DAILY PHYSICAL ACTIVITY AND BONE MINERAL DENSITY IN OLDER WOMEN

ATIVIDADE FÍSICA NA VIDA DIÁRIA E DENSIDADE MINERAL ÓSSEA EM MULHERES IDOSAS

ACTIVIDAD FÍSICA EN LA VIDA DIARIA Y DENSIDAD MINERAL ÓSEA EN MUJERES ANCIANAS

ARTIGO ORIGINAL

Maria Carrasco[1]
(Physical Education Teacher)
Ignacio Martínez[2]
(Sport Medicine Doctor)
María Dolores Navarro[3] (Nurse)

1. Department of Physical Activity and Sports Sciences. Faculty of Sport. UCAM. Universidad Católica San Antonio. Campus de los Jerónimos, Guadalupe, Murcia (Spain).
2. University of Murcia. Campus Espinardo, Murcia (Spain).
3. Nursing home Noguera del Arco. Calle Pintor Pareja, Albacete, Spain.

Correspondence:
Department of Physical Activity and Sports Sciences. Faculty of Sport. Catholic University of San Antonio. Campus de los Jerónimos nº135. 30107. Guadalupe, Murcia (Spain).
mcarrasco@ucam.edu

ABSTRACT

Introduction: the fast aging of contemporary population has influenced the development of strategies for the prevention of osteoporosis among elderly people. Daily physical activity is believed to increase bone mass and possibly help to prevent bone loss in old people. However, the minimal amount or intensity of physical activity to induce higher bone mass in old women remains insufficiently studied. Objective: to examine the association between the amount and the intensity of daily physical activity and bone mineral density (BMD) in the hand, in elderly women. Methods: the study subjects were 24 women (age 66-78 years), who carried an accelerometer-based body movement recorder in their wrist for 7 days for individual quantification of their daily physical activity. To measure BMD, the right hand with dual-energy X-ray absorptiometry (DXA) was developed. Results: a significant relationship between weekday counts and T-score (r=0.99), and horizontal weekday counts and T-score (r=0.99), was found in normal bone and osteoporotic bone group respectively. The relation between T-score and the minutes of physical activity was not clear in both groups. Conclusion: the higher quality of the bone in the hand is associated with the higher weekday physical activity intensity in this elderly women sample. The combination of accelerometry and X-ray absorptiometry at the hand level brings similar results than other less accessible methods.

Keywords: accelerometry, aged, bone density.

RESUMO

Introdução: o rápido envelhecimento da população contemporânea tem influenciado no desenvolvimento de estratégias para a prevenção da osteoporose em idosos. A atividade física diária é vista como uma possível estratégia para aumentar a massa óssea e ajudar a prevenir a perda óssea em pessoas idosas. No entanto, é essencial saber a quantidade mínima ou a intensidade adequada de atividade física que produza o aumento da massa óssea em mulheres idosas. Objetivo: analisar, durante uma semana, a relação entre a quantidade e a intensidade da atividade física diária com a densidade mineral óssea (DMO) da mão, por meio da quantificação de atividade física diária em idosas. Métodos: a amostra do estudo foi composta por 24 mulheres (idade 66-78 anos), que realizaram atividade física, durante 7 dias, com um gravador da aceleração dos movimentos do corpo em seu pulso, para uma quantificação individual da atividade física. Para medir a densidade mineral óssea da mão direita foi utilizada a técnica de dupla absorção de raios-X (DXA). Resultados: uma relação significativa entre a prática semanal e o T-score (r = 0,99) e a prática semanal horizontal e o T-score (r = 0,99) foi encontrada no osso normal e no grupo ósseo com osteoporose, respectivamente. A relação entre T-score e a quantidade de atividade física não era clara em ambos os grupos. Conclusão: na amostra analisada, foi encontrada uma associação positiva entre a maior qualidade do osso da mão e a intensidade mais elevada de atividade física. A combinação de absorciometria acelerometria e de raios-X na mão obteve resultados semelhantes ao encontrados com outros métodos menos acessíveis.

