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DOCTORAL SCHOOL OF PHYSICAL EDUCATION AND SPORT

PhD THESIS SUMMARY

THE INFLUENCE OF RESISTANCE EXERCISES ON THE QUALITY OF LIFE IN PATIENTS WITH POSTMENOPAUSAL OSTEOPENIA/OSTEOPOROSIS

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Cluj-Napoca
2020

Content

Keywords: osteopenia, osteoporosis, resistance exercises, postmenopausal, quality of life, bone mineral density

PART I – THEORETICAL SCIENTIFIC FOUNDATION OF THE WORK

CHAPTER I. Bone system and the etiopathogeny of osteoprosis

Adult bone is composed of bone tissue, cartilage, dense connective tissue, epithelium, adipose tissue, and nerve tissue (Tortora & Derrickson, 2012, pg. 182-207).

Bone tissue alone accounts for about 18% of total body weight, and the skeletal system contains cartilage, ligaments, and tendons along with the entire bone framework (Tortora & Derrickson, 2012, pg. 182-207).

There are three types of bone cells called osteoblasts, osteoclasts and osteocytes. Osteoblasts form new bone (osteogenesis), and osteoclasts participate in bone resorption (osteolysis) (Villiers, 2009), (Yang, et al., 2012), (Cheng, et al., 2013).

Osteoblasts are derived from pluripotent stem cells, and their principal role is to synthesize the osteoid (bone matrix) and to regenerate bone tissue (Monzur, Dympna, Jose, Marc, & Gerard, 2005), (Thompson, Rubin, & Rubin, 2012).

Osteoclasts are cells that play a role in bone resorption, and they derive from hematopoietic cells of monocytes / macrophages. Osteoclasts are multinucleated, hard-membrane, bone-oriented cells that secrete specific acid and enzymes required for bone matrix dissolution / digestion (Sevgi & Duong, 2008), (Lau & Guo, 2011).

Osteocytes are differentiated osteoblasts that are embedded within the mineralized bone matrix. Osteocytes make up about 90% - 95% of the bone cells in the skeleton of an adult person (Rochefort, Pallu, & Benhamou, 2010).

They are connected to each other, but also to the osteoblast cells on the surface of the bone through a network of canaliculi that contain the extracellular fluid of the bone. Osteocytes behave like mechanosensors in the bone, which feel the physical (mechanical) stress and microtrauma, preparing in response the subsequent bone modeling or remodeling (Bonewald, 2007).

Osteoporosis is a systemic skeletal disorder characterized by decreased bone mass and deterioration of bone tissue microarchitecture (Costa, et al., 2016), (Hou, et al., 2018), (Phipps, Mitlak, Burr, & Allen, 2019, p. 389) .

The word osteoporosis comes from Latin and means porous bone (Mihail, 2007, p. 80); osteo - bone, porosis - porosity.

Osteoporosis is the most common disease that affects adults, especially the elderly. It is different from osteomalacia because it results from the diminution of the bone matrix and not due to deficient calcification. In the case of osteoporosis, the activity of cells called osteoblasts is lower than normal, and as a consequence the rate of bone formation decreases (Guyton & Hall, 2006, pg. 992-993), (Li, et al., 2009), (Chen, and others, 2014), (Li, and others, 2015), (Li, and others, 2015).

Bone loss occurs in "quiet" and progressive. Often, there are no symptoms until the first fracture occurs (International Osteoporosis Foundation, 2015), (Henriquez & Romero, 2018).

Within certain limits, osteoporosis can be considered physiological. When postural fractures and disorders occur (disabling deformities), we talk about osteoporosis - disease (Borundel, 2000, p. 916).

Osteoporosis affects millions of people worldwide, being most common among women, where the incidence is much higher after the onset of menopause (Cooper, Campion, & Melton, 1992), (Burge, Dawson-Hughes, Solomon, Wong, King, & Tosteson, 2007), (Kanis, et al., 2008), (Lai, et al., 2013), (Weber-Rajek, Mieszkowski, Niespodzinski, & Ciechanowska, 2015).

Osteoporosis is a pathological condition of the bone in which it can fracture as a result of minor trauma as a consequence of low bone mass and micro-architectural disruptions (Black, et al., 2008), (Cosman, et al., 2014), (Schultz & Wolf, 2018).

Micro-architectural deterioration occurs at both the cortical and trabecular levels of the bone and is primarily influenced by the decrease, with age, of estrogen and circulating testosterone (Hildebrand, Laib, Muller, Dequeker, & Ruegsegger, 1999), (Bousson , Peyrin, Bergot, Hausard, Sautet, & Laredo, 2004).

Worldwide variations in the prevalence and incidence of vertebral fractures were observed, with the highest rates being recorded in North America and Asia (Ballane, Cauley, Luckey, & Fuleihan, 2017).

The prevalence of fractures in the spine is similar among men and women, increasing by 5% in people under the age of 60, by 11% in those between 70 and 79 years and by 18% in

those aged over 80 years. Estimates show that more than one million postmenopausal American women will suffer a spine fracture within a single year (Cosman, et al., 2017).

It is estimated that more than 70% of people at high risk for osteoporosis and who are receiving therapy / recovery will not continue the program after the first year after it starts (Brianna R., Temitope, Jennifer, Jane, & Rebecca, 2016).

The prevalence of osteoporosis in the coxofemoral joint and spine in nine industrialized countries in North America, Europe, Japan and Australia is between 9% and 38% among women and between 1% and 8% among men. In these countries, osteoporosis affects up to 49 million people. Prevalence among women (based on bone mineral density in the hip or spine) ranges from 9% in the UK to 15% in France and Germany and from 16% in the United States to 38% in the United States. Japan. Among men, prevalence was lower, respectively between 1% in the UK and 4% in Japan (bone mineral density was measured at the hip level) and from 3% in Canada to 8% in France, Germany, Italy and Spain (Wade, Strader, Fitzpatrick, Anthony, & O`Malley, 2014).

