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ORIGINAL

MAT PILATES AND BODY COMPOSITION OF POSTMENOPAUSAL WOMEN. DENSITOMETRIC STUDY

PILATES MAT Y COMPOSICIÓN CORPORAL DE MUJERES POSMENOPÁUSICAS. ESTUDIO DENSITOMÉTRICO

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RESUMEN

El objetivo de este trabajo es cuantificar, mediante Absorciometría Dual Fotónica de Rayos- X (DXA), las modificaciones de la composición corporal que la práctica de Pilates Mat produce en mujeres posmenopaúsicas de vida sedentaria. Tras un programa de ejercicios de 9 meses de duración a razón de 2 sesiones por semana de 60 minutos cada una, se observó un aumento significativo del compartimento muscular a nivel de tronco (p=0,028), abdomen (p=0,010) y brazos (p=0,042), así como una disminución significativa de la grasa de las piernas (p=0,000). La densidad mineral ósea de la columna lumbar (L2, L3 y L4) también aumentó de forma significativa. Los resultados sugieren que la práctica de Pilates Mat en mujeres posmenopáusicas mejora su composición corporal.

PALABRAS CLAVE: Ejercicio, posmenopausia, densitometría, Pilates.

ABSTRACT

The aim of this study was to quantify the changes in body composition after Mat Pilates practice in postmenopausal sedentary women using Dual X-ray Photon Absorptiometry (DXA). After a 9-month exercise program consisting of 2 sessions per week of 60 minutes each, a significant increase was observed in the muscle mass of the trunk (p = 0.028), abdomen (p = 0.010) and arms (p = 0.042). A significant decrease was observed in the leg fat mass (p = 0.000). Bone mineral density of the lumbar spine (L2, L3 and L4) also increased significantly. The results suggest that the practice of Mat Pilates in postmenopausal women improves their body composition.

KEY WORDS: Exercise, postmenopause, densitometry, Pilates.

INTRODUCTION

The original phylosophy of Pilates Method (Pilates JH, 1998 and Pilates JH, 2000) can be summarized as health maintenance and well-being. The main aims of Pilates training are to improve general flexibility, to strengthen the trunk muscles and to coordinate posture and breathing (Latey, 2002). This has been proven in elderly women (Siqueira et al, 2010).

The physiological condition which most affects bone mass is ageing (Aguado-Henche et al, 2008), which causes osteoporosis. The microarchitecture of the bone tissue deteriorates and loses trabeculas; logically, this alteration in the bone structure leads to changes in its mechanical properties (Viladot y Roldán JC, 2001), since bone fragility and sensitivity to fractures increase.

The practice of Pilates contributes to muscle strength and to the improvement of balance, posture and movement coordination, which help reduce fall probability (Cruz-Ferreira y col. 2011), and therefore, bone fracture likelihood. Thus, Mat Pilates is very suitable for sedentary people (Küçükçakir, N et al, 2013). Mat Pilates consists in performing a combination of elongation and strength exercises while lying on a mat. The movements start from the abdominal region and include rising of the rest of the trunk and the legs, strengthening the core region. This is called *core training* (abdominal, back and pelvis-trochanter muscles). Mat Pilates is very suitable for sedentary people and does not require any previous level of physical fitness (Vaquero-Cristóbal y col. 2014).

The effects of Mat Pilates on different population groups have been studied applying different techniques, such as anthropometry, which has been widely used in sports. However, a limited amount of studies conducted with X-ray densitometry has been found in the literature (González-Gálvez y col. 2012).

The aim of this study was to determine, by means of Dual X-ray Photon Absorptiometry (DXA), whether a controlled physical activity program consisting in Mat Pilates exercises (with ball and on floor) produces beneficial changes in the different body compartments and in bone mineral density of the lumbar spine in postmenopausal women.

