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Literature review

Artistic gymnastics in youth and bone mineral density retention in adulthood – a strategy for the prevention of osteoporosis? A narrative review of the literature

Ginástica artística na juventude e retenção da densidade mineral óssea na vida adulta – estratégia para a prevenção da osteoporose? Uma revisão narrativa da literatura

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ABSTRACT

Osteoporosis affects a large part of the elderly population and leads to functional limitations. The practice of physical activity can delay osteoporosis, especially when it involves great demands of force and impact, but advanced osteopenia is hardly reversed. The main contribution of exercise seems to be in youth, through the maximization of bone mineral density (BMD) peaks. Studies on retention of BMD in adulthood in response to different physical activities are needed. Artistic gymnastics (AG) fits the profile of activities with high osteogenic potential, with movements that combine strength and impact (jumping, etc). Children and adolescents who practice AG tend to exhibit high BMD peaks. The present narrative review analyzed the literature on BMD retention resulting from the practice of AG in middle-aged and older individuals. The available evidence suggests that: a) from an early age, children, and adolescents who practice competitive AG exhibit higher levels of BMD vs. individuals of equivalent age physically inactive or practicing other sports; b) the few comparative studies that investigated the potential for BMD retention due to the practice of AG in youth, indicate that, at least until middle age, former gymnasts of both sexes tend to exhibit greater bone mass than the general population. Despite these promising results, there is a lack of research on BMD retention in older adults who practiced competitive AG in their youth. This would be important since it is in this age range that advanced osteopenia occurs and a higher prevalence of osteoporosis is effectively observed.

Keywords: aging; osteopenia; bone; sports; health.

RESUMO

A osteoporose acomete grande parte da população idosa, contribuindo com limitações funcionais. A atividade física pode retardar a osteoporose, especialmente quando envolve grandes demandas de força e impacto, mas a osteopenia avançada é dificilmente revertida. A principal contribuição do exercício parece situar-se na juventude, pela maximização dos picos de densidade mineral óssea (DMO). Estudos sobre a retenção da DMO na vida adulta em resposta a diferentes atividades físicas são necessários. A ginástica artística (GA) encaixa-se no perfil de atividades com alto potencial osteogênico, com movimentos que combinam força e impacto (saltos, etc). Crianças e adolescentes que a praticam tendem a exibir picos de DMO elevados. A presente revisão narrativa analisou a literatura acerca da retenção da DMO decorrente da prática de GA em indivíduos de meia idade e idosos. As evidências disponíveis permitem pensar que: a) desde idades precoces, crianças e adolescentes que praticam GA competitiva exibem níveis maiores de DMO vs. indivíduos de idade equivalente fisicamente inativos ou que praticam outras modalidades desportivas; b) os poucos estudos comparativos que investigaram o potencial de retenção da DMO devido à prática de GA na juventude indicam que, pelo menos até a meia idade, ex-ginastas de ambos sexos tendem a exibir maior massa óssea que a população em geral. Apesar desses resultados promissores, há carência de pesquisas acerca da retenção da DMO em idosos que praticaram GA competitiva na juventude. Isso seria importante, uma vez sendo nessa faixa que se observa osteopenia avançada e, efetivamente, maior prevalência de osteoporose.

Palavras-chave: envelhecimento; osteopenia; osso; desporto; saúde.

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Introduction

Osteoporosis is a public health problem, with a high prevalence in the elderly and characterized by an extreme reduction in bone mineralization, making them more fragile and susceptible to fractures [1]. It consists of a painful and disabling condition, with a negative impact on quality of life. About 15 years ago, the International Osteoporosis Federation (IOF) estimated that about 9 million fractures occurred annually from causes related to osteoporosis [2]. In Brazil, there are about 10 million diagnosed individuals, with more than 100,000 cases of fractures per year [3]. Osteoporotic fractures have serious consequences, leading to early dependence and immobility. The mortality rate of the elderly in the first year after disabling hip and femoral neck fractures can reach 15 to 20% of cases [1,3,4].

