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PHYSICAL ACTIVITY IN OSTEOPOROSIS : A ROLE OF PREVENTION IN ELDERLY POPULATION?

Physiotherapy

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KEYWORDS

Introduction

Osteoporosis (OP) is a progressive systemic disease characterized by low bone mass and micro-architecture deterioration of the bone tissue, with a consequent increase of bone fragility and risk fracture [1,2.]

OP is also considered like a common metabolic disease in the elderly and is closely associated with patient age. Its main signs are overall bone tissue density loss and structural fiber changes.

OP incidence increases significantly with advancing age [3] and is usually silent without any signs and symptoms of de-creasing bone density. Bone fracture often occurs as the first presentation of osteoporosis [4]. Significant morbidity, cost and reduced quality of life have been attributed to osteoporosis .

There are non modifiable and preventable (modifiable) risk factors for OP.

Non modifiable risk factors include age, height, weight, body mass index (BMI), and menopause which are not preventable. The preventable risk factors include calcium intake, exposure to sunlight, smoking, alcohol intake, exercise, underlying disease condition such as rheumatoid arthritis, systemic lupus erythematosus, and other autoimmune disorders, steroids intake, hormone replacement therapy, e Preventive strategies are a crucial first step to over-coming this global problem.

OP itself is asymptomatic, and often remains undiagnosed until a fragility fracture occurs in the most part of elderly patients population.

The diagnosis of Osteoporosis

Diagnosis and treatment of osteoporosis are extremely important.
Since the definition of osteoporosis includes bone mass as a parameter, measurement of the bone mineral density (BMD) has become an essential element in the evaluation of patients who are at risk for osteoporosis.

Despite the known impact of fragility fractures, osteoporosis still remains unrecognised and untreated in over 50% of patients who present with fragility fractures.

Among the osteoporotic skeletal fractures, osteoporotic vertebral fracture (OVF) is the common type of osteoporotic fractures in older adults.

The musculoskeletal disorders including osteoporosis and bone fragility fractures rank as the second common cause of disability estimated by the years lost due to disability worldwide.

The major determinants of bone strength are bone turnover ; skeletal microarchitecture and bone mineral density (BMD).

While BMD can be readily measured by dual-energy X- ray absorptiometry (DXA), the technologies used to determine skeletal microarchitecture, such as histomorphometric analysis and micro-computed tomography (μCT) of the transiliac crest bone biopsy[8,9], high resolution peripheral quantitative computed tomography (HRpQCT) (4), and magnetic resonance imaging (MRI) (5) are not routinely available[10].

Bone mineral density (aBMD) by dual-energy X-ray absorptiometry (DXA) is the current gold standard to diagnose osteoporosis, to assess osteoporotic fracture risk, and to monitor treatment-induced BMD changes. However, most fragility fractures occur in patients with normal or osteopenic aBMD, indicating that factors beyond BMD impact bone strength. Recent developments in DXA technology such as TBS Trabecular Bone Score , VFA Vertebral Fracture Algorithm, and hip geometry analysis are now available to assess some of these non-BMD parameters from the DXA image[5,6,7].

When bone mass is under 2, 5 SD of the reference mean of young premenopausal women, women has developed osteoporosis.

Dual-energy x-ray absorptiometry scan screening is recommended in all women more than 65 years of age or in women aged 50 to 64 years with certain risk factors.

With its high precision, DXA is well suited for use in the diagnosis of osteoporosis, to aid decisions about the treatment of the patients and to monitor the patients.

Prevention of osteoporosis undertake by maximizing bone tissue accretion during growing yr, maintaining bone tissue acquisition during adulthood and reducing bone loss in elderly [8,9].

Among preventive tools, physical activity is certainly a valid instrument of prevention, in fact physical activity contributes to a healthy energy balance and increases muscle mass and bone mass.

OP has many bad consequences which impact both life quality according to morbidity like pain, fractures and immobility, and mortality[11].

The old generation is increasing, and as people are getting older osteoporosis will affect a constant bigger part of the population. Even if there now days are more people who are training, the total physical activity in the population is markedly reduced.