METHODS

PARTICIPANTS

As it is shown in Table 1, 37 multipara postmenopausal women participated in this study. Their ages ranged between 48 and 82 years old, being the mean 67.9 years. In the younger women, menopause was determined as twelve consecutive months without period. According to their Body Mass Index, none of them was overweight. They were all right-handed and non-smoker. The mean age of menopause was 48.8 years. Due to risk factors associated to this age (diabetes, osteoporosis, hypertension, cardiovascular diseases…), a medical evaluation was requested to all the participants prior to the beginning of the program in order to assure that they did not suffer from any acute pathology or disease which could hinder sport practice: brief clinical history, general medical check with laboratory tests and spirometry. The participants belonged to the medical district of Príncipe de Asturias Hospital. None of them was following hormone replacement therapy or taking calcium supplement or vitamin D.

Table 1

Descriptive statistics of the study sample (n = 37)

Variable	Mean	Standard deviation
Age (years)	67.97	7.328
Age of Menarche (years)	13.29	1.382
Age of Menopause (years)	48.84	4.847
Cups of coffee/day	1.79	1.008
Labours	3.65	1.041
Body Weight (Kg)	66.8167	7.66881
Height (cm)	155.7167	5.69112
Body Mass Index (Weight/Height^2)	27.6247	3.75057

EXERCISE PROGRAM

The Mat Pilates program was conducted at the municipal sport centre Virgen de Val of Alcalá de Henares. The room was spacious, very bright, well ventilated and with tatami floor, so that the exercise program was healthy, comfortable and safe. The program started with a briefing for all participants, who signed the corresponding informed consent. Three women withdrew from the study after two months due to illness.

Given the characteristics of the study population, Elizabeth Larkam’s proposal (2005) was followed when designing the sessions.

The sessions took place twice a week for 9 months, they lasted 60 minutes and included exercises for the lumbar and hip regions. Each session consisted of 10 minutes of breathing and warm-up, 46 minutes of exercises with a maximum of 8 repetitions each, and lastly, 4 minutes of guided breathing (after an exercise with a higher difficulty level). The exercises included abdominal muscles (rectus abdominis and oblique), gluteus, thighs (quadriceps and hamstrings) and the lumbar region, as described by Calvo JB, 2012. The changes in posture occurred gradually during the session, going from standing to sitting, getting down onto hands and knees, lying in prone, lateral and supine positions. Elastic bands and fit balls were used as additional equipment. All sessions were conducted by the same sports instructor.

DENSITOMETRIC STUDY

Two densitometry scans were performed, after calibration of the device, on each participant, one of the whole body and one of the lumbar spine, before and after completing the exercise program. A Norland XR-26 densitometer was used, with software version 2.3 (Norland Co., Fort Atkinson, Wisconsin, USA. Emsor SA. Madrid).

The densitometer was calibrated daily according to the manufacturer's calibrating standard. All metal objects were removed from the women's bodies before the measurements. They lay in supine position in the centre of the scanner table. Each whole body scan lasted on average 20 minutes, while the spine lumbar scan lasted about 8 minutes. All measurements were conducted by the same researcher. The body regions were selected according to the device software.

The following variables were analyzed, following a three-compartment model. They were directly calculated by the densitometer:

BMC: Bone mineral content (bone compartment)
LM: Lean mass (muscle compartment)
FM: Fat mass (fat compartment).
Total Body Mass = TBMC + TSLM + TFM

Variables corresponding to the bone compartment (in grams):

TBMC: Total bone mineral content, defined as the total amount of bone determined by absorptiometry.
BMCTr: Bone mineral content of the trunk.
BMCAb: Bone mineral content of the abdomen.
BMCA: Bone mineral content of the arms.
BMCL: Bone mineral content of the legs.

Variables corresponding to the muscle compartment (in grams):

TSLM: Total soft lean mass = Total Body Mass - (TBMC + total fat mass), where 90% corresponds to muscle mass.
SLMTr: Soft lean mass of the trunk.
SLMAb: Soft lean mass of the abdomen.
SLMA: Soft lean mass of the arms.
SLML: Soft lean mass of the legs.