The increase in bone mineral density (BMD) in youth is acknowledged as crucial to increasing fracture resistance at older ages. Most epidemiological studies indicate that increasing BMD during growth tends to reduce the risk of fractures due to bone loss [5-7]. Evidence indicates that 50% of BMD in old age is due to the peak reached in youth [6,8]. Therefore, the BMD achieved during puberty is a consistent marker of osteoporosis risk [9]. One-standard deviation reduction in bone mass achieved in the growth process can increase the risk of osteoporotic fractures by about 90% [10].

Given this, strategies to prevent osteoporosis should be applied throughout life, with many advantages arising from interventions capable of increasing bone mineralization at an early age [5]. Many authors suggest that the best way to prevent osteoporosis is to apply physical efforts capable of increasing the BMD during youth [1,5,6]. For this reason, several professional organizations [1,5,11] recommend that optimizing BMD at the end of the growth process is a major strategy to prevent osteoporosis and promote bone health in adulthood.

In this context, the possible retention of BMD due to physical activity in youth is an important aspect when analyzing the role of physical activity in the prevention of osteoporosis. Investigations that provide information on this topic are important within the relationship between sports and health promotion. The end of childhood to the beginning of adolescence represents a period in which biological factors associated with growth and bone development vary considerably [5] since accelerated biological changes occur. Despite this, the idea of an opportunity window when the bone is more responsive to exercise is attractive. Planned interventions using motivating sports for children could benefit bone mineralization not only immediately, but with lifelong impact [12,13].

Among the modalities with the potential to increase BMD, artistic gymnastics has been gaining popularity among children and adolescents, including in school settings. Several reports suggest that gymnasts exhibit greater BMD than athletes involved in modalities with lower impact on the bone structure [14, 15]. On the other hand, there are doubts about what happens to bone mass when the practice of artistic gymnastics is discontinued. Some studies indicated that there could be retention for a few years, but data are still episodic and sparse [16-19]. Reviews capable of summarizing the current knowledge are useful for professionals and researchers who deal with the modality, whether in professional intervention or in identifying gaps for future research.

The studies that investigated the relationship between artistic gymnastics and BMD retention are mostly cross-sectional, limiting the contribution of meta-analyses due to the lack of pre- vs. post-intervention data. On the other hand, a search involving the terms "gymnastics", "adulthood", and "bone mineral density or bone mass" and correspondent MeSH terms in Pubmed, Scielo, Web of Science, Sportsdiscus, and Scopus found only 18 articles related to the topic. Thus, we decided not to exclude studies and to adopt a narrative approach (although the review can be considered exhaustive) to summarize the results on the relationships between the practice of artistic gymnastics, bone health, and osteoporosis. The review focused on data that support or oppose the notion that artistic gymnastics practiced during growth can influence the bone structure in adulthood.

In the first part, we present the main features of the pathophysiology of osteoporosis. Next, we analyze the bases on which certain types of physical exercise are considered to contribute to a greater peak in BMD during youth. Based on this, the last part of the review deals with the contribution of artistic gymnastics to maximizing bone mass in childhood and adolescence, as well as presenting the studies that analyzed the hypothesis that these gains would extend into adulthood.

Pathophysiology of osteoporosis

To fulfill their functions, bones have contradictory properties: in addition to being rigid enough to resist the compressive loads imposed by gravity, they need to be flexible to absorb this energy, therefore deforming without breaking [20]. Bone is a tissue in permanent renewal, depending on incident lines of force. In this way, it is reinforced where necessary, resisting the pressures and deformations that represent a risk, while remaining relatively light.

The balance between bone formation and resorption is promoted by three types of cells: osteoblasts, osteocytes, and osteoclasts [21]. Osteoblasts originate in the bone marrow and are responsible for the formation of bone tissue, producing the organic matrix in which crystallized calcium salts will be deposited. As the bone matrix is synthesized, osteoblasts are involved in it and are called osteocytes, which lodge in gaps within the mineralized bone tissue. Osteoclasts respond to the body's need for calcium, whereupon they simultaneously remove osteoid and calcium salts. Therefore, their function is to promote bone resorption, decalcifying the bone tissue.

