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REVIEW

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Association between physical activity, physical fitness and stress with bone mineral density of elderly: a narrative review

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ABSTRACT

Introduction: Aging is a physiological process that decreases muscle, skeletal and autonomic capacity, which increases the likelihood of developing chronic diseases. In addition to these losses, stress can be an aggravating factor to senescence and may be indirectly identified by increased cortisol. Researches indicates that a good amount of daily physical activity and adequate levels of physical fitness can minimize age-related losses and minimize the impact on bone mineral density (BMD). **Objective:** to present how the level of physical activity, physical fitness and stress are associated with elderly people's BMD. **Methods:** Pubmed and Medline databases were searched for scientific articles in Portuguese and English. The descriptors were: Stress, Physical Activity, Physical Fitness, Elderly and Bone Mineral Density. The research and the study of the scientific articles were carried out from October to December 2018. **Conclusion:** The level of moderate physical activity improves physical fitness and increases BMD. While high levels of cortisol contribute to decreased BMD.

Key-words: Stress; Elderly; Physical Activity; Physical Fitness; Bone Mineral Density

INTRODUCTION

Population aging is a global reality[1]. It is estimated that currently 605 million people across the globe are over 60 years old, and these figures will be much higher in the future [2]. In Brazil, researches indicates that in 2020 there will be about 32 million elderly people[3,4], equivalent to 13.8% of the entire Brazilian population[5].

All this increase in life expectancy is especially related to the treatment and control of infectious diseases and the high prevalence of chronic noncommunicable diseases (CNCD) in the elderly population[4]. Among the CNCDs are degenerative musculoskeletal diseases, which generate serious functional limitations[4-6-7], being denominated in the literature as fragility[8-11].

It is important to point out that the degeneration of the musculoskeletal system occurs gradually through the physiological process of aging, involving neuromuscular factors (eg, reduced nerve conduction velocity, decreased muscle activation, changes in posture such as increased thoracic kyphosis and knee semi-flexion, and amplitude limitation of movement) and musculoskeletal conditions, such as sarcopenia and osteopenia[12]. These factors are directly related to the decrease in physical activity levels of the elderly[12,13].

In addition to these losses, the hormonal changes inherent to the advancement of age are characterized by a decrease in estrogen levels, testosterone levels and an increase in cortisol levels, by modifying bone resorption and by decreasing bone mineral density (BMD)[7-14] and muscular strength[7-14-15].

The literature demonstrates that stress measured by increased production of cortisol[16] may lead to a reduction in the number of osteoblasts, thereby reducing the formation of bone matrix[17], favoring the development of osteoporosis[16].

On the other hand, studies demonstrate that physical activity plays a rehabilitative role with regard to physical fitness in any population[18-19] and present satisfactory results, including bone remodeling[20], favoring the increase of BMD due to stimulus osteogenic due to increased mechanical stress in the bone[21].

However, information regarding the benefits of regular physical activity, the temporal fitness condition and the role of stress on elderly people's BMD are mostly available in isolated studies, not allowing the understanding in a single document of these three aspects (i.e, physical activity, physical fitness and stress) and its relationship with BMD, which motivated this review to present how physical activity, physical fitness and stress levels are associated with BMD of the elderly.

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REVIEW

In order to meet the objective of presenting how the level of physical activity, physical fitness and stress are associated with elderly BMD, we have chosen to present the most relevant information extracted from the selected articles on each influencing aspect of BMD and their respective association.

For the development of this narrative review, the databases Pubmed, Medline and Scielo were searched for scientific articles in Portuguese and / or English. The keywords searched were: stress AND elderly, physical activity AND elderly, physical fitness AND elderly and bone mineral density (BMD) and elderly (BMD AND elderly). The research and analysis of the scientific articles were carried out from October to December 2018. This study reviewed articles that dealt with the relationship between physical activity and physical fitness with BMD and cortisol with BMD. The following criteria were used:

1. To be research with human beings;
2. The sample should be composed of the elderly;
3. Have been peer reviewed and written in English or Portuguese

In accordance with established criteria, the selected studies are characterized in Figure 1.