In 2010, 22 million women and 5.5 million men suffered from osteoporosis in the European Union. About 3.5 million new fractures were recorded, including 620,000 fractures in the hip, 520,000 vertebral fractures, 560,000 fractures in the forearm and another 1,800,000 fractures in different anatomical areas (Hernlund, et al., 2013). Economic expenditure has been estimated at about 35 billion euros and these costs are expected to increase by 25% by 2025. Most individuals who have suffered an osteoporotic fracture or are at risk of suffering a fracture are left untreated, and the number of patients who are receiving treatment is constantly decreasing (Svedbom, et al., 2013).

In Europe, the prevalence of vertebral fractures among women is the highest in Scandinavia (26%), and the lowest in Eastern Europe (18%).

In 2010, in Romania there were approximately 94,000 new fractures, including about 14,000 fractures in the coxofemoral joint, 16,000 vertebral fractures, 16,000 in the forearm bones and 48,000 fractures in other anatomical areas (pelvis, ribs, humerus), tibia, fibula, collarbone, sternum and other fractures in the femur). The cost of treating these fractures amounted to 129 million euros. The money was distributed in a proportion of 68% of the total of 129 million euros for the actual treatment of the fractures, 27% for the long-term care of the fractures and 5% for the preventive medicine treatment. It is estimated that by 2025, the incidence of fractures will reach 110,000, ie an increase of 16,000 fractures compared to 2010. It is expected that fractures in the coxofemoral joint, vertebrae, bones of the forearm and in other anatomical areas will increase respectively. with 3000, 2400, 2300 and 8200

respectively. Expenditure in this regard will increase by 2025 by about 17% to 151 million euros (Ivergard, et al., 2013).

The population of Romania, which presents an increased risk of suffering from osteoporosis, is the one over 50 years old. Thus, for ages 50-59, 1,525,000 women and 1,401,000 men are at increased risk for osteoporosis, between 60-69 years, 1,124,000 women and 916,000 men have a high risk, between the ages of 70 - 79 years (991,000 women and 666,000 men), between 80 - 89 years (408,000 women and 218,000 men) and those over 90 (29,000 women and 11,000 men) are at high risk for suffering from this disease. Therefore, at the age of 50, 7,289,000 people are at high risk for osteoporosis, of which 4,077,000 are women and 3,212,000 men (Ivergard, et al., 2013).

The estimates made in Romania, indicate that in 2010, the people who suffered from osteoporosis according to age are the following: 48,069 women and 17,925 men between the ages of 50 - 54 years; 73,152 women and 23,940 men aged 55-59; 89,661 women and 30,798 men aged 60-64; 100,394 women and 28,490 men (65 - 69 years); 154,845 women and 30,264 men (70-74 years); 163,500 women and 28,634 men (75-79 years); 206,264 women and 38,014 men (80+ years). Thus, after age 50, 835,885 women and 198,065 men suffered from osteoporosis (Ivergard, et al., 2013).

The incidence in Romania in 2010 of 100,000 inhabitants for fractures in the coxofemoral, vertebral, bones of the forearm and "other fractures" is also different depending on the age and gender of the person.

In Romania, the costs for a hip fracture amount to about € 2,168, based on the costs in Slovenia (Dzajkovska, Albert I., & Ales, 2007). If we stratify the cost according to the criterion of the fractured anatomical area, for the fractures in the hip the highest amounts are recorded (€ 61 million), followed by “other fractures - in different anatomical areas” (€ 53 million), the spine (€ 7 million)) and fractures in the radial-carpal joint (€ 2 million). It is estimated that the population over the age of 50 will increase from 7.3 million in 2010 to 8.2 million in 2025, which corresponds to a 12% increase. The total number of fractures is expected to increase from 94,000 in 2010 to 110,000 in 2025, thus registering an increase of 17%. The number of fractures of the hip, spine, "other fractures" and at the level of the radio-carpal joint will increase by 3000, 2400, 2300 and 8200 respectively. Therefore, there will be an increase between 14% and 21% depending on the anatomical area concerned. . It is estimated that this increase will be 13% among men and 20% among women. From an economic point of view, it is estimated that it will reach a figure of about £ 151 million in 2025, this being in 2010 when the figure was only £ 129 million. Therefore, a total increase of

17% of the expenses can be registered. Costs will increase by 20% for women and 13% for men (Ivergard, et al., 2013).

The costs for people with osteoporosis and osteopenia in Australia, including direct and indirect costs, have been estimated at $ 2.75 billion and an increase to $ 3.84 billion is expected in 2022, with a 10-year cumulation of 33.6 billions of dollars.

Osteoporosis is an economic burden that will grow in the years to come because people over the age of 65 are expected to double by 2040 (Waldrop, Cheng, Devin, McGirt, Fehlings, & Berven, 2015).

Osteoporosis is a multifactorial disorder, the causes and mechanisms are diverse, which is why there are numerous classifications of osteoporosis (Carmen, 2005, p. 195).

Osteoporosis is classified according to the etiology and severity of the condition. Thus, this condition can be classified into primary and secondary osteoporosis.

I. Primary osteoporosis (Carmen, 2005, p. 196)

- Postmenopausal;
- Age (senile, involuntary osteoporosis);
- Juvenile;
- Idiopathic (idiopathic of young adult, idiopathic of premenopausal woman, idiopathic of man).