The human skeleton is made up of about 20% trabecular (spongy) bone and 80% cortical (compact) bone [20,21], which have different mineralization levels. While cortical bone has 80% of its volume mineralized, trabecular bone has only 15-25%, with the remaining volume occupied by the bone marrow, fat, and blood vessels. The outer surface of long bones (diaphysis) is covered and protected by a membrane called the periosteum, while the inner surfaces are covered by a membrane made up of delicate connective tissue called the endosteum. Both the periosteum and the endosteum are capable of producing osteoblasts and osteoclasts. Calcium consists of the mineral content of bones, in balance with the amount found in other body fluids and tissues. These reserves are interchangeable: if there is a calcium deficit, the bone resorption process makes it available to the rest of the body [20].

Normally, there is balance in the activity of osteoblasts and osteoclasts [21]. Bone apposition reflects a renewing of the bone matrix (anabolism), replacing the tissue reabsorbed by the osteoclasts and functionally adapting the bone to the external demands. The reabsorption process (catabolism) is important to maintain constant extracellular calcium levels. Many factors influence this balance, such as genetic constitution, nutrition, and mechanical stimuli. When catabolic predominate over anabolic processes, bone loss occurs, which is called osteopenia. When factors inhibiting bone formation are present, such as hormonal deficits, limitations in calcium absorption, or physical inactivity, a negative balance in the balance of bone remodeling is hastened, resulting in bone weakening and, ultimately, osteoporosis.

The peak of BMD occurs between 15 and 20 years of age in both sexes [4,5]. After that, bone mass begins to decline, a process that occurs throughout life due to an imbalance in remodeling. Bones lose both their collagen matrix and mineral content but retain their basic organization. In women, bone mass decreases rapidly during the three to seven years immediately after menopause, mainly due to a lack of sex hormones [22,23]. Thus, bone resorption exceeds bone formation as women approach 40 years of age. In men, BMD declines at a slower pace, but over longer periods [24]. In females, trabecular bone decreases at a rate of 1-2% per year, reaching 2-10% annually after menopause, while in males, the loss is approximately 0.4% per year, starting from the age of 50. It is estimated that BMD declines with aging at 30-40% for women and 20-35% for men, in comparison with the peak attained in youth [1,20].

Due to the absence of symptoms, bone mass can be lost for years before osteoporosis is diagnosed. As already mentioned, in postmenopausal women osteopenia is more accelerated, so osteoporosis tends to be more acute than in men since hormones such as estrogen and progesterone seem to play a proactive role in bone remodeling – in addition to inhibiting bone resorption and directly participating in intestinal calcium reabsorption, there is evidence that osteoblasts and osteocytes have specific receptors for these hormones, which would explain the acceleration of osteopenia in females after this phase [21,20].

The pathophysiology of osteoporosis also appears to relate to the overactivity of osteoclasts, resulting in deep and abnormal resorption cavities, concomitantly with a decline in osteoblast activity with an incomplete filling of these cavities. The bone, therefore, becomes more porous and fragile. Although bone remodeling occurs at all skeletal sites, turnover is faster in trabecular bones compared to denser cortical bones. Trabecular bone is more reticulated or spongy, making the sites where it predominates more prone to the effects of osteoporosis [1,21].

The rate of osteopenia varies according to body segment, nutrition, hormonal status, and physical activity habits [3,25], and its extension is different among individuals of equivalent age. If osteopenia is inevitable, a question arises to what extent osteoporosis is an inexorable aspect of aging or can be prevented. In any case, the impact of physical exercise on bone health is recognized, at least in terms of attenuating the bone demineralization process. The next section discusses the relationships between physical activity and the development of osteoporosis.