Epidemiology

The structure of the society has changed; transport with cars and more passive professions. It's estimated that 30-50 % of the women and 15-30 % of men will suffer from osteoporotic associated fracture during life time.[12]

In the present narrative review, we wanted to pay attention to the possible influence of physical activity on the pathophysiological molecular pathways of osteoporosis and to the use of different exercise training in treatment of osteoporosis.

From the literature analyzed, in relation to the effects of physical activity on bone metabolism, it is shown that exercise acts on molecular pathways of bone remodeling involving all cellular types of bone tissue.

In relation to clinical trials adopted in patients with osteoporosis, it is evident that a multi-component training, including aerobic activity and other types of training (resistance and/or strength exercises), is the best kind of exercise in improving bone mass and bone metabolism in older adults and especially osteopenic and osteoporotic women but also in low percent in the man.

Recent studies have shown that an age-related decrease in intestinal calcium absorption is closely related to senile osteoporosis and bone loss[10]. A lack of exercise among the elderly is also an important factor in promoting osteoporosis[11]. Here we report on the beneficial effects of a combination of aerobic and non-aerobic exercise for patients with senile osteoporosis.

After the age of around 40 years it is possible to detect deterioration of the function of physiological systems, with associated anatomical and ultrastructural changes. For instance, progressive cognitive declines affect memory and learning; skeletal muscle atrophies and becomes progressively weaker (known as sarcopenia) and ageing-related declines in bone mineral density lead to osteopenia and osteoporosis[13]. Chronological age is a convenient and often very good predictor of health status, disease burden and physical capability, but there is considerable inter-individual variability, with some older people having very good health and others show accelerated onset of weakness, disability and frailty.

The lifestyle and medical advances that contribute to longevity are achievements to celebrate, but they also bring unintended and considerable social, economic and health challenges as life expectancy increases faster than the period of life spent in good health, termed 'healthy life years' (discussed in Rechel et al. 2013)

Physical activity

The benefit of physical activity over other interventions such as diet is that physical activity raises the skeleton's resistance to fractures through improving and preserving both BMD and neuromuscular ability. This leads to reduction in skeletal frailty and prevent falls . It's doubtful that the same exercise requirements in prevention for osteoporosis are the same as for other diseases such as pathology in the cardiovascular system [11].The adaption of the bone tissue to exercise varies through life and is related to age and the individual health.

The exercise pattern should be analyzed according to which type of training, intensity, frequency and duration of each period. It exist no systematic review on the field which includes women in all age groups. Most of the researches are in general on post-menopausal women. The studies which involve premenopausal females and children are sparse. There exist just a few studies which include men and elderly patients.

Frailty is recognised clinically as a geriatric syndrome that arises due to multiple deficits to body systems. Frail people experience severe impairments to physical and mental function that restrict their ability to complete necessary activities of daily living.

Frailty is usually diagnosed according to two classifications Higth Risk and Low risk (Tb.1 and Tab.2).

Physical activity reduces the risk of developing cardiovascular and metabolic disease through better control of blood pressure, cholesterol and waist circumference in a dose-dependent manner: more activity leads to lower risk of cardiovascular and metabolic disease (Earnest et al. 2013). The metabolic benefits of increasing fatty acid oxidation in skeletal muscle, rather than accumulating intramuscular and adipose tissue stores around themajor organs as well as lowered blood pressure helps to reduce the risk of developing type 2 diabetes mellitus and cardiovascular disease (Roberts et al. 2013; Stewart et al. 2005).

In the nervous system, regular exercise helps to maintain cognitive function (Lautenschlager et al. 2008) and possibly also the numbers of peripheral motor neurons controlling leg muscles (Power et al. 2010, 2012) and overall improves balance and coordination to reduce risk of falls (Franco et al. 2014; Gillespie et al. 2012; Rubenstein et al. 2000).

Aims of training treatment

Each treatment, medical, physical and rehabilitation, in postmenopaus al and senile period must be adapted to reduce the risk of fracture.

