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**Original Article**

# The Relationship of Physical Activity and Anthropometric and Physiological Characteristics to Bone Mineral Density in Postmenopausal Women

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## Abstract

The aim of this study is to investigate the relationship of physical activity and anthropometric and physiological characteristics to bone mineral density (BMD) in postmenopausal women. Ninety-seven postmenopausal women with an average age of 50.71 ± 6.86 yr were selected to participate in this study. After completing consent forms and the questionnaire on physical activity, the amounts of calcium and 25-hydroxyvitamin D levels in participants' blood were measured by blood tests. The BMDs of the subjects in the lumbar spine (L2–L4) and hip were measured by dual-energy X-ray absorptiometry device and the results were recorded. Also, anthropometric characteristics including height, weight, body fat percentage, body mass index, waist-to-hip ratio (WHR), digit ratio (2D:4D), skeletal muscle mass index, hand and calf circumferences and physiological parameters, including handgrip strength, quadriceps isotonic extension strength and balance of the subjects, were measured. The results showed that the 2D:4D ratio and skeletal muscle mass index had a significantly positive relationship with BMD of the lumbar spine ($p \leq 0.05$) and the hip ($p \leq 0.05$). Also, there was a negative relationship between the BMD of lumbar spine and hip and WHR ($p \leq 0.05$). Moreover, there was a positive relationship between the calf circumferences and lumbar spine BMD ($p \leq 0.05$). Contrary to this, there was no significant relationship between the calf circumference and the hip BMD, and between hand circumference with lumbar spine and hip BMD ($p > 0.05$). Results of physiological indices showed a significant positive relationship between physical activity, handgrip strength, quadriceps isotonic extension strength, standing on 1 foot with the lumbar spine and hip BMD ($p \leq 0.05$). But the relationship was not observed between BMD and the ability to squat down on the floor ($p > 0.05$).

Based on these results, it seemed that we can use some physiological and anthropometric indices that are important determinants of BMD and risk of osteoporosis in postmenopausal women.

**Key Words:** 2D:4D; bone mineral density; handgrip strength; physical activity; postmenopausal women.

## Introduction

Aging is related to decreased functions of muscles and bones, leading to osteoporosis and sarcopenia *(1)*. Osteoporosis is a silent disease that is characterized by loss of bone density. This disease has been proposed as a growing health problem in the world and in Asian countries due to

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older populations (2). Osteoporosis is a systemic skeletal disease identified by reduction of bone density and destruction of bone tissue and increase of bone fragility (1), and experts classified it into 2 types: primary (intrinsic bone disorder) and secondary (caused by another disease or side effects of treatment). Primary bone disorders may be related to immobility (inability to move) (3). The World Health Organization (WHO) defines osteopenia and osteoporosis based on bone mass: osteopenia is bone mass less than −1 and more than −2.5 standard deviations in relation to the mean bone mass of young adults, and osteoporosis is bone mass less than −2.5 standard deviations in relation to the mean bone mass of young adults (4).

The aging process, along with changes in body composition, leads to bone and muscle loss. Progressive loss of muscle mass occurs approximately at the age of 40 (5). After menopause, muscle mass is reduced by 3% per year, and between the ages of 40 and 80 yr, 30%–50% of muscle loss occurs (5).

The aim of the present study was to evaluate the relationship of physical activity and anthropometric and physiological characteristics to bone mineral density (BMD) in postmenopausal women. In the past decades, several studies have been conducted in this field and mixed results were obtained from different societies, but this relationship has not been studied in Iranian women. Also in the present study, the researcher wants to examine the relationship of 2D:4D ratio, waist-to-hip ratio (WHR), and calf circumference to BMD in postmenopausal women for the first time.

## Materials and Methods

This was a descriptive study and the University Ethics Committee approved the terms of the project. Participants declared their preparation on a voluntary basis, after announcements in medical offices and associated laboratories. The participants in the study who suffered from hypothyroidism or hyperthyroidism, parathyroid and adrenal glands, diabetes, established rheumatologic diseases; had a history of drugs affecting BMD (corticosteroids); had advanced heart disease or any type of cancer; had an implant in the body, fractures in the previous months, complete bed rest for 3 consecutive months; or those who were smoking and consumed alcohol were excluded from the study (6,7). In the first session, the level of physical activity was measured using the Beck questionnaire of physical activity (8). Also, participants filled in consent forms, and general health information on menopause and age of menopause onset were required from the subjects. In addition, blood levels of calcium and 25 OHD were measured and people who had normal blood levels participated in the study. After explaining the procedures and working methods, measurements were carried out. First, the anthropometric indices and then physiological parameters were measured. All measurements were performed at 8–12 AM. In a separate meeting, the BMD of participants was measured and was classified according to WHO classification in 3 groups: healthy, osteopenic, and osteoporotic.

### *Anthropometric Measurements*

Heights and weights of the subjects were measured and then body mass index was calculated using the formula of weight divided by the square of height. Also, for the measurement of WHR, first, the waist and the hip circumferences were measured in a standing position, then by dividing the waist-to-hip circumference, WHR was calculated. For measuring calf circumference, a tape measure was used on the right leg. While the subject was standing, a tape was placed around the largest part of the leg circumference and the maximum circumference of leg was recorded (subcutaneous tissue was not compressed) (9). To measure the hand circumference, a tape was used. The widest part of the palm was measured by using tape and wrapping it around the palms (10).

In addition to measure skeletal muscle mass (SM), the skeletal muscle mass index (SMI) was used. To calculate the SMI, first SM was calculated using the following formula (11):

$$\begin{aligned} \mathrm{SM} = {} & 0.244 \times \mathrm{weight} + 7.80 \times \mathrm{height} \\ & + 6.6 \times \mathrm{sex} - 0.098 \times \mathrm{age} + \mathrm{race} - 3.3 \end{aligned}$$

$$\left(R^2 = 0.86,\ p < 0.0001,\ \mathrm{SEE} = 2.8\ \mathrm{kg}\right)$$

where sex = 0 for female and 1 for male, race = −1.2 for Asian, 1.4 for African American, and 0 for white and Hispanic.

Then SMI was calculated by dividing the SM (kilogram) by squared height (square meter) (11).

The digit ratio of the right hand was calculated according to the method recommended by Manning et al (12). The lengths of the index and ring fingers were measured on the palmar surface of the hand from the basal crease proximal to the palm to the tip of the finger using digital calipers (Mitutoyo, model digimatic caliper 500-151-20, Mitutoyo, China) with the accuracy of 0.01 mm. After measuring the length of the fingers, again measurements were repeated and the mean of the 2 measurements was recorded. The 2D:4D ratio was obtained by dividing the length of the index finger by the length of the ring finger (12).

### *Physiological Measurements*

#### *Handgrip Strength (HGS)*

HGS was measured using a digital dynamometer (Seahan, model SH5003, Seahan Co, South Korea). The participants performed the test in a sitting position on a chair, with their elbow extended to 180° along the vertical axis and their wrists in slight extension. This test was repeated 3 times with 15 s between trials, and the mean value was recorded in kilogram (right hand was dominant in people and the reliability $r = 0.96$ for the present device was recognized as high) (13).