Physical activity and osteoporosis prevention

Physical inactivity is a risk factor for osteoporosis, which is why intervention programs including exercises are indicated as a strategy to maintain bone integrity. It is interesting to note that osteoporosis and sarcopenia (the loss of muscle mass and strength typical of aging) are closely related. First, it is logical to think that the reduction in muscle mass and strength results in lower conditions to apply tension on the bone, reducing the external mechanical pressures that stimulate the formation of the bone matrix. Mutual influences exist also at the level of tissue formation – since muscle and bone cells derive from common mesenchymal progenitor cells, they both secrete cytokines and growth factors that mutually influence their metabolism [26]. In short, maintaining muscle mass helps in bone preservation. Consequently, the Brazilian Society of Rheumatology recommends the regular practice of muscle strengthening exercises, particularly in the lower limbs to preserve the overall bone mass [25].

The impact of physical activity on bone metabolism is due to mechanical stress and hormonal influence. The mechanical tension applied longitudinally to the bone causes deformation in certain areas, generating endogenous signals captured by the osteocytes. As a result, osteoblasts migrate to sites at risk of fracture, reinforcing them with new bone apposition. On the other hand, in the absence of this type of stimulus, osteoclasts reabsorb calcium in places where there is no need, weakening the tissue [24]. It has been shown that bedridden patients under prolonged immobilization can exhibit a 1%/week decline in trabecular bone density [27].

Two factors are at the origin of mineralization resulting from longitudinal stress applied to bones: the magnitude and rate of deformation induced by loads. This suggests that training aimed at stimulating bone apposition should include, in addition to exercises with high percentages of maximum strength, also muscular power exercises. The osteogenic effect is greater when loads approaching the limit of bone strength are applied a few times, than in exercises performed with lower loads and many repetitions [1,20]. In other words, training effects are closely associated with implementing high loads or mechanical impact [1,19,25]. Furthermore, the osteogenic effect is specific to the regions over which tension is applied [1]. Consequently, varying the exercises means increasing the chances of a positive impact on BMD in more bones.

The possibilities of reversing osteopenia at advanced ages are reduced [1,6]. Thus, the peak bone mass achieved in youth appears to be a central factor in reducing the risk of osteoporosis [6,7]. The literature suggests that this would perhaps be more effective than later interventions or palliative measures [1]. Therefore, it is essential to keep in mind that bone resistance is increased during the growth process. In this phase, interventions should seek to increase the total bone mass as much as possible.

The benefits of high-impact activities apply to children, appearing to hold even in adults genetically predisposed to have reduced BMD [12,28]. It is well accepted that bone mass achieved in adolescence is a predictor of BMD in old age, particularly in regions such as the hip, femoral neck, and lumbar spine [28,29]. In addition, the physical activity levels in adolescence are positively associated with other indicators, such as bone size, mineral content, and resistance of several bones in adulthood. [5]. Such retention of BMD has been understood as an opportunity to reduce the risk of future osteoporosis.

The growth period, particularly puberty is privileged for the osteogenic effects of physical activity [1,4]. Evidence is strong that resistance training is effective in increasing BMD in adolescents [5]. Although the ideal intensity is still undefined, it is accepted that overloads should be vigorous and applied longitudinally to the bones [30,31]. Impact activities – that is, where ground reaction forces are reflected in the skeletal system – appear to have the greatest potential for bone mineralization [5,32]. In this type of exercise, the movements favor muscle power in concentric and eccentric contractions performed in short periods and with high intensity. Good examples are plyometric exercises, in which successive jumps are often applied [33]. However, different exercise routines involving jumping, even in school settings seem to have beneficial effects on BMD [34].