Variables corresponding to the fat compartment (in grams):

TFM: Total fat mass = Total Body Mass – (TBMC + TSLM).
FMTr: Fat mass of the trunk.
FMAb: Fat mass of the abdomen.
FMA: Fat mass of the arms.

FML: Fat mass of the legs.

Variables corresponding to Bone Mineral Density (BMD) of the lumbar spine (in grams/centimetre^2):

BMD-L2L4: bone mineral density of the lumbar vertebrae L2, L3 and L4.
Each vertebra was also measured individually:
BMD-L2: BMD of the second lumbar vertebra.
BMD-L3: BMD of the third lumbar vertebra.
BMD-L4: BMD of the fourth lumbar vertebra.

STATISTICAL METHOD

The statistical analysis was conducted with the software package SPSS for Windows (Inc., Chicago, IL, USA) version 15.0. The mean values of each densitometric variable obtained at the beginning and at the end of the exercise program were compared using a repeated measures t-test (with a confidence interval of 95%). In the cases where the variables did not follow a normal distribution, a Wilcoxon signed-rank test was used.

RESULTS

Table 2 shows the descriptive statistics of every densitometric variable before and after the exercise program, together with the statistical significance. The values are presented in grams. $p \leq 0.05$ *; $p \leq 0.01$ **; $p \leq 0.001$ ***

Table 2

Descriptive statistics of the body compartments and differences before and after the Mat Pilates program

	Before	After	
Variables	*Mean ± SD (grams)*	*Mean ± SD (grams)*	*P*
TBMC	2265.30 ± 238.0	2275.40 ± 230.4	0.328
BMCTr	745.20 ± 94.5	755.20 ± 90.2	0.369
BMCAb	316.30 ± 58.4	322.60 ± 47.1	0.437
BMCA	309.50 ± 39.7	302.70 ± 44.3	0.063
BMCL	808.80 ± 103.3	807.40 ± 98.7	0.833
TSLM	33802.82 ± 5757.4	34033.32 ± 5865.1	0.459
SLMTr	15381.09 ± 2987.7	15865.50 ± 3135.3	0.028*
SLMAb	6959.90 ± 1174.0	7410.70 ± 1458.1	0.010**
SLMA	3865.00 ± 828.0	3728.50 ± 795.6	0.042*
SLML	11710.20 ± 2029.0	11616.50 ± 2022.1	0.597
TFM	31441.20 ± 6093.5	30866.80 ± 6224.6	0.193
FMTr	15768.60 ± 3235.9	15717.60 ± 3471.0	0.871
FMAb	7593.20 ± 1996.8	7435.60 ± 2048.4	0.439
FMA	4388.60 ± 790.5	3931.00 ± 708.8	0.331
FML	14726.20 ± 1923.4	10667.20 ± 2764.9	0.000***

The body compartment with the largest variation was the muscle compartment (Figure 1), where the muscle mass of the trunk (p = 0.028) and the abdomen (p = 0.010) increased significantly, while the arm muscle mass decreased slightly (p = 0.042). The rest of the variables analyzed for the muscle compartment did not show significant changes.