Palavras-chave: *acelerometria, idoso, densidade óssea.*

RESUMEN

Introducción: el rápido envejecimiento de la población contemporánea ha influenciado el desarrollo de estrategias para la prevención de la osteoporosis en ancianos. La actividad física diaria es vista como una posible estrategia para aumentar la masa ósea y ayudar a prevenir la pérdida ósea en personas ancianas. Sin embargo, es esencial saber la cantidad mínima o la intensidad de actividad física que produzca el aumento de la masa ósea en mujeres ancianas. Objetivos: analizar durante una semana la relación entre la cantidad y la intensidad de la actividad física diaria con densidad mineral ósea (DMO) de la mano, a través de la cuantificación de actividad física diaria en ancianas. Métodos: la muestra del estudio fue compuesta por 24 mujeres (edad 66-78 años), que realizaron actividad física durante 7 días con un acelerómetro de pulso basado en grabador de movimiento corporal para una cuantificación individual de la actividad física. Para medir la densidad mineral ósea de la mano derecha fue utilizada la técnica de doble absorción de rayos X (DXA). Resultados: fue encontrada una relación significativa entre la práctica semanal y el T-score (r = 0,99) y counts de semana horizontales y T-score (r = 0,99), fue encontrada normalidad en el hueso normal y grupo óseo con osteoporosis, respectivamente. La relación entre T-score y la cantidad de actividad física diaria no era clara en ambos grupos. Conclusión: en la muestra realizada, fue encontrada una asociación *positiva entre la mejor calidad del hueso de la mano y la intensidad más elevada de actividad física. La combinación de absorciometría, acelerometría de rayos X en la mano, obtuvo resultados semejantes a los encontrados en este estudio y mejores que otros métodos menos accesibles.*

Palabras clave: *acelerometría, anciano, densidad ósea.*

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INTRODUCTION

The rapid aging of contemporary population has influenced de development of strategies for the prevention of osteoporosis among elderly people. This systemic skeletal disease is characterized by the disrepair of bone microarchitecture, the loss of bone mineral density (BMD), and its relationship with bone fracture. Hip and vertebral column fractures are associated with a high morbidity and mortality in elders, being an important public health problem with devastating consequences for their health and quality of life[1-3]. Osteoporosis affects one out of four women and one out of eight men from age 50, increasing significantly in women after menopause. Therefore, it is estimated the most prevalent worldwide chronic disease, especially in women over 65.

BMD is a complex trait, influenced by both genetic and environmental factors and possibly interactions between them. Among the array of environmental factors, nutrition, physical activity, and sexual hormonal factors are believed to be involved in its regulation[4]. The more practical strategy for prevention osteoporosis falls on calcium dietary intake and physical activity. However, evidence for the association between these factors is inconsistent and sometimes unclear. Even there is a general consensus that combining physical activity and dietary calcium supplementation moderately reduces the rates of cortical bone loss in younger and older women, positive[5,6] or weak[7] relationship could be found in the literature.

The practice of physical exercise could retard bone loss, improve neuromuscular capacity, enhance balance and decrease falls incidence in the elderly. The promotion of exercise in normal daily live can be also a potentially strong tool to reduce health care costs. Walking in a moderate intensity leads to a significant increase in BMD at lumbar spine level in elderly women[8], even combining it with a gymnastic program[9]. And it seems that this treatment should have a duration ranged from 6 to 12 months to be effective[2]. Weight bearing exercise has also been effective increasing BMD in elderly women[10]. A one-year long swimming exercise program combining aerobic and strength training ensures the maintenance of BMD in postmenopausal women[11]. High impact exercises such as jumping, are more efficient on improving BMD than low impact exercises, such as walking or swimming[12].

On the other hand, the activities that older adults tend to engage in most frequently are leisurely walking, housework, or gardening. Daily physical activity is believed to increase bone mass and possibly helps prevent bone loss and subsequent osteoporosis. Studies in men suggest that physical activity is imperative for the augmentation of cortical bone size and trabecular bone mineral density[13]. But the minimal amount or intensity of physical activity to induce higher bone mass in women remains insufficiently studied.

Accelerometer-based measurement of movement is an accepted method for monitoring physical activity with reasonable reproducibility[14,15]. Measurements during normal life have not been performed so far, and there are a few quantitative data to suggest the degree of intensity and amount of physical activity needed for strengthening bone.

The aim of this study was to examine the association between the quantity and intensity of daily physical activity and bone mineral density in the hand, using a week quantification of daily physical activity in elderly women.