Khan *et al.* [35] reviewed the literature associating physical activity in childhood with bone mineral content in adulthood. Studies have been described demonstrating that pre and peri-pubertal gymnasts exhibited BMD gains much higher than those that could be achieved in adulthood. Despite highlighting the influence of biases due to sample selection or nutrition, it has been suggested that BMD responses tend to be greater when the bone is exposed to mechanical loads before the end than after puberty. In addition, studies with retired athletes indicate that, at least partially, bone gain in adolescents may persist in adults. Thus, it appears that physical activity during the most active period of maturation (concerning the longitudinal growth of the body) would play a vital role in optimizing the peak bone mass and that these benefits tend to extend into adulthood. It should be noted that BMD responses to exercise appear to be greater during pre-adolescence [1,5,36]. MacKelvie *et al.* [13] demonstrated that the onset of puberty would be a particularly sensitive period for bone mineralization due to physical exercise. In girls, this would correspond on average to the range of 10-12 years, while in boys the corresponding maturation stage would be between 12-14 years.

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If the peak BMD occurs at puberty, 26% of total bone mineral content accumulates in just two years at this stage of life [37]. Changes in BMD during adolescence are sensitive to the pattern of physical activity and a decrease in its levels can have a negative impact, significantly reducing the peak bone mass [5]. Therefore, puberty represents a relatively small window for optimizing the effect of physical activity interventions. Active children may reach late adolescence with 10-15% greater bone mineralization than physically inactive counterparts [5, 30]. This can be an advantage in preventing osteoporosis.

Artistic gymnastics and bone mineral density

It appears from the previous sections that maintaining high levels of physical activity is essential to preserving bone health. The positive influence of physical exercise on BMD would be the result of the transmission of mechanical loads to the skeleton, adding the gravitational force to the muscle tension at the tendon insertion sites [1,6,38]. Although the effects of exercise on the skeletal system are not yet fully understood, data from most studies suggest a significant correlation between BMD and lifetime rates of physical activity [1,5,6,24,39].

During the early stages of puberty, the bone may be particularly responsive to the weight-bearing and high impact of exercise, achievable in a variety of youth sports and activities [5]. In terms of bone health, the objectives of physical exercise during the growth phase are related to maximizing the BMD. Other factors also contribute to this purpose, such as adequate calcium intake, but exercises that apply tension to the bones are considered the most effective isolated strategy [39, 40]. The combination of high-impact activities (such as jumping) with mobilization of high relative loads is recognized as an ideal intervention [1,5,6,20]. Furthermore, the regional specificity of bone apposition favors modalities that involve a wide variety of movements [41].

It seems clear that artistic gymnastics fits this profile well. Some gymnastic movements can produce forces 10-15 times greater than body mass [1]. Just to illustrate, a two-year study of gymnasts showed increases in BMD of 2-4% during the competition phase, with a 1% reduction in the transition phases [42]. It is therefore understandable why some studies indicate that gymnasts tend to exhibit greater bone mass than other athletes whose impact on the lower limbs can be considered high, as is the case of runners [19].

Regarding bone development and the possibilities of reaching higher BMD peaks, there is consistent evidence that artistic gymnastics (recreational or competitive) brings benefits from an early age. Even reduced training volumes can provoke favorable adaptations [43]. Gruodyte-Raciene *et al.* [44], for example, demonstrated that children aged 4 to 6 years who practiced gymnastics about 1-2 h per week for 16 weeks already exhibited better geometric and architectural bone properties than non-practicing children. In the same direction, Zanker *et al.* [45] showed that 7-8-year-old girls and boys who had been practicing gymnastics for 3-4 years exhibited higher BMD than untrained children.

Another argument that has been deconstructed concerns possible damage to the development of the skeleton due to delays in menarche or occurrence of oligomenorrhea (irregular menstruation) in girls submitted to the large volumes of training usually applied in artistic gymnastics. A study developed with former Swedish gymnasts aged 19 to 23 years revealed that despite the age of menarche being on average two years later than in girls who did not practice the modality, total and regional BMD were similar between the groups [46].

