskeletal conditions, and not participating in a supervised systematic exercise program. Each participant signed a written consent after being informed of the study aim and procedure. Height and weight were measured using standardized equipment (SECA 780 medical weighing machine). All the subjects were measured barefoot and with light clothing by the same researcher. Body mass index (BMI) was calculated as follows: BMI=kg/m^2. Subjects' characteristics are presented in table I.

MEASUREMENTS

Daily physical activity

Daily physical activity (DPA) was monitored with the accelerometer ActiGraph GT3X (Pensacola, FL, USA). It provided activity counts and minutes in three axes of movement, which is recom-

Table I. Descriptive statistics for the sample

Descriptive variables	Sample				
	n	Min	Max	Mean	SD
Age (years)	42	65	79	70.71	4.5
Weight (kg)	42	41.5	112	71.94	13.5
Height (cm)	42	139	168	150.57	5.5
BMI (kg/m^2)	42	19.2	41.32	31.75	5.1

BMI: body mass index.

mended to estimate the physical activity level of older adults (15). A 10-second epoch was used. The trunk location has become the most common placement for the monitors, whereas little evidence suggests that one position is better than another (5) and pragmatic guidelines such as comfort or ease of use have taken precedence. Having into account the bone mineral density and the strength measures, the wrist was chosen to attach the accelerometer. Subjects could only remove the device for sleeping or having a shower. They wore the accelerometer during 7 days. For the data analysis two weekend days and two randomly weekdays were analyzed. The average of the DPA intensity for the four days was represented by the variable Counts (counts/min), for the two weekdays by WCounts (counts/min), and for the two weekend days by WndCounts (counts/min). In the same way, the average of the minutes of physical activity achieved by the sample in the four days was represented by the variable PA (min/day), for the two weekdays by WPA (min/day), and for the two weekend days by WndPA (min/day). To determine moderate-to- vigorous physical activity cut-point (MVPA) we followed the most common criteria used in studies where exercise programs were not included when monitoring physical activity with accelerometers: 760 counts/minute (10,16-18). Sedentary women (< 500 counts/min) were excluded (7). Thus, two groups were created attending to the daily physical activity intensity: the moderate physical activity group (MPA; 500-760 counts/min) and the vigorous physical activity group (VPA; > 760 counts/min).

Bone mineral density

Bone mineral density was measured with dual-energy X-ray absorptiometry (AccuDEXA, SHICK, USA; DXA). The central finger of the dominant hand was chosen for the assessment accepting that the DXA of the hand can be effectively used for screening osteoporosis (19). This test was assessed in the Radiology Unity of the Northeast Local Hospital (Caravaca de la Cruz, Murcia, Spain). T-score was chosen as the reference value to determine the bone quality in order to compare bone density with a different DXA assessment studies. The diagnosis of normal, low bone mass, osteoporosis and severe osteoporosis was based on the World Health Organization (WHO) diagnosis classification (20), valid for measurement at the spine, hip or forearm: Normal = T-score > -1, Low Bone Mass (osteopenia) = -1 < T-score > -2,5, Osteoporosis or severe osteoporosis (+fractures) = T-score ≤ -2,5.

Hand-grip strength

Maximal hand-grip strength was measured using a Takei dynamometer (TKK 5001). Participants were in a standing position with the testing shoulder adducted and neutrally rotated, elbow flexed at 90°, forearm in midprone and wrist in a neutral position. Women were instructed to squeeze the dynamometer using maximal effort. The best result of three trials was recorded for each hand. And the average of both hands grip strength was obtained for data analysis. Two sets of the test were assessed for familiarization. This procedure has been accomplished elsewhere (21,22).

Baseline characteristics of the sample regarding DPA, bone mineral density and hand-grip strength variables are presented in table II.

POWER CALCULATION

Accelerometry MVPA was used as the reference variable to estimate our study sample size and power. Based on previous research (17,23) we consider a standard deviation of 8 min/day and an estimated error of 5 min/day. Our sample size (n = 42) for a confidence interval of 95% provide a study power of 81%.

STATISTICAL ANALYSIS

Data was analyzed using the SPSS computer software program (version 21.0, SPSS Inc, Chicago, Ill.). Cases providing a minimum of 10 h of registered wear time for at least five days were included in the analyses. Bouts of more than 100 min of continuous zero count data were considered non wear time and excluded. Since all outcome variables were normally distributed (Kolmogorov-Smirnov test), descriptive statistics of the sample were computed and presented as range, mean and standard deviation (SD). According to the sample distribution, SPA and MVPA groups were separated. Following MVPA cut-point Student's t-test for independent

Table II. Bone mineral density, DPA and hand-grip strength scores of the sample at baseline