METHODS

The study was performed with 24 women older than 65 years from a rural area (Otos town, Murcia, Spain). They were primary attention service doctor's patients that were recruited from the local medical center in the first week of February, 2011. Doctor chose them for the X-ray absorptiometry densitometry because they checked their bone mineral density since ten years. They were screened to ensure that they fulfilled the selection criteria: women from a rural area, aged between 65 and 80 years, having no neurological, cardiovascular, metabolic, inflammatory or musculoskeletal conditions, and not participating in a supervised systematic exercise program. The participants were divided into three groups: positive bone (PB, T-score>-0.3, n=8), negative bone (NB, -0.4<T-score>-0.9, n=8), and osteoporotic bone (OB, T-score<-1 n=8). The study was approved by the Ethics Committee of the University of Murcia. Each participant signed a written consent after being informed of the aim and the procedure of the study. Subjects' characteristics are presented in table 1.

Height and weight were measured using standardized equipment (SECA 780 medical weighing machine). All the subjects were measured barefoot and with light clothing.

The amount and the intensity of daily physical activity were measured with the ActiGraph GT3X at the level of the wrist. This device was designed to monitor human activity. It is capable of collecting activity data from three axes, which is recommended to estimate the physical activity level of older adults[16]. The triple axis mode collects acceleration data in both the vertical and horizontal axis right-left, and horizontal front-back. It brings the activity in counts/minute and the steps given minute by minute. It could also determine the intensity of the physical activity.

The trunk location (hip or lower back) has become by far the most common placement for the monitors[17]. Whereas little eviden-

Table 1. Characteristics of the subjects.

	Group	N	Minimum	Maximum	Mean	Std. Deviation
Age (years)	PB	8	67	76	69.7	4.2
	NB	8	66	76	70.5	4.4
	OB	8	69	78	72.5	4.3
Weight (Kg)	PB	8	65,5	98.5	85.4	14.3
	NB	8	60,2	80.0	72.7	8.9
	OB	8	41.5	86.5	69.1	20.6
Height (m)	PB	8	1.5	1.5	1.5	0.0
	NB	8	1.5	1.6	1.5	0.0
	OB	8	1.4	1.6	1.5	0.1
BMI (Kg/m^2)	PB	8	29.9	41.3	37.3	5.0
	NB	8	26.1	36.7	32.1	5.1
	OB	8	19.2	38.4	30.9	8.2
T-score	PB	8	-0.3	1.0	0.3	0.6
	NB	8	-0.9	-0.4	-0.6	0.2
	OB	8	-1.8	-1.1	-1.5	0.3

BMI=Body Mass Index, T-score= bone standard deviations respect to young, healthy people, PB=positive bone group, NB=negative bone group, OB=osteoporotic bone group.

ce suggests that one position is better than another[18]. Following manufacturer's instructions and having into account that bone mineral density was going to be measured at the hand, in the present study the wrist was chosen to attach the accelerometer using a wrist strap. The unit could be worn either above or beneath clothing, and it was not necessary for the device to make contact with the skin. But it must be held tightly against the body to prevent erroneous readings. They could only remove the device for sleeping or having a shower.

The sampling period to wear the accelerometer is between 3 and 7 days[19], and weekdays and weekend days need to be sampled[20]. In the present study, subjects wore the accelerometer during 7 days. For the data analysis two weekend days and two randomly week days were analyzed.

Weekday women's patterns of leisure time were based on housework tasks such as cooking, cleaning, sewing, sweeping or ironing. Habitually they went to the supermarket walking and carried bags in their hands or in a trolley. Most of them had an orchard where they cultivated vegetables and flowers. In the afternoons they usually went for a walk with their friends. They woke up at seven o'clock in the morning and went to bed at about eleven o'clock in the night, having a break of two hours after eating. In weekend days these patterns didn't change substantially, but resting time were prolonged. They woke up about two hours later and went to bed at the same time.

Accelerometer variables related with daily physical activity intensity was measured in the three axes of movement and in the horizontal axis separately. *Counts*, *weekday counts* and *weekend counts* variable represents the movement in the vertical and horizontal axis right-left, and horizontal front-back. Whereas *H counts*, *H weekday* and *H weekend counts* represents only the movement in the horizontal front-back axis. Counts or H counts refers to the average of the four days daily physical activity either in the three or in the horizontal axis. Weekday/Weekend counts or H weekday/weekend counts concerns to the weekday/weekend counts choosing only the two weekday or weekend days, either in the three or in the horizontal axis.

On the other hand, the amount of daily physical activity was shown in *PA*, *weekday PA* and *weekend PA* variables. Those means the minutes of physical activity accumulated in the four days and in the two weekdays and two weekend days. To obtain these values, it has been chosen the three axes movement.