It is a fact that children and adolescents who practice artistic gymnastics tend to exhibit better bone structure than those engaged in activities with lower strength/power requirements or longitudinal tension on the bones. Cassel *et al*. [47] compared girls aged 7-9 years who practiced gymnastics or swimming or were physically inactive. Despite being lighter than girls in the other groups, gymnasts always exhibited higher BMD per kg of body mass. Maïmoum *et al*. [48] carried out a similar study, comparing bone mass and geometry in girls aged 10 to 18 years who practiced artistic gymnastics, rhythmic gymnastics, or swimming, or were physically inactive – again, the results were advantageous for those who practiced gymnastics, especially after menarche. In agreement with those findings, Burt *et al*. [14] published a systematic review summarizing the literature on the impact of artistic gymnastics on the skeletal health of male children and adolescents. The trend of studies including girls was confirmed, in the sense that gymnasts exhibited higher BMD and wider bones than non-practicing individuals.

Experimental or longitudinal studies are occasional, due to the difficult control of potentially confounding variables. Nickols-Richardson *et al*. [49] and Laing *et al*. [50] found a significant increase in BMD among adolescent girls after one and three years of practicing the modality, respectively. In a later work, Laing *et al*. [51] confirmed this trend in younger children (4-8 years old) who practiced recreational artistic gymnastics for 24 months. Increases in BMD (total and in different body regions) occurred in comparison with children who were inactive or involved in non--gymnastic activities. We could locate two longitudinal studies that reported data in the same direction. Bass *et al*. [16] followed female prepubescent gymnasts (around 10 years of age) for 12 months, observing an increase of 30-85% greater in BMD vs. girls who practiced activities of lower impact, especially in body sites exposed to greater training loads. Exupério *et al*. [15] compared the increase in BMD and bone geometry/formation in girls aged 11-16 years who practiced and did not practice gymnastics followed for 12 months. Increases of 10-19% in bone mass at different sites were detected in gymnasts but not in controls.

Physical exercises performed during the growth phase tend to increase the peak BMD, particularly when they involve high levels of longitudinal stress on the bones [3,5]. For this reason, the official position of the American College of Sports Medicine (ACSM) regarding the relationship between physical activity and osteoporosis proposes two general strategies to increase fracture resistance at advanced ages [1]: a) maximize the increase in BMD during the first 30 years of life; b) minimize the reduction in BMD after 40 years of age.

In this sense, artistic gymnastics again deserves attention. Its profile is generally associated with a high impact on bones and high strength demands, with positive effects on the BMD. Despite the few available studies, it can be affirmed that the practice of artistic gymnastics at a competitive level increases the chances of reaching higher peaks of BMD. From an early age, gymnasts seem to exhibit greater bone mass than children of a similar age, even if they practice other sports. However, since the main contribution of physical activity in the prevention of osteoporosis lies in maximizing BMD in youth, in addition to the potential effects of artistic gymnastics on BMD it is important to clarify a question: a) would there be retention of the BMD achieved at end of growth in gymnasts, contributing to the reduction of the risk of osteoporosis in advanced ages?

Research examining the potential retention of BMD in former practitioners of competitive artistic gymnastics is scarce. Bass *et al*. [16] compared retired elite gymnasts with a control group matched for age, height, and body mass. The BMD in former gymnasts was 0.5-1.5 standard deviations higher than the mean of women in the control group, in practically all evaluated sites. Scerpella *et al*. [52] evaluated gymnasts and non-gymnasts in a period that comprised four years before and nine years after the menarche, observing higher BMD in the forearm (radius) that remained for about four years after the discontinuation of the sports practice. In another trial, the same group [31] compared girls who underwent substantial gymnastic training before and after the menarche with non-practitioners, followed up to eight years after menarche. The loads applied during training brought benefits in BMD and geometry of bone architecture, which remained higher than in non-practitioners of the modality.