In the elderly fractures, especially those of the lower limbs, derived from two processes: the loss of bone integrity and an increased risk of falling.

In patients with osteoporosis or Highrisk of falling, the rehabilitation must be considered.

How to prevent and / or together with other drug treatments to increase quality of life, health and reduce the risk of fracture and recidive [12].

At the end, great importance reporting the existence of skeletal risk factors of low bone density and extraskeletal fall to prevent fractures in selected subjects.

People with higher activity levels and physiologicalfitness have a lowermortality risk (Feldman et al. 2015).

Maintenance of a physically active lifestyle throughmiddle and older age is associated with better health in old age (Hamer et al. 2014) and longevity (Manini et al.2006; Stessman et al. 2009)

Bone Mineral Density (BMD) lost in exercise

More than 20 randomized, controlled trials[21] suggest that regular physical exercise can reduce the risk of osteoporosis and delay the physiologic decrease of BMD. Short-term and long-term (measured up to 12 months) exercise training such as walking, jogging and stair climbing in healthy, sedentary postmenopausal women resulted in improved bone mineral content.3 Bone mineral content increased more than 5 percent above baseline after short-term weight-bearing exercise training. With reduced weight-bearing exercise, bone mass soon reverted to baseline levels.[22,23] Similar increases in BMD have been found in women who participate in strength training. In the elderly, progressive strength training has been demonstrated to be a safe and effective form of exercise that reduces risk factors for falling and may also enhance BMD[25].

Recently a review showed [13] the role of physical exercise in postmenopausal osteoporosis and elderly subjects .

Estrogen deficiency results in diminished bone density in women. Weight-bearing exercise can significantly increase the BMD of menopausal women. Furthermore, weight-bearing exercise and estrogen replacement therapy (ERT) have independent and additive effects on the BMD of the limbs, spine and Ward's triangle (hip).

Included studies have several limitations: samples small study, large variability of bone loss in controls, high accuracy variability measurement of the bone mineral density and age of the heterogeneity menopause population , with a different trend of physiological bone loss.

It is confirmed that the increase in BMD is site-specific: the proximal femur if the exercise involves the hip like the squat's case, the step ,the walking, the press machine; or on the lumbar spine if it is in extension exercises, with weights and / or gravity; or on the wrist if it is instead of exercises with the use of the upper limbs. In particular, relatively hip, the exercise is effective if the trochanter It involves both gluteus, on the littke trochanter if it involves the 'iliopsoas, and, in according to studies of Kerr et al. [14], on the Ward's triangle if it involves the adductors and hip extensors.

Above all, Cussler et al. [15]with a controlled clinical trial of 144 subjects

studied on the effect of more specific exercises on BMD at the hip and trochanter level, have showed that trochanter BMD is related positively to the total lifted weight ($p < 0.001$). The high correlation with trochanteric BMD level, was the squat with weights (0.0023 g / cm2, $p < 0.001$) and military press (lifting a bar on the height of the shoulders and collarbone up to above the head, taking knees and straight back) (0.0012 g / cm2, $p < 0.01$). BMD of the lumbar spine and femoral neck not showed a significantly relation with the total weight, while the total body BMD was correlated with the weight during the march (0.0006 g / cm2, $p < 0.01$).

The authors concluded that there are different explanations for effectiveness site-specific exercises: muscle insertion, different weights / or stretching type of contraction, duration and nature of exercise. The muscle's strength can produce a stronger impact on trochanter than more femoral neck; even if weight or stress impact are distributed on both, the muscle insertion is on trochanter and the impact transmission through the femoral neck is not effective to stimulate sufficiently the new bone formation and bone mass growth, especially in a segment constituted by cortical bone than trabecular bone.

Likewise Frost studies , the increase in muscle strength and bone growth with training muscle was demonstrated in elderly [15]; Nevertheless the amount of weight represents in many studies the only way to evaluate the total impact of this type of exercise [16].

However the Weight doesn't describe sufficiently the distribution and localization of mechanical impact due to exercise.

Kohrt et al. They have evaluate increasing BMD manufactured by exercises wich involved the reaction force from the ground in addition to the joint (6), showing only with the first an increase of BMD in femoral neck.