Factors that accelerate bone loss are genetic predisposition, maternal history of hip fractures, steroid hormone use, dietary calcium deficiency, vitamin D deficiency, systemic diseases, nutrient absorption disorders, treatment with aromatase inhibitors (for breast cancer), kidney disease, smoking, administration of heparin and oral anticoagulants, prolonged immobilization, hyperparathyroidism, hyperthyroidism, diabetes, high alcohol consumption and deliberate weight loss, especially with a body mass index of less than 20 kg / m^2 (Compston, 2018). According to the literature, the risk factors are as follows:

a) Genetic factors (Boudin & Hul, 2017), (Tabatabaei-Malazy, Salari, Khashayar, & Larijani, 2017), ethnicity and gender (Pietschmann, Rauner, Sipos, & Kerschan-Schindl, 2009), (Phipps, Mitlak, Burr, & Allen, 2019, p. 391). Bone growth and development throughout life is influenced by both heredity (Boudin & Hul, 2017) and external factors. The general shape and the relationship between the components of the bone system are genetically determined. Bone mass, thickness, shape and internal architecture are influenced by external factors such as diet and mechanical stress to which the bone test is subjected. The race of the individual has a decisive influence on the bone mass. Thus, Asian and Hispanic children show a lower bone mass compared to

Caucasians, while black children have the highest bone mass (Baxter-Jones, Burrows, Bachrach, Lloyd, Petit, & Macdonald, 2009), (Burrows, Baxter-Jones, Mirwald, Macdonald, & McKay, 2009). Among the Asian population, calcium and vitamin D levels among children are also low, compared to those in the Caucasian area (Burrows, Baxter-Jones, Mirwald, Macdonald, & McKay, 2009), (Ekbote, Khadilkar, Chiplonkar, & Khadilkar, 2011). Even among adults, bone mineral density is lower in Asia compared to the Caucasian, black, or Hispanic population (Shin, et al., 2010);

b) Age (Giusti & Bianchi, 2015), (Phipps, Mitlak, Burr, & Allen, 2019, p. 391). The risk of osteoporotic fracture increases with age. A bone mineral density T-score of -2.5 at the age of 75 implies a much higher risk of fracture than if the same score (-2.5) was at the age of 50 (Villiers, Bone health and osteoporosis in postmenopausal women, 2009); (Giusti & Bianchi, 2015);
c) Nutrition (Chan, 1991), (Berriche, et al., 2017), (Tabatabaei-Malazy, Salari, Khashayar, & Larijani, 2017), (Phipps, Mitlak, Burr, & Allen, 2019, p. 391);
d) Vitamin D status (Oh, Yoo, Lee, Hyun, Ko, & Chu, 2014), (Holick, 2004), (Rizzoli, Bischoff-Ferrari, Dawson-Hughes, & Weaver, 2014), (Phipps, Mitlak, Burr, & Allen, 2019, p. 391);
e) Weight / obesity (Greco, Donini, Lenzi, & Migliaccio, 2014), (Robinovitch, Hayes, & McMahon, 1991). BMI (body mass index) below 21 is associated with low bone mineral density and increased risk for fractures, which may also indicate nutrition deficiencies (Tang, Eslick, Nowson, Smith, & Bensoussan, 2007);
f) Excessive alcohol use (Kelepouris, Harper, Gannon, Kaplan, & Haddad, 1995), (Scane, Francis, Sutcliffe, Francis, Rawlings, & Chapple, 1999), (Hoidrup, Gronbaek, Gottschau, Lauritzen, & Schroll, 1999), (North American Menopause Society, 2002), (Kanis JA, et al., 2005), (Mukamal, Robbins, Cauley, Kern, & Siscovick, 2007), (Berg, et al., 2008), (Guo, Qu. , Bai, Ma, & Chai, 2013), (Mostofsky, Mukamal, Giovannucci, Stampfer, & Rimm, 2016), (Cheraghi, et al., 2019), (Phipps, Mitlak, Burr, & Allen, 2019, p. 391) or alcoholism. Moderate alcohol consumption has no adverse effects on bone density, with some studies claiming that moderate alcohol consumption has protective effects against hip fractures (Ngugyen, Eisman, Kelly, & Sambroak, 1996), (Jill, et al., 2012); A 2019 meta-analysis concludes that people who consume alcohol are at an increased risk for osteoporosis compared to people who do not use alcohol. Thus, the higher the alcohol consumption, the higher the risk of osteoporosis, the

researchers finding a positive association between alcohol consumption and osteoporosis (Cheraghi, et al., 2019);

g) Excessive coffee consumption (Stetzer, 2011), (Oh, Yoo, Lee, Hyun, Ko, & Chu, 2014), (Berriche, et al., 2017), (Phipps, Mitlak, Burr, & Allen, 2019, p. 391). Previous studies have suggested that a high intake of caffeine may increase the risk of osteoporosis and cause calcium excretion in older women, which has been associated with accelerated bone loss (Macedo, Brentegani, & Lacerda, 2015), (Nash & Ward, 2017), (Peacock, Mattick, & Bruno, 2017). Excessive coffee consumption has been shown to increase oxidative stress, which negatively influences the viability of osteoblasts (Choi, Cho, Lee, & Park, 2013). And in the case of carbonated drinks, the phosphorus from these drinks has a negative effect on the health of the bones (National Osteoporosis Foundation, 2017);

