

Bone Mineral Density in Prepubertal Female Swimmers

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Abstract

The purpose of this review study is to present the effect of swimming practice on bone mineral density in prepubertal female children as compared with the same age of children and gymnasts following former studies. The bone mineral density of prepubertal swimmers is the same as that of general girls. The impact load from the vertical direction increases the bone mineral density of the several sites in female gymnasts, but the increase in bone mineral density of swimmers due to mechanical stimulation may not be observed.

Publication History:

Received: November 23, 2020

Accepted: December 01, 2020

Published: December 03, 2020

Keywords:

Gymnast, Femoral neck, Bone mineral content, Spine, Radius

Introduction

It is important to maintain the independence of the elderly and the quality of life in aged people. The stroke and the fracture on femoral neck lead to deterioration of physical function, which causes bedridden and long-term care. This has caused an increase in medical expenses and social security costs, and has become a major social problem in developed countries. As these preventive measures, a lifestyle that focuses on moderate exercise, a well-balanced diet, and adequate sleep in younger ages is recommended.

It has been pointed out that osteopenia and osteoporosis are problems that affect various bone tissues due to aging. Osteopenia is a decrease in bone mass due to a decrease in bone calcium deposition, a decrease in bone density and insufficient bone synthesis. The osteoporotic phase is bone loss and skeletal tissue atrophy without bone resorption. It often occurs in postmenopausal women, and causes such as aging, abnormal hormone secretion, lack of exercise or insufficient nutrition have been reported. In order to prevent age-related osteoporosis, it is important to increase the bone mass level in children and adults as much as possible, and to prevent age-related loss of bone mass and bone quality.

The puberty is a very important period for bone formation during growth, and it has been reported that the stage of female peak bone mass acquisition is 3 years from 11 to 14 years [1]. Furthermore, it has been pointed out that physical activity in childhood is an important determinant of peak bone mass in women and may contribute to bone stiffness and trabecula after the secondary sexual characteristics [1].

Therefore, in this study, we organized related literature with the keywords "BMD/BMC", "Children/prepuberty", and "swimmer", and examined the bone mineral density of prepubertal (pre-secondary sexual characteristics) swimmers. The purpose was to compare BMD/BMC in female swimmers with other athletes.

Research Method

Eight original papers submitted to overseas specialized journals were extracted. Five studies were excluded with regard to measurements, number of subjects, and age.

Results and Discussion

The three extracted studies were conducted in pre-adolescent girls, and bone mineral density and/or bone mineral content were measured by dual energy X-ray absorptiometry (DEXA), but studies using other measurement BMD/BMC were excluded. Studies involving adult

women were also excluded from the study. Figure 1 presents number of subjects, sports, body composition and BMD/BMC.

Body Compositions in the Prepubertal Female Athletes

Cassell et al. [2] measured the whole body bone mineral density of 14 gymnasts, 14 swimmers (5 synchronized swimmers, 9 swimmers) and 17 girls of the same age. As a result, gymnasts showed significantly lower body fat percentage and body fat mass than swimmers and general girls ($p < 0.001$), but among the three groups in terms of height, weight, and lean body mass. No significant difference was found in. Courteix et al. [3] measured bone mineral density and bone mineral content of 10 swimmers, 18 gymnasts, and 13 girls of the same age by the DEXA method. The measurement sites were the whole body, lumbar region (lumbar vertebrae 2 to 4), radius, femoral neck, greater trochanter, and Ward's triangle of the thigh. There were no significant differences in height, weight, body fat percentage, lean body mass, and calcium intake, but the body mass index (BMI) was significantly reduced in gymnasts ($P < 0.01$). Courteix et al. [4] measured the bone mineral density and bone mineral content of 12 swimmers, 32 gymnasts, and 16 girls of the same age by the DEXA method. The measurement sites were the whole body, lumbar region (lumbar vertebrae 2 to 4), radius, femoral neck, greater trochanter, Ward's triangle of thigh, head and ribs. As a result, there were no significant differences in height, weight, body fat percentage, lean body mass, and calcium intake, but the body mass index (BMI) was significantly reduced in gymnasts ($P < 0.01$). In these three studies, the study contents and research results could be compared because the subjects were prepubertal gymnasts, swimmers and general girls. The difference among the three studies on body composition is that the two studies by Courteix et al. did not show a significant difference in the body fat percentage of gymnasts compared to swimmers and general girls. The fat percentage in gymnasts was around 15%, which was more than 5% lower than the other two groups. Therefore, the gymnasts in these studies were lean. The swimmers however practice every day had the same body fat percentage as general girls supports the results of previous studies that the body fat percentage is unlikely