Weight alone is not enough to highlight the exercise more effective, but it must also calculate the strength of the expected ground reaction.

Subjects who exercise regularly usually have above-average bone mass. However, the positive effect of exercise on the bones of young women is dependent on normal levels of endogenous estrogen. The low estrogen state of exercise-induced amenorrhea outweighs the positive effects of exercise and results in diminished bone density. When mechanical stress or gravitational force on the skeleton is removed (e.g., bed rest, immobilization of limbs or paralysis), bone loss is rapid and extensive.

No randomized, prospective studies have systematically compared the effect of various activities on bone mass. Recommended activities include walking and jogging, weight training, aerobics, stair climbing, field sports, racquet sports, court sports and dancing. Swimming is of questionable value in terms of bone density (because it is not a weight-bearing activity), and there are no data on cycling, skating or skiing. Any increase in physical activity may have a positive effect on bone mass in women who have been sedentary. To be beneficial, the duration of exercise should be between 30 and 60 minutes and the frequency at least three times per week.

Have Aerobic exercise a role in bone protection?

In the review cited Cochrane, nine studies have evaluated the effect of aerobic exercise [26-34]. From 561 subjects, 266 were subjected to the exercise and 295 to control. Among these studies, only two [28-29] were of a high quality (score from 3 up). Except in two studies all controls continued their normal activities.

The compliance (adherence to treatment), when indicated, have a variability from 39% to 83% [28].

Exercises related upper limbs, lower limbs andspine, a mixture of calisthenics, stretching, muscle strengthening and walking. Exercise intensity was measured in only two studies: with heart rate , the measurement of the maximum dynamic stress (RM or Repetition Maximum: The maximum number of times in which a weight can be lifted with appropriate procedures prior to a fatigue) or of total body weight [33-34].

The effect of exercise was measured in different locations (lumbar spine, hip, wrist) and with different systems of measurement of BMD (for example Dual Photon Absorptiometry, Quantitative Computed Tomography), so it is difficult to combine the results of different studies.

Seven studies measured the effects of aerobic exercise on the column with 186 subjects training and 189 controls [28-30,32-34], five on the hip, with 161 subjects in training and 174 controls and two on the wrist with 80 subjects undergoing training and 106 controls[32]. The results have demonstrated a significant effect of aerobic exercise on BMD of spine and wrist, but not hip.

Reducing risk of falling a key role in the fracture

About 40% of people over age 65 falls each year [35].
Inactivity and alteration of neuromuscular functions are known risk factors for falls and hip fractures To confirm, in a prospective cohort study of 9704 women> 65 years, a high level of physical activity was associated to a reduced risk of fractures of the femur, but not of the wrist. Similarly they were found lower Hip fractures in women who maintained at least two hours/week intense physical activities.

In the literature they were identified risk factors for fall: weakness, loss of coordination, kyphosis, increased postural sway, decreased walking speed, functionality reduction [40-41].

However, a recent Cochrane review with 13 RCTs on exercise and physical therapy in the prevention of falls in the elderly showed that the overall results of disparate interventions aimed at preventing falls no showed evidence of efficacy. Instead, the conclusion of studies on 566 women, above 80 years age, with individualized programs based on progressive muscle strengthening, balance and walking were effectiveness in relation to the number of subjects that recorded falls in period of one year [43-45].Studies investigating the effect of exercise alone in non-institutionalized subjects.

They showed effectiveness in preventing falls.

Jensen [45] has shown that a program with individualized strategies including education, modification of the environment, individualized exercise programs, aids, drugs, orthotics prevented falls and damage it in people aged over 65 years.

Each intervention program should be individualized on the basis of the presence of a factor of risk to fall by evaluating different interventions that are aimed at different risk factors (intrinsic and extrinsic).

The Role of year for the balance and agility in prevention falls

A recent review [46]studied the role of the exercises for balance and agility in falls prevention on over age 50 subjects.