Furthermore, the minutes of very light, light, moderate, vigorous and very vigorous daily physical activity intensity developed in the three axes of movement were specified in *Very light PA*, *light PA*, *moderate PA*, *vigorous PA* and *very vigorous PA* variables. The range of these intensities was established according to Martinez *et al.*[21] indications: very light PA= 0-499 counts/minute, light PA= 500-1999counts/minute, moderate PA=2000-2999 counts/minute, vigorous PA=3000-4499 counts/minute, and very vigorous PA=4500 – 5999 counts/minute.

T-score was measured at the right hand with dual-energy X-ray absorptiometry (DXA) (AccuDEXA, SHICK, USA). It refers to the number of standard deviations of the person tested with respect to the mean of young, healthy and the same race and sex people. The DXA of the hand can be effectively used for screening osteoporosis[22]. This test was performed in the Ray Unity of the Northeast Local Hospital (Caravaca de la Cruz, Murcia, Spain). All scanner and analyses were done by the same operator. The scanner was calibrated daily by bone phantoms for quality assurance.

Analisis Statistics

The study design was descriptive. Since all outcome variables were normally distributed (Shapiro-Wilk), descriptive statistics of the groups were calculated. Levene test, one factor ANOVA and Bonferroni *post-hoc* test confirmed that T-score between groups were statistically different. This allowed us to dismiss NB group out of the statistical analysis with the objective of comparing the most different T-score groups (PB and OB). Differences in the variables were studied using an independent samples t-test. Correlate Bivariate (r-Pearson) was used to determine the strength and direction of the relationship between two variables in each group. The independent predictors of the parameters were tested using multiple linear regression analysis. The percentage of the variation of T-score with all covariates was calculated. Data were analyzed using the SPSS computer software program (version 15.0, SPSS Inc, Chicago, Ill.).

RESULTS

The independent samples t-test shows no significant differences between groups in BMI, counts or minutes of physical activity. However, both groups were statistically different in T-score (p<0,05) (table 2).

Table 2. Values for the positive and the osteoporotic group (mean±SD).

Variable	Group	N	Mean±SD	t	df	p
BMI (Kg/m^2)	PB	8	37.3±5.0	1.3	14	
	OB	8	30.9±8.2			
T-score	PB	8	0.3±0.6	5.4	14	*
	OB	8	-1.5±0.3			
Counts (counts/day)	PB	8	770.2±300.1	0.2	14	
	OB	8	745.2±179.9			
Weekday counts (counts/day)	PB	8	720.3±251.1	-0.1	14	
	OB	8	734.6±179.7			
Weekend counts (counts/day)	PB	8	820.2±354.1	0.3	14	
	OB	8	755.7±207.2			
H counts (counts/day)	PB	8	743.5±234,1	-0.7	14	
	OB	8	877.6±285.7			
H weekday counts (counts/day)	PB	8	730.6±212.0	-0.8	14	
	OB	8	870.0±231.6			
H weekend counts (counts/day)	PB	8	756.3±271.8	-0.5	14	
	OB	8	885.2±375.9			
PA (min/day)	PB	8	746.0±171.9	0.8	14	
	OB	8	665.0±81.9			
Weekday PA (min/day)	PB	8	695.9±198.8	0.4	14	
	OB	8	648.0±76.6			
Weekend PA (min/day)	PB	8	796.1±149.0	1.3	14	
	OB	8	682.0±87.8			
Very light PA (min/day)	PB	8	525.0±315.8	-0.4	14	
	OB	8	599.5±189.8			
Light PA (min/day)	PB	8	755.2±139.6	0.8	14	
	OB	8	684.7±94.9			
Moderate PA (min/day)	PB	8	131.2±167.9	-0.1	14	
	OB	8	141.7±82.7			
Vigorous PA (min/day)	PB	8	27.5±52.4	0.5	14	
	OB	8	14.0±14.4			
Very vigorous PA (min/day)	PB	8	1.0±2.0	1	14	
	OB	8	0.0±0.0			

*Significant difference between groups (p<0.05). BMI=Body Mass Index, T-score=bone standard deviations respect to young, healthy people; Counts (counts/day)=number of counts/day in the three axes; Weekday or weekend counts (counts/day)=number of counts/day in weekday or weekend dais in the three axes; Hcounts (counts/day)=number of counts/day in the horizontal axe; Hweekday or weekend counts (counts/day)=number of counts/day in weekday or weekend dais in the horizontal axe; PA (min/day)=minutes of physical activity/day; Weekday or weekend PA (min/day)=number of minutes/day in weekday or weekend dais. Very light/light/moderate/vigorous/very vigorous PA (min/day)=minutes of daily physical activity developed at those intensities.