Bone is a type of tissue that is in constant renewal, which consists of a balanced work between cells of osteoblasts and osteoclasts, that perform the remodeling of this tissue (i.e. bone matrix)[22]. This process is physiological, in order to maintain the bone resistance the bone remodeling happens according to the mechanical demands on the bone, and is continuously to replace the aged bone with a new one[23].

BMD is the result of this dynamic process of formation of bone tissue, and is characterized by tissue concentration in a given volume of bone[22]. The greater the BMD, the stronger and more resistant the bones and consequently the less fragile and brittle.

Some factors may interfere with BMD, such as advancing age in combination with intrinsic factors (e.g. peak bone mass accumulated in youth, genetics, hormonal, biochemical and vascular factors) and extrinsic factors (eg nutrition, physical activity, conditions clinics and drugs) that combined can accelerate the decline of bone mass[22], hence the importance of balancing these factors throughout life.

Regarding the hormonal factors that influence BMD, we highlight hyperparathyroidism (i.e. clinical condition characterized by excessive production of parathyroid hormone), deficiency of vitamin D uptake, reduction in estrogen levels, testosterone, increased insulin, and levels of cortisol which acts by inhibiting bone formation through its action on osteoblasts[22,23].

Studies have shown that inhibition of bone formation occurs gradually as the person ages, and that osteopenia (i.e., preclinical condition suggesting gradual loss of bone mass) is the first official mark of this event[12]. It is noteworthy that high levels of cortisol inhibit calcium reabsorption in the renal tubule and calcium absorption in the intestine by