The definition of mobility used was "a fast movement, slender, active", while for the balance was "the stability of the body." On the balance exercises are included modifyding stability of a static nature (eg. the monopodalic station or in tandem with the foot), while for agility were the activities that altered the dynamically stable (dance, walk Fast playing ball, running with obstacles).

Research has selected 13 randomized controlled trials.

Exercises for balance

The recent review shows that exercises can reduce the rate of fall in elderly populations, if comprise exercises for balance[47-53] .Two studies [52-53]report the the practical results of Tai Chi in the frequency of falls in males and females>70 years population. The first study (6), which compared the efficacy of Tai Chi for 15 weeks in a workout computerized exercises or on a educational programm, showed that both techniques of exercise were more effective than the education alone, in the absence of differences between Tai Chi and specific exercise. In the second study, tai chi practiced for 48 weeks did not change the rate of falls compared to a more generic exercise program .
A recent systematic review [54]concludes that there is modest evidence that Tai Chi have efficacy in falls reductions.

Exercises for agility

Two studies have examined the effectiveness of this type of training: Liu-Ambrose, of 104 women 75-85 years with osteopenia, associated

exercises for agility and muscles toning for 25 weeks, showed a significant reduction in the risk of falling than stretching and relax exercise.

Shigematsu [52-53] using aerobic exercise in a dance form of agility exercise, it has It demonstrated that improve the performance compared to the control group and the tests of static stability dynamic: monopodalic station with closed eyes, the functional reach and the path around two obstacles. Davis et al. (3) conclude that, although there is no conclusive evidence that training for agility reduce falls, confirm that this type of exercise provides similar efficacy to the exercises for the strengthening muscle in the falls prevention and, therefore, could be proposed for this purpose to subject can not do it.

Exercises for postural control

The correction of the thoracic kyphosis secondary to osteoporosis ,has been studied by Lynn and coll [54] not only because it predisposes to pain, but also because increase fall's risk.

In subjects with kyphosis, a compensatory strategies in inclused like hip rather than those physiological and most of the ankle, during the momentary changes in the equilibrium conditions.

These reactions were enhanced with dynamic postural proprioceptive training in women osteoporotic with kyphosis[55].

The pain can be a product, as well as osteoporotic vertebral subsidence, also of postural deformities, such as scoliosis and kyphosis.

The muscle strengthening of back muscles is significantly correlated with the reduction of fractures and vertebral kyphosis [56], and in more severe kyphosis can determine tenderness for compression of last ribs on the iliac crest and determine a restrictive lung impairment [57-59].

The review of Pfeiffer et al. [60] shows that, on the basis of the literature, the reinforcement of the extensor backbones muscles reduces kyphosis, vertebral fractures, the spine and chest pain [56-58].

Malmros et al. [62] shown that the reduction of the dorsal kyphosis with strengthening muscular of back extensor muscles and rehabilitation, improves static and dynamic posture, can reduce the pain, increase mobility, reduce depression and improve quality of life.

Since repositioning the center of gravity results in a reduction of body movements , the increase of which is well correlated to falling risk and fractures, the modification of the center of gravity obtained with postural re-education for the dorsal kyphosis may be accompanied by a lower rate of falls and fractures in the limbs .

Tab .1 High risk fracture subjects

Reference	District	Tipology	Times	Quantity-Amount	Load	Aims
Cussler EC et al (2003)	Wrist	Pronation/Supination Flexion/Extension	3 times/week	1-2 series x 10-15 ripetions	Natural/Light	Wrist's Mobility
Wolf SL et all (2003) Verhagen AP et all (2004)	Back	Cat position	**3 times/week**	1-2 series x 10-15 ripetitions	Natural/ Low Overload	Alignment, Mobility
Sinaki M et all (2002)	Back	Prone, sphinx position	**3 times/week**	2 series x 8 ripetitions (5"-5")	Natural	Alignment, Strengthening
Sinaki M et all (2002)	Back	Body stability	**3 times/week**	2 series x 8 ripetitions (5"-5")	Natural	Strengthening of Core Stability
Chang JT et all (2004)	Lower Limbs (LL)	Raised in isometric hold	**3 times/week**	2 series x 10 ripetitions (5"-5")	Natural	Strengthening
Kohrt WM et al (2005)	Lower Limbs	Jumping, jogging, skipping	Not Allowed			> District's compression
Kohrt WM et al (2005)	Upper Limbs(UL)	Twisting, Bending forward	Not Allowed			> District's compression
Kohrt WM et al (2005)	Upper/Lower Limbs	Stretching	Daily Attendance	Not Specified		Flexibility