h) Smoking (O'Neill, Felsenberg, Varlow, Cooper, Kanis, & Silman, 1996), (Voort, Geusens, & Dinant, 2001), (National Osteoporosis Foundation, 2003, pg. 1-37), (Vestergaard & Mosekilde, 2003), (Vestergaard & Mosekilde, 2003), (Vestergaard & Mosekilde, 2003), (Kanis JA, et al., 2005), (Papaioannou, et al., 2006), (Oh, Yoo, Lee, Hyun, Ko , & Chu, 2014), (Cusano, 2015), (Christos, et al., 2015), (Black & Rosen, 2016), (Phipps, Mitlak, Burr, & Allen, 2019, p. 391). Some people consider the most toxic substance for bone to be nicotine, which we find in cigarettes. One study confirmed that postmenopausal women who smoked or were still smoking at the time of study had a much higher risk of developing a hip fracture (Jenkins & Denison, 2008). Smoking decreases bone mineral density and cortical bone thickness / strength even in young men (Lorentzon, Mellstrom, Haug, & Ohlsson, 2007). Smoking during pregnancy may adversely affect the bone mineral density of the child (Grossman, 2011), (Holroyd, Harvey, Dennison, & Cooper, 2012). Smoking from an early age, especially during growth, has been associated with low bone mineral density (Dorn, Beal, Kalkwarf, Pabst, Noll, & Susman, 2013) and may lead to poor bone tissue quality (International Osteoporosis Foundation, 2015);

i) Sedentarism (Borer, 2005), (Phipps, Mitlak, Burr, & Allen, 2019, p. 391);

j) Handgrip strength. Miller et al. (Miller, Crotty, Harrison, & Andrews, 2003) followed a batch of 1,251 participants 70 years of age and older and found that participants with reduced strength at this level suffered fractures during 12 months;

k) Sleep quality and duration (Evans, et al., 2005), (Specker, Binkley, Vukovich, & Beare, 2007), (Shin, et al., 2010), (Fu, Zhao, Lu, Jiang, Ma, & Zhu , 2011), (Kobayashi,

Takahashi, Deshpande, Shimbo, & Fukui, 2012), (Chen, et al., 2014), (Cunningham & Pace, 2015), (Sasaki, Fujiwara, Yamashita, Ozone, Teramen, & Kihara, 2016).

l) Glucocorticoid use (Phipps, Mitlak, Burr, & Allen, 2019, p. 391) over 3 months (prednisolone 5mg daily or more) (Kanis J. A., et al., 2004). More than 50% of women with osteoporosis who use drugs for this condition have a level below the optimal 25-hydroxyvitamin D3 (Holick, Vitamin D deficiency, 2007);

m) Malabsorption problems such as celiac disease and short bowel syndrome affect calcium and vitamin D uptake, as well as other nutrients essential for bone metabolism (Coates, Fernstrom, Fernstrom, Schauer, & Greenspan, 2004), (Phipps, Mitlak, Burr, & Allen, 2019, p. 391).

n) Person history, especially if he has suffered a previous fracture after the age of 50 (Kanis J. A., et al., 2004). Any previous fracture doubles the risk of a new fracture. The risk for a subsequent fracture is 20% in the first year after a vertebral fracture. Spine fractures can be asymptomatic and can only be detected by use of X-rays at the lumbar and cervical spine or by lateral evaluation of vertebrae using DEXA osteodensitometry (Genant, Li, Wu, & Shepherd, 2000). The risk of fracture increases if in the family history, the parents (mother, father or both) suffered a hip fracture (Kanis J. A., and others, 2004).

o) Contraceptive use plays an important role in the onset of osteoporosis, as these can cause menstrual cycle disorders, and in some cases can lead to amenorrhea (lack of menstruation), which may later contribute to osteopenia and osteoporosis (Heaney et al., 2000).

p) Diabetes (Mastrandrea, Wactawski-Wende, Donahue, Hovey, Clark, & Quanttrin, 2008), (Burghardt, et al., 2010), (Wongdee & Charoenphandhu, 2011), (Pritchard, et al., 2012), (Patsch , et al., 2013), (Farr, Drake, Amin, Melton, McCready, & Khosla, 2014), (Shah, et al., 2017);

r) Anxiety or depression;

s) Sarcopenia (Monaco, Vallero, Monaco, & Tappero, 2011), (Monaco, Castiglioni, Vallero, Monaco, & Tappero, 2012), (Iolascon, Giamattei, Moretti, Pietro, Gimigliano, & Gimigliano, 2013), (Rizzoli , et al., 2014);

ș) Endocrine disorders (Tabatabaei-Malazy, Salari, Khashayar, & Larijani, 2017).

CHAPTER II. Clinical and paraclinical presentation in osteoporosis

1. Bone and vertebral fractures

One of the most general signs and symptoms known is the predisposition for bone fractures. Unfortunately, this is also one of the most serious symptoms that a person may experience (Gehlbach, Burge, & Puleo, 2003), (JeanHailes, 2017).

Osteoporotic fractures are more common than heart attacks, strokes, and new cases of breast cancer (Phipps, Mitlak, Burr, & Allen, 2019, p. 390).

A "brittle fracture" is a sign that indicates a low bone mineral density. This fracture may occur after a fall from a height lower than that of the orthostatic position, a fall that a normal, healthy and strong bone would normally withstand. In the United States, fractures of this kind are very common, with around 1.5 million people suffering from such a fracture. Even so, with all these alarming signs, only 1/4 - 1/3 of these people undergo proper treatment in this regard or are interested in the health of the bones through specific investigation methods (Shier, Jackie, & Ricki, 2012, pp. 131-132).

The most common fractures occur at the level of the thoracic spine (middle of it), the upper portion of the lumbar spine, at the level of the hip (proximal femur) and at the proximal level of the forearm (Colles fracture) (Gimigliano, 2018).

Hip fractures are those that endanger life in particular, because a fracture at this level increases the risk of mortality by 15% - 20% (Gimigliano, 2018).

When the standard deviation (SD) of bone mineral density decreases by one percent, the risk of spine fracture increases 1.5 - 2 times, and the risk of hip fracture increases 2.6 times (Gimigliano, 2018).