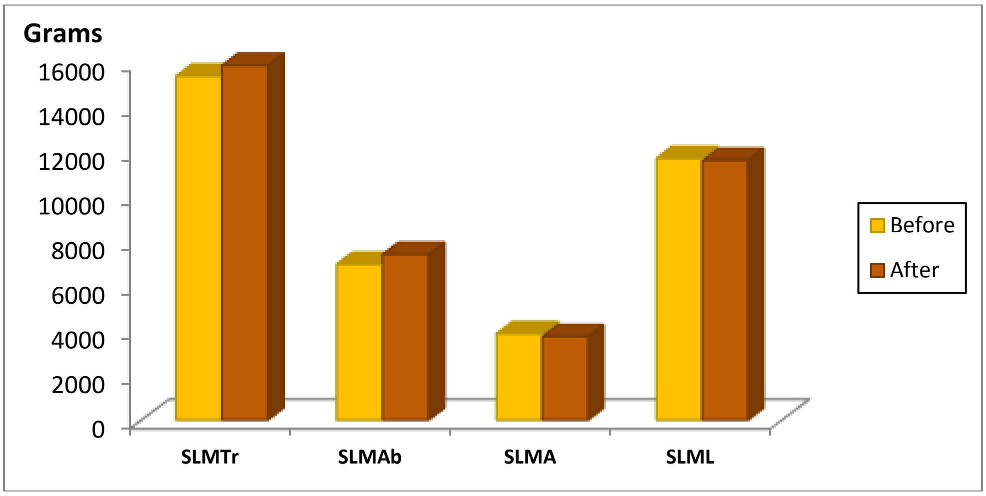

Figure 1. Lean mass per region before and after exercise

In the bone compartment, the bone mineral content values (Figure 2) showed only small non-significant variations. The values of the fat compartment decreased (Figure 3) both globally and in each body region under study. This decrease was very significant for the legs (p=0.000).