Tab.2 Low risk fracture subjects

Reference	District	Tipology	Times	Quantity-Amount	Load	Aims
Cussler EC et al (2003)	Wrist	Pronation/Supination Flexion/Extension	3 times/week	2-3 series x 10-15 ripetitions	Natural / Low Overload	Mobility
Davis JC et all (2004) Gillespie LD et all (2003)	Back	Cat Position	3 times/week	1-2 series x 10-15 ripetitions	Natural / Low Overload	Alignment, Mobility
Bonaiuti D et all (2002) Cussler EC et all (2003)	Lower Limbs	Squat, Adduction/Abduction Flexion/Extension of Hip	3 times/week	2-3 series x 12-15 ripetitions or 8-10 ripetitions	From 50% To 85%	Alignment, Strengthening
Cussler EC et al (2003)	Upper Limbs	Pronation/Supination	3 times/week	2-3 series x 12-15 ripetitions or 8-10 ripetitions	From 50% To 85%	Strengthening, Mobility
. Sinaki M et al.(2002)	Lower Limbs	Jumping	Daily Attendance	From 3-5 J To 50 J 10 ripetitions	Natural	Not Recommended with osteoarthritis
Liu-Ambrose T et all (2004)	Lower Limbs	Jogging	3 times/week	20' minutes	Natural	Back's and Hip Disease
Kohrt WM et al (2005)	Men	Same type of exercises	3 times/week	1 series x 15 ripetitions UL 2 series x 15 ripetitions LL	From 50% To 85%	Strengthening, Mobility

Conclusion

Studies among adults report that exercise rather prevents bone loss, inhibiting the endocortical bone resorption rather than new periosteal bone formation. There are no common training recommendations for prevention of osteoporosis, but there is a general consensus that weight-bearing activity combined with resistance training is optimal. The evidence shows that regular physical activity is safe for healthy and for frail older people and the risks of developing major cardiovascular and metabolic diseases, obesity, falls, cognitive impairments, osteoporosis and muscular weakness are decreased by regularly completing activities ranging from low intensity walking through to more vigorous sports and resistance exercises Although no clear optimal duration and intensity has been delineated, there is general consensus that the activity should be of high impact, done 3-5 times weekly, if possible daily, and last for 10-45 minutes per time. The activity should be of a magnitude 3-9 times corresponding to the body weight. There exist few RCT today which are performed among men and children. Before final conclusions can be made; it's necessary with several long term trials and further studies which involve men, premenopausal women and children.

The exercise pattern should be analyzed according to which type of training, intensity, frequency and duration of each period. It exist no systematic review on the field which includes women in all age groups. Most of the researches analysed are in general on post-menopausal women. The studies which involve premenopausal females and children are sparse. There exist just a few studies which include men and elderly patients in generals.

The subjects involved in physical activities remains low amongst older adults, particularly those living in less affluent areas. Elderly population may be encouraged to increase their activities if influenced by clinicians, friends or family, keeping costs low and enjoyment high, facilitating group based activities and raising self-efficacy for exercise. The literature suggest that, in general, both aerobic and coordination exercise, as well as higher scores on health- and skill-related fitness indices, are positively associated with better performance of various cognitive functions in the elderly population. The mechanisms underlying these relationships may be differentially related to specific processes involved in cognitive and muscular control.

From the literature's data is showed the importance of the exercise training group and the self-management group exercise, these consideration indicate the usefulness of self-management group exercise to reduce the incidence of disability in older adults. Thus, increasing self-management group activities in each community should be encouraged.

However in necessary of other many specific study to have one best focun on the exercise training elderly population guide line.

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