

Effects of Pilates-Interventional Program on Calcaneus-Bone Density Parameters of Adult Women

Efectos de un Programa de Intervención de Pilates Sobre
Parámetros de Densidad Ósea en el Calcáneo de Mujeres Adultas

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SUMMARY: Physical exercise has a positive influence on bone tissue and therefore, is recommended in order to prevent the bone mass loss during the aging process. Similarly, normally practice of exercise potentially prevents the incidence of osteoporosis and bone fractures in adult women. In order to evaluate the differences of a Pilates-Interventional Program on parameters of bone density (right and left calcaneus) for six months, a total of 22 women (48.18 ± 9.59) participated in the study. Bone mineral density (BMD) was estimated by the broadband ultrasonic attenuation (BUA) and the speed of sound signals (SOS), through "Sahara" sound device. The BUA showed significant difference in the right and the left leg (both, $P < 0.01$), the SOS of the right leg ($P < 0.05$), whereas the BMD was not proved to be statistically significant at the end of the treatment. In conclusion, the bone mineral density by BUA increased, while the speed of sound of the right leg decreased. Thus, our findings might imply a better level of bone strength after a specific intervention focused on the Pilates method.

KEY WORDS: Physical exercise; Calcaneus; Broadband ultrasonic attenuation; Speed of sound signals.

INTRODUCTION

Age and loss of BMD have been studied for long time with multiple theories (Blanchet *et al.*, 2013). Osteoporosis is a systemic skeletal disorder characterized by decrease of bone loss in aging process (Karlsson *et al.*, 2001; Rasic & Tasic, 2009) and micro architectural deterioration of bone tissue (Rasic & Tasic). The peak (maximum) of bone mass is achieved between the ages of 30 and 35, when the speed of new bone formation and resorption is relatively small and quite similar (Babic, 2004). Osteoporosis can occur in both sexes, and the risk increases with age, especially in women due to reduced production of estrogen during menopause, when some women may lose up to 15 % of the total bone mass (Kohrt *et al.*, 2004). Early detection of osteoporosis is the first step towards the successful prevention, treatment and rehabilitation. The golden standard in BMD measuring is the method of dual exposure to X-rays (DEXA), and one of the methods for measuring BMD, which is diagnosed by an ultrasound technique usually on the calcaneus of a non-dominant foot, is the quantitative ultrasound osteodensitometry (QUS) (Lazic & Spasojevic, 2012).

The calcaneus is the largest of the tarsal bones and carries the total of body weight (Schencke & del Sol, 2010). Calcaneus injuries are reported by patients with high complications (Firoozabadi *et al.*, 2013). Thus, it is necessary to treat the injuries of calcaneus such as open fractures with a main aim: maximize function and appropriate quality of life according to expectations for outcome (Beltran & Collinge, 2012).

Physical exercise in youth and adolescence positively affects the bone mass increase (Bielemann *et al.*, 2013), while training in adulthood may maintain the bone mass and mechanical competence (Ahola *et al.*, 2009). Similarly, exercise potentially prevents illness such as osteoporosis and bone fractures in women (Ahola *et al.*) because of decrease of bone loss in aging process (Karlsson *et al.*; Rasic & Tasic) and transformation of skeleton through increase of peak bone mineral density (Ahola *et al.*; Karlsson *et al.*; McKay *et al.*, 2000). Therefore, physical exercise is recommended as an intervention strategy to promote the optimal bone density

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during youth and to lower the speed of body mass loss in middle-aged and elderly adults (Martyn-St James & Carroll, 2008; Karlsson, 2004). According with a correct bone health, the American College of Sport Medicine (ACSM) recommends a mixture of endurance and resistance activities for maintaining of bone mass in adult and elderly women (Kohrt *et al.*). Similar study with Finnish females population aged between 35-40 years, worked out for 6 months intensely, showed an increase in bone mass density under the influence of training, which correlates with 12 month changes of bone mass (Ahola *et al.*).

The purpose of the present study was to evaluate the differences in bone density of right and left calcaneus of a sample of adult females during six-months Pilates-Interventional Program.

MATERIAL AND METHOD

Participants. The study analyzed a sample of 22 female participants (48.18±9.59) who voluntarily participated in the present study. The inclusion criteria of participants in the present study were i) not to have acute or terminal illness. Men were excluded because of the amount was not representative of the total. Participants were informed of the purpose of the present study.