2. Height loss

With the aging process, height reduction seems to be normal, but when we suffer from osteoporosis, the height reduction is much more visible, representing a characteristic sign of osteoporosis. This is the consequence of spinal cord fractures or fractures at this level. Height reduction is gradual, and the earlier we observe this, the more likely we are that these changes will have a minimal effect on quality of life (Mayo Clinic Staff, 2016), (Gimigliano, 2018).

It is not known exactly the incidence of vertebral fractures, but it is estimated that in 50% of cases of vertebral fracture patients do not seek medical intervention.

3. Posture

A common sign of osteoporosis is the modification of body posture. This postural change is the one that most affects the individual physically and mentally (Gimigliano, 2018).

People with osteoporosis often take an inadequate posture, as a consequence of bone loss and bone mineral density in the spine. In these cases, a fracture can occur even after a light fall, and if this happens, the vertebrae can be crushed in the area where the fracture occurred. By adopting an unnatural position (bent forward), this can influence the individual's ability to perform the proposed daily activities. This posture can affect the breathing process, as the lungs become restricted with less room to expand inside the chest (Gass, 2018).

4. Fragments of broken nails

Although not so well known, the hands and nails can provide a specialist with important details about the general health of the patient, about what is happening inside the body. Thus, broken nail fragments may suggest osteoporosis, as a consequence of poor diet in nutrients necessary for the proper functioning of the body (Brown, 2015), (Gass, 2018).

5. Muscle and joint pain

With age, these symptoms can make their presence felt, as a consequence of the degenerative process of the body. These symptoms can also be seen in osteoporosis (Brown, 2015), (Mayo Clinic Staff, 2016).

Acute pain is usually due to compression fractures that may go unnoticed up to 4 weeks after the fracture occurred (Gimigliano, 2018).

Also, pain and skeletal deformities associated with osteoporosis, decrease muscle strength (Gimigliano, 2018).

Weak musculature of the extensors of the back related to body weight or flexural strength of the spine increases the possibility of suffering a compression fracture at the vertebral level (Gimigliano, 2018).

6. Vitamin D deficiency

It is well known that people with osteoporosis also have a decrease in the level of vitamin D. Vitamin D is very important in maintaining bone health because it helps to fix

calcium in the bones, which subsequently gives resistance to bone. One bad thing a person can do is ignore the low levels of this vitamin in their body (Gass, 2018).

7. Body weight changes

For many people, losing weight can be a good thing because maintaining optimal weight helps maintain health. However, for underweight people, it is considered that a lower body mass index may be a sign of osteoporosis, because the bone is stimulated by mechanical loading, and the greater the weight acting on the bone, the more the bone is stimulated. good (Gass, 2018), (Mayo Clinic Staff, 2016).

8. Back pain

A very common symptom in people with osteoporosis is back pain. These back pains may be the consequence of other conditions, but when besides these pains are present the muscular and joint pains, the reduction of the body height, the changes in the body weight, it can be suspected that the person in question suffers from osteoporosis (Gass, 2018), (Driver & Stoppler, 2017), (Gimigliano, 2018).

9. Bone mineral density

While most signs and symptoms are relative, the most defining sign that a person is suffering from osteoporosis is the test for measuring bone mineral density. The result obtained in this test is compared with the ideal bone mineral density of a 30-year-old person, which represents the score T. The differences recorded refer to the standard deviation (SD), and the more standard deviations below 0, indicating a negative number, the lower the bone mineral density of the respective person, and the chances of suffering a fracture are higher (Gass, 2018).

10. Handgrip strength

There are many studies conducted in postmenopausal women that show that the handgrip strength is the most important functional test related to bone mineral density (Brown, 2015).

Osteoporosis and falls are the most important risk factors for fragile fractures (Hong, et al., 2015). Hip fracture, as a consequence of osteoporosis, remains a major challenge for the public health of the population (Kanis, McCloskey, Johansson, Cooper, Rizzoli, & Reginster, 2013).

Postural alignment is altered in older people with low bone mineral density. Muscle performance may be altered by decreased muscle mass and strength. Weak spine extensor muscle is associated with hyperciphosis (Katzman, et al., 2011) and may limit activities such as forward bending, reduced walking speed, increased difficulty while climbing stairs, and poor balance (Balzini, et al., 2003). , (Sinaki, Brey, Hughes, Larson, & Kaufman, 2005). Spinal deformities directly cause restrictive lung problems, constipation, chronic pain and depression, which contributes to decreased mobility and independence (Johnell & Kanis, 2006), (Lewiecki & Laster, 2006). In addition, hyperciphosis can cause iliocostal pain (Sinaki M., 2010) and headache (Sinaki, Garza, & Itoi, 2012), all of which interfere with the ability to participate in physical activity. An incorrect posture (hyperciphosis) is relatively unstable because the body weight center changes, and hyperciphosis causes changes in position as a consequence of incorrect alignment of the joints (Granito, Aveiro, Renno, Oishi, & Driusso, 2012).

Low muscle mass in the lumbar spine area is often present in people with osteoporosis, but also in those with thoracic kyphosis, and as a result mobility is limited (Cunha-Henriques, Costa-Paiva, Pinto-Neto, Fonsechi-Carvesan, Nanni, & Morals, 2011).

Decreased bone mass in elderly patients may cause progressive microfractures, which may ultimately decrease the height of the vertebral bodies as a consequence of vertebral compression fractures (Hsu, Chen, Tsauo, & Yang, 2014).