Zanker *et al*. [53] compared total and regional bone mineral density between sedentary former gymnasts and women who had never participated in sports or structured exercises, analyzing the BMD retention in former gymnasts aged 20-32 years who had discontinued training 3-12 years ago. The groups were matched for age, body mass, and height. In general, former gymnasts started their training at least three years before menarche and remained in training for two years or more after that period – overall, they trained continuously for 5-12 years and stopped between 14 and 22 years old. Former gymnasts had higher BMD than sedentary controls at all measurement sites. Interestingly, there was no significant decline in BMD as a function of the time of abandoning gymnastics. These results suggested that high bone mass in former female gymnasts was maintained through early adulthood despite interruption of training for up to 12 years.

Erlandson *et al*. [54] investigated whether there would be retention of the benefits of gymnastics during growth in the geometric parameters of the adult bone, 10 years after retirement from the sport. Geometric and densitometric parameters measured by computed tomography of the radius and tibia were compared between retired gymnasts and controls aged 22 to 30 years. Retired gymnasts had significantly greater total area and adjusted trabecular and cortical bone mineral content than controls, even after 10 years of leaving the modality. The same group [55,56] published longitudinal studies in which gymnasts from 8 to 15 years old were measured and compared with non-gymnasts of similar age, being reassessed 14 years later. Gymnasts had discontinued training on average 10 years before the study. Adjusted comparisons for age, height, body mass and age of menarche revealed that gymnasts had greater bone mass at baseline than non-gymnasts in the whole body, lumbar spine, hip, and femoral neck (12-17%). Ten years after stopping the training routine, these differences remained.

A few studies have evaluated the possibility of retaining bone mass achieved by gymnasts during the growth period, in later stages of adulthood. Kirchner *et al*. [18] and Pollock *et al*. [57] assessed the BMD in former university gymnasts vs. controls matched for age and body mass. Kirchner *et al*. [18] examined premenopausal women aged 29 to 45 years (mean 36.5 years). Although they did not report the time that the former gymnasts had stopped practicing the modality, their BMD was greater in all evaluated regions, including the lumbar spine, femoral neck, Ward's triangle, and total, even when the influence of total current physical activity in the last 10 years was statistically controlled. Pollock *et al*. [57] examined the BMD of women who had practiced competitive artistic gymnastics, also performing comparisons with a control group of similar age (around 45 years). Both groups were followed for 9 years. The gymnasts started training at 10-12 years-old, and stopped between 21-27 years-old. Former athletes showed higher absolute BMD in all regions, although the percentage of decline was similar between the groups.

These results are promising in terms of the impact of artistic gymnastics in youth on the BMD at older ages. However, it was not possible to locate similar studies with elderly people. This would be nonetheless interesting since this is the period when osteopenia is more advanced and the prevalence of osteoporosis is effectively high.

Conclusion

The current evidence indicates that, when practiced before the end of puberty, artistic gymnastics may confer residual benefits on bone mass during adulthood. Research is clear in the sense that this occurs in the first few years after the growth period. Although limited, studies give room to think that the BMD tends to be greater among peri-menopausal women and middle-aged men who practiced competitive artistic gymnastics in their youth than in the general population of equivalent age.

However, there is a lack of trials investigating whether such retention remains in individuals in which osteoporosis is more prevalent. The decline in BMD is known to accelerate after menopause in women and after 65 years old in men, but data on former gymnasts in this age group could not be located. To support that the practice of artistic gymnastics in childhood/adolescence can contribute to the prevention of osteoporosis, studies are needed to determine whether biologically relevant levels of BMD – that is, sufficient to reduce the risk of osteoporotic fractures – would be maintained in older individuals who practiced the sport competitively in their youth, in comparison with counterparts with no previous experience in the modality and with reference data for the general population.

The confirmation of the premise that achieving a higher peak BMD in youth would contribute to less osteopenia at advanced ages is important in practical terms, particularly regarding sports with high osteogenic effects. The ratification of the potential impact of artistic gymnastics as a strategy to prevent osteoporosis would be important for planning exercise programs during the growth period, incorporating lifelong bone health-related goals into those more traditionally pursued.

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