In PB it was found a positive correlation between T-score and weekday counts (r=0.99) (figure 1). And a negative correlation with the horizontal weekday counts (r=-0.97). But there were no correlation with minutes of physical activity. Weekday counts were negatively correlated with very light physical activity (r=-0.99). But there were no correlations with moderate or vigorous intensity.

On the other hand, in OB the correlation between T-score and weekday horizontal counts was positive (r=0.99) (figure 2). And there was a negative correlation with weekday minutes of physical activity (r=-0.96). Meanwhile, weekday minutes of physical activity correlated significantly with light intensity (r=0.96).

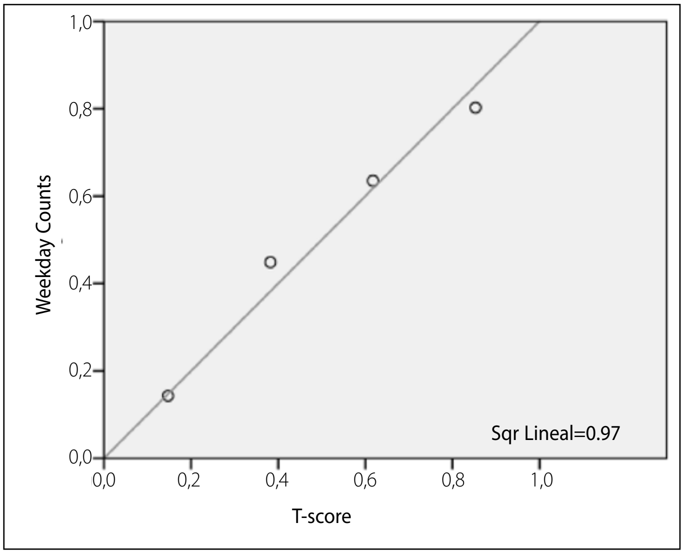

Figure 1. T-score and weekday counts linear regression in PB group.

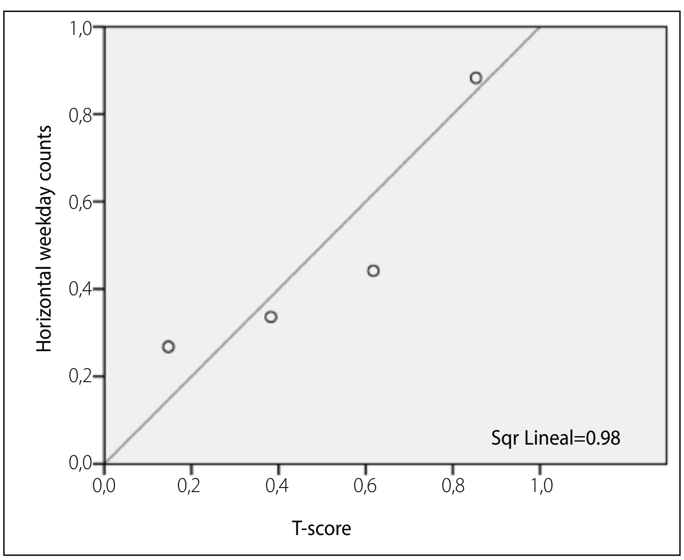

Figure 2. T-score and horizontal weekday counts linear regression in OB group.

DISCUSSION

In the present study, amount and intensity of daily physical activity have been related to the T-score of the hand bone in elder rural women. It is showed that a higher T-score is associated with a higher intensity of physical activity developed in weekday days either in normal or in osteoporotic bone group. It appears that the amount of physical activity does not play an important role in both groups' T-score value.

In the hand densitometry it was shown bone information related to a reference number (T-score) and to the cellular structure of the bone (Bone Mineral Content-BMC, Trabecular Area, BMD). T-score allows the possibility of classify subjects according to their bone structure, so we decided to use it instead of BMC, trabecular Area or BMD, as it has been done in other studies[23,24].