Descriptive variables	Sample				
	n	Min	Max	Mean	SD
T-score	42	-3.1	1	-0.79	1.1
Counts (counts/min)	42	283.83	1269.31	767.77	271.7
WCounts (counts/min)	42	246.24	1405.54	753.57	266.9
WndCounts (counts/min)	42	321.44	1409.3	781.97	302.6
PA (min/day)	42	309.5	1125.25	733.53	147.9
WPA (min/day)	42	298	1168.5	714.98	159.1
WndPA (min/day)	42	321	1082	752.08	161.9
Grip strength (kg)	42	18	23.4	21.22	1.7

DPA: daily physical activity. T-score: bone standard deviations respect to young, healthy people. Counts: total intensity registered by the accelerometer. WCounts: weekday intensity registered by the accelerometer. WndCounts: weekend day intensity registered by the accelerometer. PA: minutes registered by the accelerometer. WPA: weekday minutes registered by the accelerometer. WndPA: weekend day minutes registered by the accelerometer.

samples was used to determine differences between moderate (MPA) and vigorous (VPA) physical activity groups. A multi-variate analysis was arranged to determine the interaction effect in the most relevant variables. The correlation coefficient (r of Pearson) and the coefficient of variation (r^2) were used to determine the strength and direction of the relationship between two variables in MVPA group. The level of significance was set to $p \leq 0.05$, with an interval confidence of 95% ($IC_{95\%}$).

RESULTS

After accelerometer data analysis, there were 6 sedentary women and 36 women in the MVPA group. Sedentary women were excluded.

In the MVPA group, the 45.24% developed their daily physical activity in a moderate intensity (MPA; 500-760 counts/day), and the 35.71% achieved and overtake the MVPA cut-point (VPA; 761-1,270 counts/day). There were statistical differences between MPA and VPA in age, T-score Counts (counts/min), PA (min/day), and grip strength (Table II). Distinguishing between week days and weekend days, there were also statistical differences between MPA and VPA in WCounts (counts/min), WndCounts (counts/min), WPA (min/day) and WndPA (min/day) (Table III).

There were significant correlations between moderate-to-vigorous counts/min and age (r = -0.43; p = 0.009), T-score (r = 0.35; p = 0.039), and grip strength (r = 0.42; p = 0.01) in the MVPA group. The coefficient of determination ($r^2 = 0.18$; 0.12; 0.18 respectively) pointed out that the impact of physical activity intensity on T-score was of 12% and on grip strength was of 18% (Figs. 1 and 2). In the same way, the influence of age on physical activity intensity was of 18% (Fig. 3).

Moreover, in the MVPA group WndPA (min/day) correlated with age (r = -0.46, p = 0.005), T-score (r = 0.37, p = 0.025), and grip strength (r = 0.46, p = 0.005). The coefficient of determination ($r^2 = 0.21$; 0.14; 0.21) showed the minutes of physical activity developed at a higher intensity during weekend days has an impact on T-score of 14% and on grip strength of 21%. But age was still influencing these results (21%).

DISCUSSION

In the present study, most of the old women sampled achieved a moderate-to-high intensity in their daily physical activity. The ones that raised higher intensities preserved better bone quality and grip strength. Women that achieved higher intensities also accomplished more minutes of daily physical activity, and minutes accumulated during weekend days at higher intensities has more to do with bone and strength results. Otherwise, age has to be considered as an interaction factor regarding accelerometry measures.

According to our results, the 85.71% of our old women sample were active in their daily living. But the scores registered by accelerometry are higher than the ones in the studies using the same cut-point criteria (10,16,18) when comparing the average of counts/min and the minutes/day to a moderate-to-high intensity. Having into account that participants had similar ages, were not enrolled in an exercise program, and accelerometry data was recorded for 4 days in all cases, we assume that differences could be related to the accelerometer placement. Wearing the monitor on the wrist involves obtaining higher scores than on the hip regarding counts and minutes of daily MVPA.

Despite that, our results point out that the sample achieved an average of 106.63 min/week of MVPA, with similar results for weekdays and weekend days. This is not enough to achieve the American College of Sports Medicine and the U.S. Department of Health and Human Services (24) guidelines for preserving health in adults and older adults. Therefore, daily physical activity is not enough to achieve health conditions in our old women sample. However, our VPA group accumulated more minutes of physical activity either in the weekdays or in the weekend days than MPA group. Moreover, the high regression coefficient between moderate-to-vigorous counts/min and PA (min/day) imply a positive interaction of time and counts. In other words, movements in a higher intensity accumulated more quickly were accomplished during a longer period of time. This is in accordance with Camhi (25) and Scott (12) accelerometry regression data measured at the level of the hip in old women. Consequently, despite our old women sample don't achieve the healthy guidelines, they are a highly active group. Encouraging them to increase the minutes achieved in their daily living could help to accumulate more vigorous intensity minutes, favoring the healthy guidelines approach.