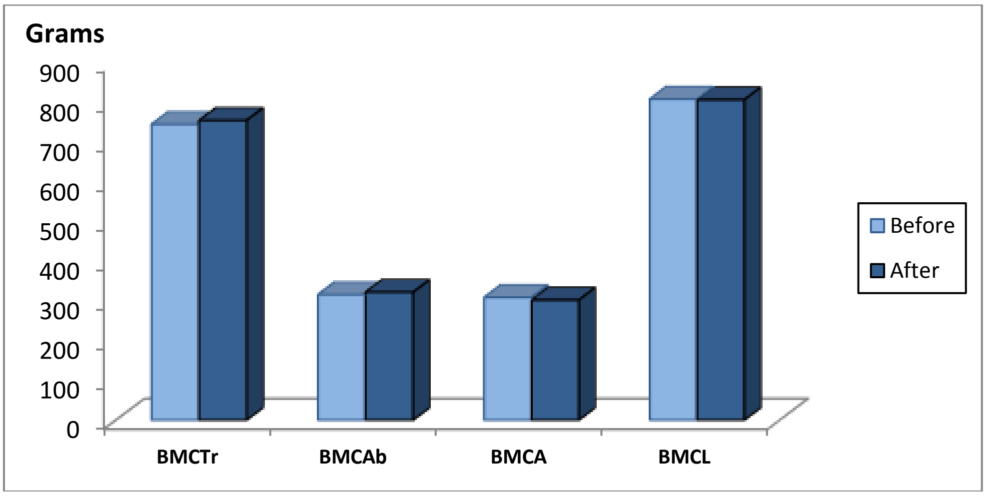

Figure 2. Bone Mineral Content per region before and after exercise

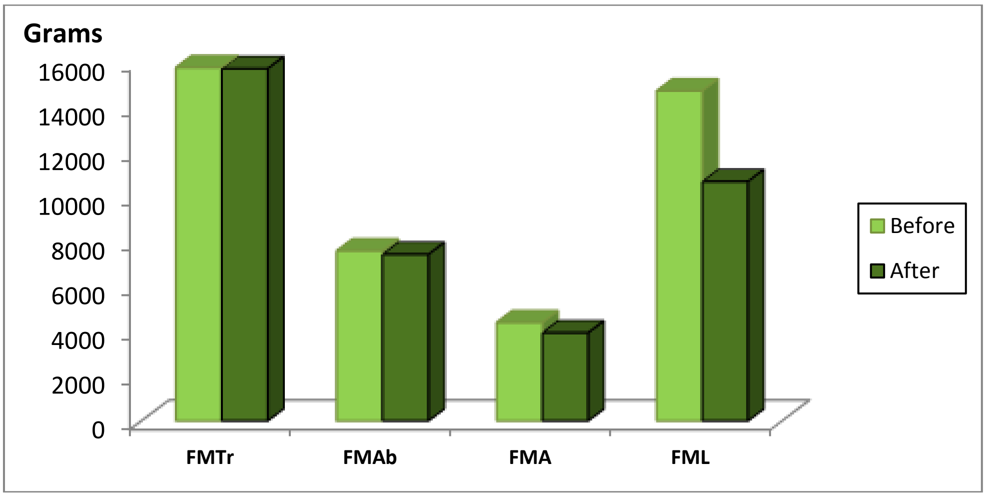

Figure 3. Fat mass per region before and after exercise

Regarding the lumbar spine densitometric study (Figure 4), the bone mineral density increased significantly in L2 ($p \leq 0.001$), L4 ($p \leq 0.010$) and in the combination of L2-L3-L4 ($p \leq 0.001$). Table 3 shows BMD in g/cm^2 before and after exercise.

Table 3
Descriptive statistics of the lumbar spine BMD and differences before and after the Mat Pilates program

	Before	After	
Variables	*Mean ± SD*	*Mean ± SD*	*p*
BMD-L2	0.838 ± 0.13	0.874 ± 0.13	0.001***
BMD-L3	0.841 ± 0.15	0.863 ± 0.15	0.010**
BMD-L4	0.840 ± 0.20	0.869 ± 0.19	0.055
BMD-L2L4	0.840 ± 0.15	0.867 ± 0.15	0.001***

Values in g/cm^2

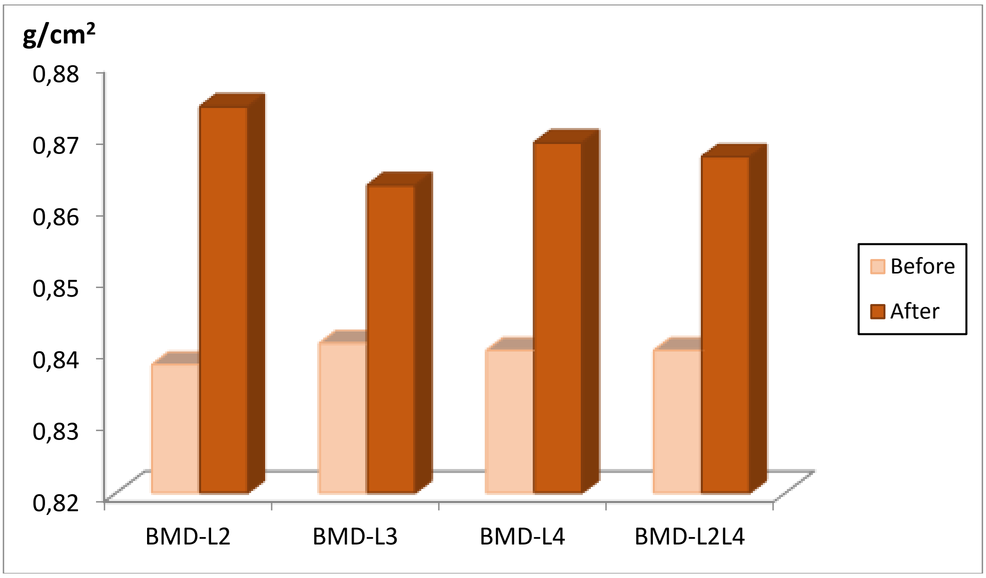

Figure 4. Lumbar spine Bone Mineral Density before and after exercise

DISCUSSION

Several studies have proven that the practice of Pilates has a beneficial effect on body composition (Adrado-Gonzalvo AR et al. 2012). The effects of Pilates on muscular strength have been studied by means of dynamometry (Sekendiz et al., 2007), the changes on muscle activity have been assessed with EMG (Emery K, 2010), and on body composition using techniques such as anthropometry (Jago et al., 2006; Cakmakçi, 2011) or bioelectrical impedance analysis (BIA) (Segal et al., 2004). However, there is lack of studies which analyze the changes in body composition due to the practice of Pilates using Dual X-ray Photon Absorptiometry (DXA).