The literature commonly offers relations between the amount and intensity of exercise with BMC, trabecular Area, or BMD[13,25,26]. Periosteal and endocortical bone surface could be analyzed with them. Loading affects both the periosteal and endocortical surfaces, but the magnitude of the effects vary according to whether the surface is anterior, posterior, medial, or lateral and whether the region is proximal, central, or distal along the bone's length[27]. Bones are not perfect tubes with a single diameter and cortical thickness along their length. Thus, as pointed out by Petit *et al.*[28] inferences about surface-specific effects, or lack of effects, must be made cautiously. In this case, T-score becomes an appropriate solution to classify women owing to their bone quality.

T-score was the only variable statistically different between PB and OB group. This indicates that in a homogeneous and small older women group, different bone structure can be found. The whole sample shows a wide range of T-score values from 1.0 to -1.8. Following the device's instructions, -1 or below was considered osteoporotic bone. The World Health Organization criteria specify that osteoporosis is present in women when the BMD is 2.5 SD or more below that of the mean in a young adult population. This is represented in a T-score of -2.5 or below[29]. Women in this T-score are at higher risk of suffering a bone fracture. It can be considered that women in OB group had a decreased bone density that should be classified as osteopenia since it doesn't reach osteoporosis values. In this regard, we agree whit Seeman *et al.*[27] stating that the most persons of the whole population have a BMD above -2.5 SD, and that it is difficult to find persons with a T-score below -2.5.

The accelerometry is a good way for obtaining physical activity data. There are several methods of analyzing accelerometric data. Respect to the intensity, root-mean-square average, power spectrum integral and acceleration count have been previously used as measures of activity[25]. At the vertical direction, the highest acceleration has been shown to be mainly related to the heel strike[25].

In the present study, accelerometer assessment was made in the wrist. Such movement could be generated in any direction (more frequently in the horizontal axis) and is not necessarily associated with surface impact. That's the reason why the intensity of the movement at the three axes (vertical and horizontal axis right-left, and horizontal front-back) and in the horizontal axis was analyzed separately.

Both groups, PB and OB, reached a mean of 720.3 and 734.6 weekday counts, with no significant differences between them. This activity value is equivalent to a light intensity. In PB group there were a strong correlation between T-score and weekday counts. Nevertheless, the intensity of activity in the horizontal axe indicates that it is not relevant regarding a higher T-score. But it is associated with a higher T-score in OB group, which means a more osteopenic bone. Therefore, the higher intensity of activity in the horizontal axe is related with a worst bone structure, and in the three axes, with a better bone structure. On the other hand, PB weekday counts were negatively related with minutes of very light intensity physical activity. Although there were no significant relations with other levels of intensity, it is clear that the more weekday counts developed, the less sedentary activity done. However, it is necessary to specify that in our results, the higher intensity of the physical activity developed in weekdays is more relevant regarding a better T-score value in a normal bone, although there were no significant differences between weekday or weekend counts/day.

Respect to the amount of physical activity, there were no correlations in PB group while in OB group exists a negative correlation between weekday minutes of physical activity and T-score. It means that women with worst bone structure developed least quantity of physical activity. Moreover, it seems that this physical activity was of a light intensity. It could clarify that it is not the amount but the intensity of physical activity the variable that really affects bone structure in older women. In this way, we agree with Jamsa *et al.*[25] and Stengel *et al.*[12], who showed that exercise including high accelerations (jumps) was positively associated with the BMD changes on proximal femur and with Zhang *et al.*[30], Yamazaki *et al.*[8] and Going *et al.*[10], that related the intensive physical activity (walking or weight bearing) with a higher BMD in the spine and distal radius in postmenopausal women. But our results differ from Lorentzon *et al.*[13] that assure physical activity amount as an independent strong predictor of BMD in all sites measured.

CONCLUSION

A noninvasive, safe, and low-cost method that accurately measure bone quality and weekday physical activity is needed to assure all population assessment. In our old women sample, the combination of accelerometry and X-ray absorptiometry at the hand level brings similar results than other less accessible methods. Owing to the arm movement, either triaxial or horizontal counts must be analyzed as they provide relevant information respect to the weekday physical activity intensity and the bone structure.

The higher weekday physical activity intensity is related with a better bone structure, as it has been proved after specific exercise program. But it is necessary to specify that the intensity reached on weekdays is more effective than the weekend dais regarding this benefit in our old women sample. The level of the intensity and the amount of physical activity should still be clarified since there were no significant differences between normal or osteoporotic group.

Other variables such as diet, hormonal factors or previous fractures could influence bone mineral density scores and should have taken on account. A larger sample is necessary to ensure these results.

All authors have declared there is not any potential conflict of interests concerning this article.

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