In this regard, the age is determining the daily physical activity intensity achieved by our old women sample. VPA group was statistically younger than MPA group, and the impact of age in the accomplishment of higher levels of physical activity intensity by younger women was of 18%. It is common to find differences between younger and older groups of age with respect to either intensity or quantity of daily physical activity results (26-28), independently of the cut-point used. Other studies also reveal negative correlations between age and minutes of physical activity (12). Age is also a factor that should be taken into account when measuring daily physical activity with accelerometry. Shorter age ratios of samples could clarify these results.

Respecting DXA measurement, women that achieved a vigorous intensity in their daily physical activity preserved their bone mineral density in a normal level according to WHO diagnosis classification (20), while the moderate intensity implies a bone density of osteopenia. In this line, higher physical activity intensity had an impact on bone density of 12%. Results in the literature are not clear, despite accelerometry protocol have little variations and DXA is usually scanned at the hip or the spine. Correlation analysis did not show significant relationships between accelerometry variables and BMD in Ashe (10), Gerdhem (29) and Gabá (30) old women samples, whereas Gouveia (31) found a low but positive association between habitual physical activity and total body and femoral neck BMD in old women. In the same line, Chasting (32) shows low but positive relations between low intensity physical activity and femoral neck BMD, Johansson (33) also found similar

Table III. Differences between MPA and VPA groups

Variable	Group	n	Mean ± SD	t	df	p	$IC_{95\%}$ (M_{MPA}-M_{VPA})
Age (years)	MPA	19	72.42 ± 4.1	4.2	32	0.0002	2.67; 7.77
	VPA	15	67.2 ± 2.8				
Weight (kg)	MPA	19	72.04 ± 14.2	0.7	32	0.940	-9.6; 10.34
	VPA	15	71.67 ± 14.1				
Height (cm)	MPA	19	150.47 ± 4.1	-0.5	32	0.582	-4.94; 2.82
	VPA	15	151.53 ± 6.9				
BMI (kg/m²)	MPA	19	31.88 ± 6	0.4	32	0.721	-3.03; 4.34
	VPA	15	31.22 ± 4				
T-score	MPA	19	-1.25 ± 0.9	-3.2	32	0.003	-1.74; -0.38
	VPA	15	-0.19 ± 0.9				
Counts (counts/min)	MPA	19	719.6 ± 196.4	-3.2	32	0.001	-395.28; -112.41
	VPA	15	973.45 ± 206.8				
WCounts (counts/min)	MPA	19	729.51 ± 199.5	-2.7	32	0.009	-344.37; -51.98
	VPA	15	927.69 ± 217.9				
WndCounts (counts/min)	MPA	19	709.69 ± 223.3	-3.8	32	0.001	-474.05; -144.99
	VPA	15	1019.21 ± 246.7				
PA (min/day)	MPA	19	679.47 ± 74.7	-7.2	32	$4*10^{-8}$	-218.48; -121.84
	VPA	15	849.63 ± 59.9				
WPA (min/day)	MPA	19	671.66 ± 88.5	-4.7	32	$4*10^{-6}$	-216.82; -86.06
	VPA	15	823.1 ± 98.4				
WndPA (min/day)	MPA	19	687.29 ± 96.7	-5.7	32	$2*10^{-7}$	-255.46; -122.29
	VPA	15	876.17 ± 91.9				
Grip strength (kg)	MPA	19	20.6 ± 1.6	-4.1	32	0.0002	-3.01; -1.03
	VPA	15	22.6 ± 1.1				

MPA: moderate physical activity group. VPA: vigorous physical activity group. BMI: body mass index. T-score: bone standard deviations respect to young healthy people. Counts: total intensity registered by the accelerometer. WCounts: weekday intensity registered by the accelerometer. WndCounts: weekend day intensity registered by the accelerometer. PA: minutes registered by the accelerometer. WPA: weekday minutes registered by the accelerometer. WndPA: weekend day minutes registered by the accelerometer.

Statistical analyses: t: the computed test statistics assuming equal variances. df: degrees of freedom (df: n_1+n_2-2) assuming equal variances. p: the level of significance assuming equal variances. $IC_{95\%}$ (M_{MPA}-M_{VPA}): the interval confidence of 95% for the difference assuming equal variances.

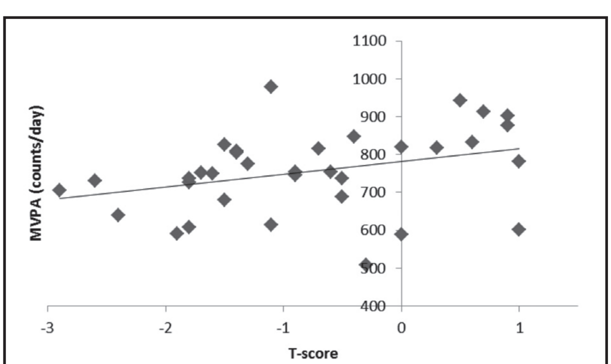

Figure 1.