Measurements. A cross-sectional study was used to assess calcaneus BMD of female participants. Body weight was measured to ±0.1 kg on an electronic scale (SECA, Hamburg, Germany) with participants wearing light indoor clothing and no shoes. Measurements were performed following the standardized techniques adopted by the International Society for the Advancement of Kinanthropometry (ISAK) (Ross & Marfell-Jones, 1991). BMI was calculated through dividing body weight (Kg) by the square of body height (cm). The calcaneus BMD was measured by an ultrasound densitometry, i.e. the method of qualitative ultrasound by “Sahara” ultrasound bone densitometer (Hologic, Inc., MA, USA), using non-ionizing ultrasound for evaluating bone density: BUA – left and right calcaneus [dB/MHz] and SOS – left and right calcaneus [m/s]. Results acquired by this method are sufficiently correlated with other methods as well as other

localizations. BMD is expressed as grams of mineral per square centimetre (g/cm²) or per volume (g/cm³) and all participants had the peak of bone mass and different intensity of bone loss. All assessment was carried out under the supervision of trained technicians.

Combining the measured values SOS and BUA by an algorithm is possible to mathematical index which provide a ‘quantitative ultrasound index’ (QUS). Except for this index, evaluated BMD is calculated, with the reference value 0.577.

Procedure. Data was collected twice. The present study was initiated in May 2011 with a pre-test and concluded in November 2011, performing a post-test (24 weeks). The interventional program had an 80% attendance rate during this period. The interventional program consisted of music-based aerobics and Pilates method, basic to intermediate level. The sessions included in this interventional program took place twice per week, and lasted 55–60 min per day-session, with an effective physical activity time of 45 minutes, in line with the requirements laid by the American College of Sports Medicine (2009). This study was approved by Ethical Committee of University of Novi Sad.

Statistical analyses. Normality of distribution was tested by means of the kolmogorov-Smirnov test. Clinical statistical methods were used for the calculations of the means and standard deviation (SD), minimal and maximum values of BUA, SOS and estimated BMD. In order to establish the differences in density of calcaneus and the speed of sound in the pre-post test, paired samples T-test was used for two dependent groups of participants. Data were analyzed using the SPSS statistical program (SPSS for Windows 19.0, Inc., Chicago, Illinois, USA). For all analyses, significance was accepted at P<0.05.

RESULTS

Based on the values of central and dispersion statistic parameters, as well as parametric normality of data distribution line, it was established that data distribution of all applied variables in this research do not deviate statistically significantly from the normal distribution (P<0.01).

Table I. Central and dispersion parameters of anthropometrical variables and body composition variables.

n= 22	Mean	SD	Min	Max	SKEW	KURT
Body Height (cm)	166.5	5.56	158.00	179.00	0.399	-0.257
Body Weight (cm)	62.22	6.23	46.00	74.00	-0.333	1.210
BMI (Kg/m ²)	22.46	2.17	18.43	25.71	-0.227	-1.011

SD= Standard Deviation; MIN= Minimum; MAX= Maximum; SKEW= Skewness; KURT= Kurtosis.

Table I shows descriptive parameters of anthropometric body composition variables: height, weight, and BMI value of participants. According to values of BMI the female participants belong to the group of normal-weight people. Tables II shows descriptive parameters for bone density variables BUA, SOS, est. BMD: mean, standard deviation (SD) pre-test/post-test

and p-value. According to descriptive parameters, there was a noticeable increase in variable values of broadband ultrasound attenuation (BUA) of the right and left leg on the post-test.

The speed of sound (SOS) was decreased by the end of Pilates-interventional program in the right leg, and slightly increased in the left leg. There was an increase in the value of assessed bone density (Est. BMD) post-test.

BUA variable showed a statistically significant difference pre-test/post-test both in right and left leg ($P < 0.01$). Statistically significant difference was noticed in the SOS after the Pilates-interventional program in the right leg ($P < 0.05$), without differences in the left leg. Estimated bone mineral density (Est. BMD) was not significantly different in the post-test assessment after the Pilates-interventional program neither in the left nor in the right leg.

Minimum and maximum value of BUA, SOS and Est. BMD are showed in Table III. Minimum and maximum values post-test are higher than values assessed pre-test.

Table II. Paired simples T-Test (BUA, SOS, Est. BMD).

	Pre-test	Post-test	P
BUA_Right (dB/MHz)	70.71±12.57	78.75±11.01	0.001
BUA_Left (dB/MHz)	71.35±12.62	80.32±8.96	0.001
SOS_Right (m/s)	1538.81±24.47	1533.2±18.27	0.027
SOS_Left (m/s)	1538.47±21.63	1538.1±19.1	0.88
Est.BMD_Right (g/cm ²)	0.4858±0.09	0.4914±0.07	0.5
Est.BMD_Left (g/cm ²)	0.4866±0.08	0.5087±0.07	0.06

BUA= Broadband ultrasonic attenuation; SOS= Speed of sound signals; Est. BMD= Estimated Bone Mineral Density.

Table III. Minimal and maximum values of BUA, SOS, Est.BMD (pre-test/post-test).