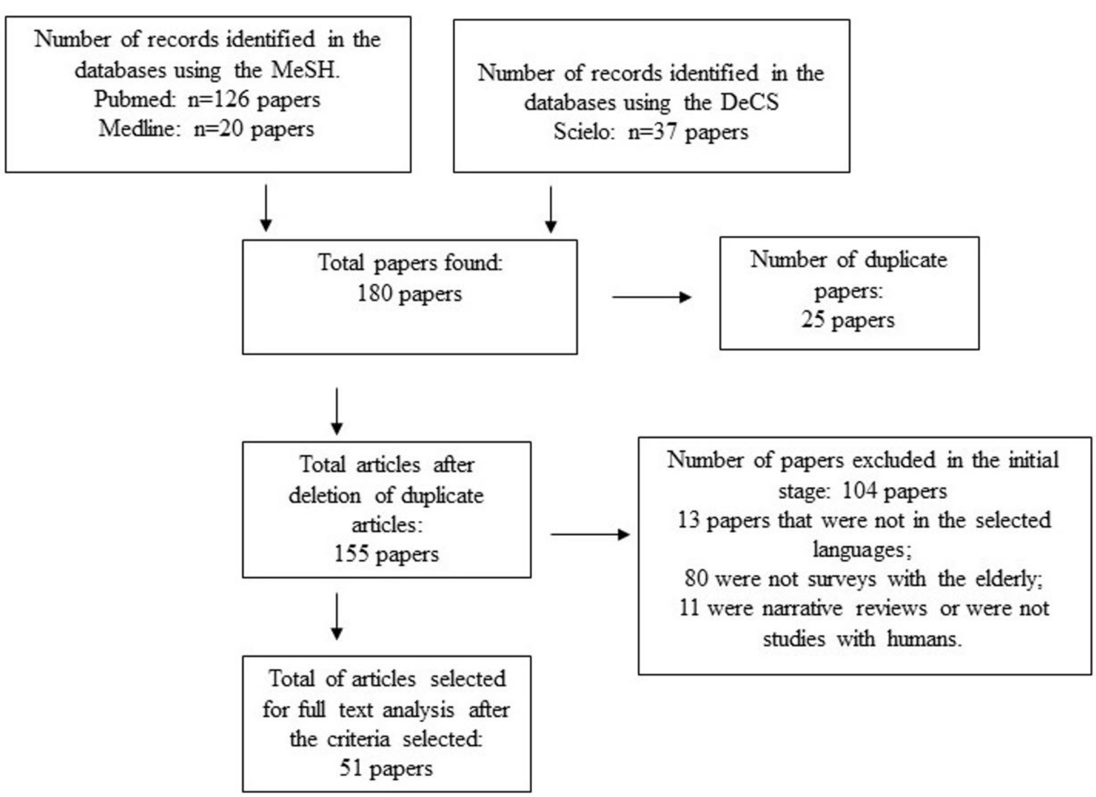

Figure 1 – Demonstrative of select papers

an independent mechanism of vitamin D, which decreases the transcellular active transport and the normal uptake of calcium and, consequently, decreases the synthesis of calcium binding proteins. Thus, the production of osteoblastic cells is compromised, the apoptosis of mature osteoblasts and osteocytes occurs, it decreases the mature osteoblasts compromising the bone mining[24].

In addition to the aforementioned situation, a high cortisol concentration may cause myopathies that result in muscle weakness and may contribute to a decrease in bone mass, by decreasing the force produced in the bone by the contraction of the muscle, and consequent diminution of the individual's mobility[25]. For these reasons, stress should be controlled among the elderly because exposure to this situation raises cortisol levels[4].

Stress acts in the biological system, and is related to environmental and / or psychological events. The same can occur in an acute, chronic or intermittent way[26], generating incapacity and decreased functional performance. Physiologically, stress is signaled by changes in the hypothalamic-pituitary-adrenal axis (HPA), resulting in release of cortisol[27], a glucocorticoid responsible for metabolic rate regulation, protein synthesis, bone mineralization, and other functions[28]. Increased cortisol secretion produces metabolic and physiological imbalances, aggravating the diseases that have arisen during the aging process[29]. These diseases include allergies and viral infections due to imbalance of immunological functions[30], depression, and cardiovascular diseases (hypertension), diabetes, osteoporosis and respiratory infections[31].

In addition to cortisol, testosterone may also contribute to the bone remodeling process and maintenance of muscle mass. Testosterone directly influences skeletal growth, maintenance and maturation[32]. When any damage or change in bone structure occurs as a decrease in mineralization, osteocytes signal to osteoblasts and osteoclasts that there is a need to initiate bone remodeling. Testosterone then stimulates calcium retention in the bone matrix and osteoblast activity, in addition to regulating the apoptosis of osteoclasts and osteoblasts[33].

It is known that testosterone assists in protein synthesis and in the reduction of muscle protein degradation[33], however, with aging, there is a decrease in free testosterone levels and a reduction in the synthesis of muscle proteins[34]. Therefore, the reduction of muscle mass and consequently reduction of the mechanical force generated by the long-term loads exerted by muscle contraction, compromising bone remodeling[34].

The cortisol / testosterone (C / T) ratio has been used as a stress biomarker because testosterone and cortisol are derived from the same biochemical precursor, so if high cortisol synthesis occurs it will correspond to a decline in testosterone synthesis[35].

In addition to hormones, which are constantly highlighted in the literature because of their influence on BMD, the reduction in the level of physical activity among the elderly has been highlighted[36,37]. Especially because reducing the mechanical load on bone will result in a decrease in osteoblast activity[22-34].

According to Cadore et al.[21], the higher the level of physical activity of the individuals, the greater the amount of muscular contraction exerted, generating a greater mechanical effect on the bones, which will positively impact the BMD.

Physical activity can have a significant effect on muscle and bone stimuli. Bone adapts its morphology and strength to the long-term loads exerted by muscle contraction resulting from physical activity (e.g. daily life activities), systemized exercises and gravitational forces, which contribute to maintaining higher levels of BMD[34].

It is clear that regular physical exercise performed on a day-to-day basis will cause the elderly to have greater functional capacity and autonomy for the activities of daily living, reflecting gait, balance, mobility, strength and muscle power[36-37] for healthier aging[37].

In general, the elderly, regardless of the type of dwelling, should move around, walk, walk, run, climb stairs, paddle, lift weight and perform jumping exercises[38], but always accompanied and if possible guided by a professional movement[39].