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Citation: Hiruma E (2020) Bone Mineral Density in Prepubertal Female Swimmers. Int J Phys Ther Rehab 6: 167. doi: <https://doi.org/10.15344/2455-7498/2020/167>

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Study	Age (yrs)	No. of Subjects & Activity	Outcomes
Cassell et al. (1996)	7-9	14 gymnasts (Gym) 5 synchronized swimmers (Swim) 9 speed swimmers (Swim) 17 controls (CON)	BMD total body Gym > Swim, CON
Courteix et al. (1998)	10.5 ± 1.4	10 swimmers (Swim) 18 gymnasts (Gym) 13 controls (CON)	BMD & BMC whole body no difference BMD & BMC L2-4 Gym > Swim, CON BMD & BMC femoral neck Gym > Swim, CON BMD & BMC Ward's triangle Gym > Swim, CON BMD trochanter no difference BMD radius Gym > Swim, CON
Courteix et al. (1999)	7-12	12 swimmers (Swim) 32 gymnasts (Gym) 16 controls (CON)	BMD & BMC whole body no difference BMD & BMC L2-4 Gym > Swim, CON BMD & BMC femoral neck Gym > Swim, CON BMD & BMC trochanter no difference BMD Ward's triangles Gym > Swim, CON BMD & BMC radius Gym > Swim, CON BMD & BMC head Gym < Swim, CON BMD & BMC ribs no difference

Figure 1: Bone mineral density and/or bone mineral content in prepubertal female swimmers. BMD total body: spine + hip, BMD: Body Mass Density, BMC: Body Mass Content.

to decrease in order to maintain body temperature during exercise in water.

BMD/BMC in Prepubertal Female Athletes

The BMD total body measured by Cassell et al. [2] is the total BMD of the lumbar spine and pelvis. It was confirmed that the bone mineral density of the waist of the gymnast was significantly higher than that of the swimmer and general girls. The femoral neck and the thigh Ward's triangle are the bone mineral densities of the thigh, which are important for the prevention of osteoporosis, and the bone mineral densities in these parts were also significantly higher in the gymnasts. The bone mineral density of the lumbar region and thigh was significantly high due to the impact load from the vertical direction in daily practice such as landing motion. In the gymnastics, they supported their body by the arms during floor exercise, vault and horizontal bar. It is considered that the bone density of the radius was also affected because the impact load was applied to the arms. It is probable that the swimmer did not affect the acquisition of bone mineral density in spite of the high intensity training because the impact load was not applied to the bone tissue. In addition, elite swimmers practice in water for most of time in each practice. The phenomenon reduces the gravitational component and reduces the load on the weight-bearing bones. Under these conditions, the subject can be considered to be in relatively weightlessness, which might be the cause of bone loss. However, from the results of these three studies, all the measured bone densities were the same as those of general girls, so daily underwater training, which is less likely to apply impact load to bone tissue, causes an extra increase in bone density as compared with gymnasts. The mechanical stimulation of the hip joint

by flutter kicking in water did not have the effect of increasing bone density more than in daily life.

Conclusion

The bone mineral density of prepubertal swimmers is the same as that of general girls. In addition, as for the bone mineral density of gymnasts, the impact load from the vertical direction increases the bone mineral density of the site, but the increase in bone mineral density of swimmers due to mechanical stimulation may not be observed.

Competing Interests

The author declare that there is no competing interests regarding the publication of this article.

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