Bone fractures are a serious worldwide problem, affecting over 75 million people, with over 2.3 million osteoporotic fractures per year globally (Svedborn, et al., 2013), (Wright NC et al. , 2014). It is reported that approximately one in five men and one in three women - corresponding to 200 million men and women worldwide - will suffer a lifetime fragility fracture (Nash & Ward, 2017). Bone fractures as a consequence of bone fragility can seriously affect the day-to-day activities and quality of life of the people concerned and are closely associated with increased mortality in osteoporosis patients (Tabatabaei-Malazy, Salari, Khashayar, & Larijani, 2017). Fractures in the spine, hips or forearm are common complications of osteoporosis and can have consequences that can negatively affect quality of life. Studies from 2018 state that approximately 8.9 million fractures occur worldwide annually due to osteoporosis (Cruz, Lins, Medeiros, Filho, & Silva, 2018). Following a fracture, which may be a consequence of bone fragility, there is an increased statistical risk of subsequent fractures in people aged 60 to 82 years (Velde, et al., 2018). Fractures at the proximal level of the humerus, forearm, and radio-carpal joint may suggest osteopenia or osteoporosis (Thompson, Evitt, & Whaley, 2010). Fracture at the distal radius may also be the

first opportunity to evaluate and treat osteoporosis to reduce the risk of future fractures due to bone fragility (Padegimas & Osei, 2013), (Sarfani, Scrabeck, Kearns, Berger, & Kakar, 2014). Fractures in the distal radius represent up to 18% of all fractures in patients over 65 years of age (Nellans, Kowalski, & Chung, 2012). Risk factors include female sex, obesity, frequent falls, white race, and diagnosis of osteoporosis (Xu, Ni, Yu, Gu, Wang, & Zheng, 2017). The prevalence of osteoporosis in patients with fractures in the distal radius is high compared to the corresponding control subjects, regardless of sex (Øyen, Brudvik, Gjesdal, Tell, Lie, & Hove, 2011). A study in Canada showed that all participants over the age of 65 were at moderate or high risk for osteoporotic fracture (Beattie, et al., 2015). Although isolated fractures at the distal radius may cause difficulties in daily activities, they do not appear to be associated with increased mortality (Shauver, Zhong, & Chung, 2015).

CHAPTER III. Primary and secondary prevention in postmenopausal osteoporosis

It has been stated that exercise can compensate, delay or mitigate the effects of osteoporosis (Fletcher, 2013), (Daly, 2017).

Physical exercises increase bone mineral density, bone mass and strength as well as its mechanical properties. It appears to act directly or indirectly on most bone cells and affects many aspects of bone remodeling (Yuan, et al., 2016).

It is well known that bone is stimulated by mechanical loads (Yokota, Leong, & Sun, 2011), and it responds to mechanical stress and adapts to the applied mechanical forces (Kohrt, Bloomfield, Little, Nelson, & Yingling, 2004), (Bailey & Brooke-Wavell, 2008), (Burgers & Williams, 2013).

Osteoblasts are stimulated by mechanical forces acting on the bone, which then produce different biological effects that are beneficial for bone health (Rubin, Rubin, & Jacobs, 2006).

Mechanical stimulation of bone has the effect of inhibiting osteoclast formation and activity (Lanyon, 1996), (Rubin J., Murphy, Nanes, & Fan, 2000), (Rubin J., Murphy, Zhu, Roy, Nanes, & Fan, 2003), (Saunders, Taylor, Du, Zhou, Pellegrini, & Donahue, 2006).

Once mechanical forces are exerted on the bone, the osteocytes detect the strain and activate the activity of the osteoblasts to form new bone (Ju, Sone, Ohnaru, Choi, Choi, & Fukunaga, 2013).

Osteocytes are thought to be the ones that feel the bone under mechanical pressure and then send signals to the nearest osteoclasts and osteoblasts to respond specifically to pressure / loading exerted (Bonewald LF, 2011), (Crockett, Rogers, Coxon , Hocking, & Helfrich, 2011). If the osteocytes do not feel the mechanical load, the activation of the osteoclasts will resorb the bone (Bravo, et al., 1996).

The osteocytes occupy the gaps and are surrounded by the bone matrix. They can initiate and control local bone remodeling by integrating mechanical signals and converting them into biological messengers (Rochefort & Benhamou, 2013).

Thus, osteocytes receive mechanical stresses on the bone and then transmit them to cells on its surface (Bonewald & Johnson, 2008).

These forces increase both mineral density and bone strength, which may be some of the main reasons why physical activity is so beneficial for bone health, it is recommended even for the prevention of osteoporosis due to the few side effects and the positive effect on osteoblast activity. (Cheung & Lora, 2012), (Niinimaki, 2012).

Exercises with moderate intensity promote bone formation and inhibit bone resorption. Thus, physical exercises have a positive impact on bone mass (Honda, Sogo, Nagasawa, Kato, & Umemura, 2008), strength, geometry and bone properties, which prevents and slows the development of osteoporosis (Welch, Turner, Devareddy, Arjmandi, & Weaver, 2008), (Senderovich & Kosmopoulos, 2018).

Mesenchymal stem cells are multipotent cells that have the ability to proliferate and differentiate into different cells including osteoblasts, chondrocytes and adipocytes. Physical exercises induce mesenchymal stem cells to differentiate into osteoblasts. A recent study compared the effects of resistance training and the effects of a sedentary lifestyle on CSM (mesenchymal stem cells) in rats and found that exercise can increase the number of cells that differentiate into osteoblasts (from mesenchymal stem cells) and inhibit adipogenic potential of these stem cells (Hell, et al., 2012), (Maredziak, Smieszek, Chrzastek, Basinska, & Marycz, 2015).

Physical exercises lead to increased mechanical signals such as dynamic tension, compression and hydrostatic pressure. These mechanical signals stimulate osteogenetic differentiation of mesenchymal stem cells and inhibit adipogenic differentiation, which may

be one of the main reasons for physical activity to prevent osteoporosis (Sawakami, et al., 2006).