Moderate-to-vigorous counts/min and T-score linear regression in moderate-to-vigorous physical activity group.

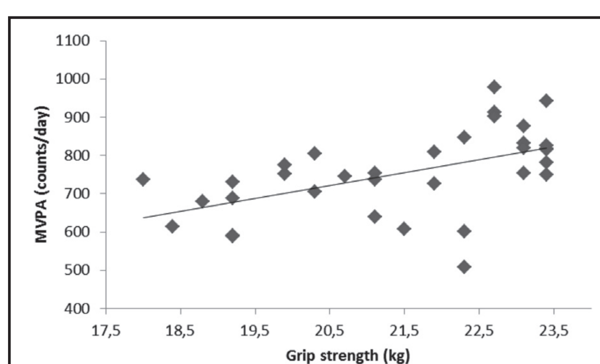

Figure 2.

Moderate-to-vigorous counts/min and Grip strength linear regression in moderate-to-vigorous physical activity group.

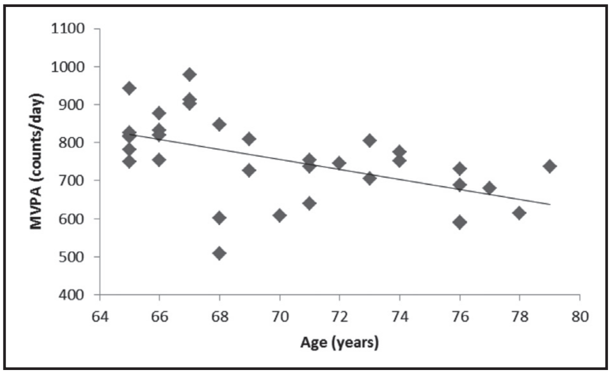

Figure 3.

Moderate-to-vigorous counts/min and age linear regression in moderate-to-vigorous physical activity group.

results when associating MVPA and femoral neck and tibia BMD, and Langsetmo (34) found that higher levels of physical activity enhance total hip and lumbar spine BMD. In our old women sample, the combination of accelerometry placed on the wrist and X-ray absorptiometry of the hand brings similar results than other less accessible methods. This methodology should be replicated in other studies with higher sample size, helping to clarify if daily physical activity has something to do with bone density.

According to normative data for elderly women (35) normal scores for grip strength are classified between 24.2 and 22.8 kg for women in the range of 60-79 years. Our VPA group scores are in the limit of normality while the MPA group is under the normality, being both groups statistically different regarding grip strength. According to the results described above VPA also accomplished more minutes of daily physical activity. Thus, in the line of Scott (12) results, we believe that not only intensity but quantity of daily physical activity is determining strength scores. Moreover, moderate-to-vigorous counts/min was significantly related to grip strength, having an impact of 18% in our old women sample. It means that if the activity performed is in a moderate-to-high intensity, muscle contraction is preserved in a normal range. This result is parallel to other studies correlations between daily intensity accelerometry and muscle power and strength in the lower extremity (10-12), and handgrip strength (11,13) in elder. It appears that accelerometer location has not meaningful implications regarding strength outcomes.

We want to point out that in our old women sample, weekend physical activity minutes were significantly correlated with T-score and grip strength. As it was indicated before, higher WndPA was achieved by VPA group, exceeding the 800 min/day. Therefore and according to Garatachea (5), in the weekend days higher levels of physical activity intensity and quantity are achieved, and these has more to do with bone and strength results than the week day scores.

Finally, and as it has been pointed out before, the population of Spain is undergoing rapid reorganization, with a large increase in the number of seniors and reductions in the number of young citizens. This old population disproportionately requires more care, culminating from common multiple chronic health conditions, disability and mental health issues (1). It creates challenges for the allocation of government spending and health care systems, generating the necessity to identify and implement effective strategies to ensure the independence and decrease the impact of disease and disability in old age. According to our results, recommendations based on the relevance to achieve higher intensity levels of daily physical activity every day of the week (not only in weekend days) should be included in the medical system guidance to older.

In conclusion, minutes per week of MVPA accomplished by our sample were not enough to achieve healthy guidelines, but higher intensities in their daily physical activity preserve bone and grip strength in a normal range, and weekend days has more to do with bone and strength results than the week day scores. Medical instructions emphasizing the relevancy of the daily physical activity intensity on active ageing could help to preserve the independence of older, reducing illness conditions and medical cost.

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