The increase in trunk muscle mass will have a positive effect on this body region, since the main function of the striated muscle is, apart from making the joints move, to strengthen and protect the skeleton, distributing the loads that it must bear (Balagué et al., 2000). The results obtained regarding muscle mass increase in the trunk and abdomen are in line with those previously found by Dorado et al. (2012). Using magnetic resonance imaging, they reported hypertrophy of the abdominal muscle wall after the practice of Pilates, especially in the rectus abdominis. A study where Portuguese women between 25 and 55 years old practiced Mat Pilates for three months showed by DXA that they improved their body composition by increasing their muscle mass and reducing their fat mass in upper and lower limbs (Cruz-Ferreira et al. 2009).

The increase in muscle mass is positively correlated with the increase in bone mass. Trabecular bone has a well-known role in force transmission. Osteoporosis causes a reduction in width and number of spongy bone trabeculae. In the vertebrae, where this tissue is the main component, this entails higher risk of vertebral crushing (Kanis, 2002). Active exercise produces an increase in muscle mass, which leads to better bone quality and force transmission.

Researchers have recently found, using anthropometric techniques and applying an eight-week program in elderly women, similar results to ours regarding the muscle and fat compartments (Fourie et al., 2013).

In contrast to men, where the fat distribution pattern is abdominal, the fat mass in women of this age follows a gynoid or peripheral pattern (Aguado-Henche S y col., 2007), showing large accumulation of fat in the legs. This explains that the largest fat loss observed after the complete exercise program happened in this body region.

The study of the lumbar spine BMD and the body compartments are of paramount importance. On one hand, vertebral fractures have high prevalence among people above 50 years old, especially women above 70 years old, being very similar among European, American and Asian patients (Díaz López JB, 2000). On the other hand, vertebrae are the bone regions with highest trabecular bone content, which is 10 times metabolically more active than the cortical component (del Río L, 2004), thus providing much more information than studies conducted on other body regions.

In comparison with children and adolescents, elderly people experience very little improvement in bone mineral density with exercise programs, but the bone mass loss can, at least, be attenuated. Moreover, the fracture risk is directly correlated to the progressive BMD drop with age, which in postmenopausal women above 70 years old reaches 1-2% per year (Gómez Cabello et al., 2012).

It is well known that exercise is effective in improving BMD in elderly people, but more suitable protocols must be defined in order to improve BMD in this population, since plain aerobic exercise, such as walking, is not effective. It should be accompanied by a type of training which produces appropriate overloads on the bone. The increase in trabecular bone due to these overloads happens at vertebral level, which is the part of the skeleton where the largest bone mass loss because of the menopausal hypoestrogenism occurs. Nevertheless, it may have higher arthrosis risk. Thus, what is beneficial to stimulate osteogenesis may be negative for the joints (Bea JW et al. 2010). For this reason, the sessions need to be given by a sports instructor, being the same for all sessions, which is our case.

Except for the three participants who withdrew from the study at the beginning of the exercise program, the rest of them completed their participation satisfactorily. The risks of Mat Pilates are minimal if it is practiced with an appropriate instructor, although a case of diaphragmatic rupture during deep Pilates breathing has been found in the literature (Yang YM et al., 2010).

The aim of this study was to quantify the changes in the densitometric variables which characterize the body composition of the sample. Further studies with exercise programs longer than 9 months are necessary to determine whether these variables change significantly in women with osteoporosis who practice Mat Pilates. Variations in z-score and t-score should be specifically included. Another limitation of the study was the lack of control of the dietary habits during the study.

CONCLUSION

DXA shows that a combination of strength and elongation exercises in a 9-month Mat Pilates program produces a significant improvement in the trunk muscle mass, the leg fat compartment and the lumbar spine bone mineral density in postmenopausal women. They are, thus, clearly beneficial for their body composition, and therefore, for their health. Consequently, Mat Pilates may delay the negative effects of ageing and reduce morbidity in this population group. Besides, in light of these results, future studies in male population and other age groups are necessary.

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