	Pre-test (Min–Max)	Post-test (Min–Max)
BUA_Right (dB/MHz)	50.81–104.24	61.43–105.83
BUA_Left (dB/MHz)	48.91–92.68	65.48–98.08
SOS_Right (m/s)	1503.56–1605.40	1501.97–1576.26
SOS_Left (m/s)	1500.94–1587.95	1505.32–1585.01
Est.BMD_Right (g/cm ²)	0.34–0.68	0.37–0.66
Est.BMD_Left (g/cm ²)	0.33–0.63	0.41–0.65

BUA= Broadband ultrasonic attenuation; SOS= Speed of sound signals; Est. BMD= Estimated Bone Mineral Density; Min= minimum; Max= Maximum.

DISCUSSION

The aim of the present study was to evaluate the differences in bone density parameter of right and left calcaneus of an adult females sample during six-months Pilates-Interventional Program. The main results show better

BUA in both right and left calcaneus, whereas the difference in SOS of right calcaneus was significant.

Physical exercise carries an important role in maintaining normal structure and functional bone strength during the lifetime (Karlsson *et al.*); therefore the bone quality in later life correlates with the habit of physical activity practice from the past. Yanagimoto *et al.* (2000) used ultrasound densitometry as a technique for measuring bone density in determining the effect of walking on bone quality. The BUA values predict fracture risk in older women white females (Brooke-Wavell *et al.*, 2008) and decrease with the aging process (Wehbe *et al.*, 2003), but the higher level of BUA was noticed in people who made more steps a day, which contributed to the normal level of bone quality (Muir *et al.*, 2013). Increasing the number of steps in daily activities by doing the simple everyday tasks, might prevent reduction of bone mineral density in postmenopausal women (Muir *et al.*), while walking itself as a unique exercise of intervention does not contribute to BMD in the lumbar region of spine although there were obvious positive effects on the upper part of the femur (Martyn-St James & Carroll).

High intensity of exercise improves the bone density in lumbar region of spine, proximal part of femur and density of calcaneus, measured by the quantitative ultrasound, among people who performed physical exercise and those who did not practice regular exercise (Vainionpää *et al.*, 2005). According to Chahal *et al.* (2014), the responsible exercise of change in the value of broadband ultrasound attenuation of calcaneus of middle-aged women, should reach the high threshold of intensity and high frequency range. In addition, may have beneficial effect on muscle strength and bone density in middle-aged women. Our findings follow the same results and conclusion of Chahal's study with the unique difference that we use Pilate's method as main content of session.

Pilates workout includes strength and flexibility exercises, and according to research the influence of strength training on bone status is still to be examined, considering the fact that three out of four studies which showed significant effect of strength training to bones were randomized studies, compared to four out of eight previous studies which were neutral or negative (Singh *et al.*, 2009). The same author confirmed through results that 9-month- strength training did not modify the BMD of premenopausal women to the whole body or regional parts of the body.

CONCLUSION

In conclusion, our findings showed that the bone density of the participants did not change either, but the value of the broadband ultrasonic attenuation (BUA) increased, and the speed of sound of the right leg decreased, which implies a better level of bone strength.

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MIKALACKI, M.; COKORILO, N.; OBRADOVIC, B.; MARIJANAC, A. & RUIZ-MONTERO, P. J. Efectos de un programa de intervención de pilates sobre parámetros de densidad ósea en el calcáneo de mujeres adultas. *Int. J. Morphol.*, 33(4):1220-1224, 2015.

RESUMEN: El ejercicio físico tiene una influencia positiva en el tejido óseo y por consiguiente, es recomendado a la hora de prevenir pérdida de masa ósea durante el envejecimiento. Igualmente, la práctica regular de ejercicio previene la osteoporosis y fractura de huesos en población adulta y mayor. Con el fin de evaluar las diferencias de parámetros en la densidad ósea (huesos calcáneos derecho e izquierdo) tras un programa de intervención Pilates de 6 meses, un total de 22 mujeres (48,18±9,59) participaron en el estudio. La densidad mineral ósea (DMO) fue estimada mediante la atenuación ultrasónica de banda ancha (AUBA) y la velocidad de las señales del sonido (VSS) a través del dispositivo de sonido "Sahara". La AUBA mostró diferencias significativas en ambos calcáneos (P<0,01), la VSS obtuvo diferencias significativas en el calcáneo derecho (P<0,5) y la DMO no mostró significancia alguna tras el programa de intervención. En conclusión, el calcáneo incrementó mediante medición AUBA mientras que VSS fue significativo en el calcáneo derecho. Nuestros resultados podrían implicar un mejor nivel de fuerza del calcáneo después de una intervención específica con Pilates.

PALABRAS CLAVE: Ejercicio físico; Calcáneo; Atenuación ultrasónica de banda ancha; Velocidad de las señales del sonido.

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