Exercise-induced mechanical stress contributes to bone strength development by influencing collagen alignment when new bone is formed (Huiskes, Ruimermam, Lenthe, & Janssen, 2000). Thus, the bone responds to mechanical loading by stimulating bone formation in areas where loading is high (Turner, 2006), (Senderovich & Kosmopoulos, 2018).

Muscle activity transmits stresses to the bone, and their dynamic tightening leads to anabolic effects by stimulating the proliferation of osteoblasts (Kaspar, Seidl, Neidlinger-Wilke, Beck, Claes, & Ignatius, 2002).

On the other hand, the absence of physical activity, prolonged immobilization in bed and weightlessness have negative effects on the bone system by inhibiting osteoblast activity and by strengthening osteoclast activity (Meyers, Zayzafoon, Douglas, & McDonald, 2005).

When a subject is immobilized, the stimulus for bone mineral density acquisition is insufficient, leading to increased bone resorption. This is due to the fact that osteocytes, as receptors for gravity, do not detect gravity that behaves as a physiological exciter of the bone (Herrero & Pico, 2016).

CHAPTER IV. Nutrition and osteoporosis

Unhealthy eating habits are risk factors for osteoporosis (Kurtulus, Bicer, Bicer, & Pehlivan, 2017). Bone skeletal formation begins with the development of the embryo, and inadequate nutrition during pregnancy can have a negative impact later in life on the bone formation and development of the child (Prentice, Schoenmakers, Laskey, Bono, Ginty, & Goldberg, 2006). Eating disorders such as bulimia and anorexia nervosa significantly decrease bone mineral density (Robinson, Aldridge, Clark, Misra, & Micali, 2016). The results of studies on the relationship between protein intake and bone mineral density are diverse (Shams-White, et al., 2017). Well-developed western countries have a higher incidence of osteoporosis compared to developing countries (Lau & Cooper, 1996). Interestingly, the countries where high amounts of dairy and animal protein are consumed have the highest incidence of osteoporosis. Three causes are suggested: (1) excess animal protein contributes to osteoporosis, while plant proteins decrease the risk; (2) the high dose of calcium is not sufficient to cover the calcium requirement, in this case a similar dose of magnesium is needed, and the vegetables are much richer in magnesium compared to the animal products;

(3) Vitamin D is a major problem in highly developed countries due to insufficient sun exposure, compared to developing countries. Thus, hip fractures have a higher incidence in Caucasian women living in temperate climates compared to women in Africa (Lau & Cooper, 1996; Iyengar & Tandon, 1999). People who relied on a diet based on western habits (high in sugar, fat, and white flour) had a lower bone mineral density compared to those who did not adopt this diet, which is a nutrient-poor diet. , energy dense (Okubo, et al., 2006; Monma, et al., 2010; Hardcastle, Aucott, Fraser, Reid, & Macdonald, 2010; McNaughton, Wattanapenpaiboon, Wark, & Nowson, 2011). Older women who consumed many sweets and many proteins of animal origin compared to those of vegetal origin, suffered from low bone mineral density in the radius, accelerated bone loss in the femoral neck and more hip fractures (Sellmeyer, Stone, Sebastian , & Cummings, 2001). Groups that consumed a lot of meat and few fruits and vegetables had negative effects on bone health, as a result of increased calcium excretion and bone resorption. Soybean also plays a protective role on bone mineral density (Shedd-Wise, et al., 2011). There are studies that demonstrate an inverse relationship to the one mentioned above, namely that animal proteins would play a more important role in reducing the risk of hip fracture compared to plant proteins (Munger, Cerhan, & Chiu, 1999), but we will see in the following that recent studies combat this hypothesis. Also, in a study that compared thirty women with osteoporosis and thirty women with normal bone mineral density, it was observed that women with osteoporosis consumed twice as much meat compared to women who had a normal bone mineral density (Berriche, et al., 2017).

Olive oil has positive effects on bone mineral density (Garcia-Martinez, Rivas, Ramos-Torrecillas, Luna-Bertos, & Ruiz, 2014).

Olive oil was studied and concluded that it has a protective role on osteoporosis, increasing the activity of alkaline phosphatase and calcium ions in the extracellular matrix of osteoblasts, thus stimulating bone formation (Garcia-Martinez, Rivas, Ramos-Torrecillas , Luna-Bertos, & Ruiz, 2014).

Consumption of fish, especially sea fish, has beneficial effects on maintaining bone density in elderly people in China (Chan, Woo, & Leung, 2011).

Fish and olive oil consumption was positively associated with higher bone mineral density in the lumbar spine in 220 healthy Greek, pre, peri, and postmenopausal women (Kontogianni, Melistas, Yannakoulia, Malagaris, Panagiotakos, & Yiannakouris, 2009). .

A study in 2017 compared eating habits between a group of thirty women with osteoporosis and thirty women with normal bone mineral density and found that women with osteoporosis consumed much more saturated fatty acids compared to women with density

normal bone mineral. Also, the consumption of monounsaturated fats was inadequate) (Berriche, et al., 2017).

The consumption of carbonated drinks and caffeine have also been identified as risk factors in the above mentioned problem. The consumption of carbonated drinks is associated with an increased risk for a fracture. Individuals, even adolescents who consume such drinks - drinks that are processed with phosphoric acid and which have a negative effect on calcium and bone metabolism - are more exposed to the risk of a fracture (Golden NH, 2000; Whiting , Vatanparast, Baxter-Jones, Faulkner, Mirwald, & Bailey, 2004).

Thus, a study of adolescent girls (grades 9 and 10) who consumed carbonated beverages showed that they had a 3-fold increased risk of fracture (Wyshak, 2000).

The same is supported by research conducted in Germany on adolescent girls (Libuda, Alexy, Remer, Stehle, Schoenau, & Kersting, 2008).