It should be noted that during the increase in chronological age, there is a decline in physical fitness, resulting in a decrease in physical abilities such as muscle strength (MS), flexibility, balance, walking speed and cardiopulmonary fitness[7,15]. Physical fitness along with the psychological changes that occur in aging (e.g. feeling of old age, stress, depression), can be determining factors for the decrease of physical activity that, along with the appearance of chronic diseases, further accelerates the aging process[7].

In addition to the physical fitness issues, another important component is the changes in body composition that occur throughout the aging process, characterized by a decrease in lean mass and an increase in body fat that can occur due to: genetic, endocrine, in the diet and in the level of physical activity, or the sum of two or more factors[40].

The loss of muscle mass and consequently muscular strength may be the main cause of deterioration of the mobility and functional capacity of the aging individual[41], which will directly impact BMD. The practice of physical activity can minimize muscle loss during aging[39-42]. Exercise programs in the elderly with a combination of resistance training and aerobic training showed an improvement in physical fitness[43].

The stimulation of muscle mass on bone mass is positively related to BMD of the upper limb and it's muscular area is associated with the cortical area of the bone[34].

One of the ways used to measure muscle mass capacity is through muscle strength measured by dynamometry (i.e. measured by dynamometer). The positive relationship between manual grip strength and bone mineral density is well established and can therefore be considered a screening tool for osteoporosis[44].

Another tool widely used to assess functional mobility, overall fitness, health decline, and inability to perform daily activities is the "Time Up Go" (TUG) test, which is a simple, quick, and practical test[45,46], which, when demonstrating the speed that an elderly person travels a distance (i.e. six meters) together with specific actions (ie raising a chair to the signal, walk to a marking distance of three meters, return the chair and sit), risk of falls[47]. It has recently been reported that the TUG performance time may be a predictor of fragility[48] as well as sarcopenia[46-49].

All this search for understanding about possible relations with BMD occurs because osteoporosis, a disease characteristic of the aging process that mainly affects postmenopausal women[15], generates many disorders and premature losses. It is estimated that 8.9 million of the fractures that occur in Brazil come from osteoporosis, in addition to the accompanying consequences that lead to a decrease in physical function and a condition of social relation, which in turn greatly interferes with people's quality of life[50].

Regarding the social factors related to aging, the issue related to the institutionalization of the elderly and their relation to the decline of BMD has been described in the literature[51]. This is due to the functional impairment caused by gait dysfunction and / or mobility limitations. In addition to cognitive decline, the elderly need long-term care, which is why many elderly people are institutionalized[51].

Furtado et al.[7] reinforces that institutionalized elderly have greater physical inactivity compared to non-institutionalized elderly people due to the limitation of the activities practiced in the institution, consequently they present functional fitness decline.

The choice of physical activity for older adults who are institutionalized is more complex, different types of interventions may be necessary[36]. It involves factors such as: sedentary lifestyle, loss of physical fitness, presence of osteopenia and/or osteoporosis, joint instability, arterial hypertension, among other factors[4]. However, even with several limitations, it is recommended to practice regular exercises, with the combination of strength, balance and aerobic exercises[37].

Considering what has been found in the studies, it can be affirmed that the practice of physical activity has shown positive effects on BMD and that the level of moderate physical activity offers more stimulus to the bone remodeling determining greater BMD. It is also known that regular practice of moderate physical activity improves physical fitness, and that this improvement in physical fitness increases BMD, because the greater the mobility of the individual, the greater the muscle contraction, the greater the bone stimuli.

On the other hand, the low level of physical activity, the loss of physical fitness and the high level of cortisol due to the stress that interferes in the production of osteoblastic cells, leads to a decrease in BMD.

CONCLUSIONS

At the end of this review we pointed out that the level of physical activity, physical fitness and stress have a close association with the BMD of the elderly, and it is suggested to professionals working with this population, attention to these factors (ie the level of physical activity, physical fitness and stress) so that the elderly have better BMD and consequent quality of life and health.

AUTHOR'S CONTIBUTIONS:

IOS, GFM: contributions to conception and design of the study; RMCC, IOS, GFM: made the selection of articles; RMCC, IOS, GFM: critical review of the manuscript. All authors read and approved the final manuscript.

CONFLICT OF INTEREST:

Nothing to declare.

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