As a consequence of industrialization, artificial sweeteners are used on a larger scale, including carbonated beverages (Guthrie & Morton, 2000). The association between sweetened beverage consumption and low mineral density, together with increased risk of fracture, has been reported in adolescents (McGartland, et al., 2003), and other studies demonstrate the link between fructose and glucose consumption and poor bone health (Milne & Nielsen, 2000; Ivatures & Kies, 1992).

A 3-year study of 96 women over 65 showed that consuming more than 300 mg of coffee a day accelerates the process of bone loss in the spine (Faisal- Cury & Zacchello, 2007).

Tea does not have the same negative effect that coffee or carbonated drinks have on bone health, but on the contrary, tea improves bone mineral density by supporting osteoblast activity (Du, et al., 2011; Hallstrom, Wolk, Glynn, & Michaelsson, 2006; Shen , et al., 2012). The consumption of green tea in large quantities has a protective effect on bone mineral density in elderly Japanese women (Muraki, et al., 2007), antioxidants playing an important role in this regard (Sugiura, et al., 2011), (Sacco, Horcajada, & Offord, 2013), (Nash & Ward, 2017).

PART II – PRELIMINARY RESEARCH CONCERNING THE EFFECTS OF THE BULGARIAN METHOD BY CONTRAST ON THE QUALITY OF LIFE IN WOMEN WITH POSTMENOPAUSAL OSTEOPENIA / OSTEOPOROSIS

II.1. Purpose of preliminary research

The aim of this study is to carry out an analysis based on the Qualleffo-41 questionnaire aimed at assessing the quality of life in the subjects included in the preliminary study and establishing an accessible and age-appropriate exercise program, in order to improve the quality of life and bone mineral density in postmenopausal women with osteopenia / osteoporosis.

II.2. The hypothesis of the preliminary research

Following the participation of women with postmenopausal osteopenia / osteoporosis in the training program using the Bulgarian method by contrast, over a 12-month period, improvements in bone mineral density, muscle strength and quality of life can be achieved.

II.3. The objectives of the preliminary research

The objectives of the preliminary study were the following:

- Knowledge of the place occupied by the training programs aimed at increasing the muscular strength in the case of women with postmenopausal osteopenia / osteoporosis;
- Knowing the options and preferences of women with osteopenia / postmenopausal osteoporosis for certain types of physical exercises;
- Knowledge of the relationships between physical exercise and bone mineral density, quality of life and muscle strength in women with postmenopausal osteopenia / osteoporosis;
- Assessment of the degree of osteopenia / osteoporosis in the subjects included in the pilot study;

- Evaluation of the quality of life through the questionnaire "Qualeffo-41" proposed and validated by the "International Osteoporosis Foundation";
- Elaboration of the training program aimed at increasing the strength of the main muscle groups from the lower limbs;
- Evaluation of the efficiency of the program through measurements on the bio-psycho-social capacity following its application.

I.4. Inclusion and exclusion criteria

Participants in the study: sedentary women (to perform less than 60 minutes of light intensity exercise - moderate weekly), non-smoker, suffering from osteopenia / osteoporosis, between the ages of 50-60 and who have no contraindications for practicing physical exercises. Women who reported problems with high blood pressure and / or orthopedic conditions that could prevent them from performing the proposed exercise program were excluded.

Inclusion criteria:

- The age of the subjects must be over 50 years;
- Follow treatment with alfacalcidol 0.5 μg / day;
- To present a total T score at the level of the spine between the values -1.5 and -3.

Exclusion criteria:

- Subjects who suffered a fracture in any segment;
- Subjects following treatment other than alfacalcidol 0.5 μg / day;
- Smoking;
- Subjects with metabolic bone disease;
- Long-term treatment with corticosteroids or patients with thyroid disease;
- Subjects already participating in an intense exercise program (once or twice a week);
- Subjects who have contraindications for intense physical exertion - high blood pressure, recent history of cardiac arrhythmias;
- Subjects with musculoskeletal problems that limit physical activity.

II.5. Methods of evaluation

All tests used in both the pilot study and the final study are scientifically validated and approved.

Bone mineral density assessment

1. "DEXA (Dual-energy X-ray absorptiometry)" - test for measuring bone mineral density using the "Hologic Horizon WI Bone Densitometer"

Description: Subjects were scanned using the Hologic Horizon WI Bone Densitometer, in the dorsal decubitus, without wearing clothing or metal-containing objects. This device performs a series of transverse scans that move at intervals of 1 cm (from vertex to heel level). This device provides information on bone mineral density [g / cm2], the values recorded being at the lumbar spine L1 ¬– L4 and at the level of the femur. The obtained scores can be observed according to the obtained T score, and if this score is less than -2.5 we speak of osteoporosis, and if the values are between -1.5 and -2.5 we speak of osteopenia.

Evaluation of muscular strength in the upper and lower limbs

1. "Arm Curl test" - test for measuring the strength of the upper limbs.

Description: From sitting on the chair, with the arms near the body, holding in the dominant hand a 2 kg dumbbell, the participant must perform as many elbow flexions in a period of 30 seconds (Rikli & Jones, 2012, pp. 45-47).

2. "Handgrip strength test" - test for measuring the isometric force of the forearm muscles.

Description: From the seated position, the participant will hold the dynamometer, at a 90 ° angle between the forearm and the arm, the prone supination hand, and the elbow next to the body. From this position, the participant will tighten the dynamometer as tightly as he can and hold for 5 seconds. It will be repeated 3 times in a row, with a pause of 15 seconds between attempts. The best result will be recorded. This test applies to both hands. The clamping force recorded with the dynamometer is an indicator used and validated in many researches (Mathiowetz, Kashman, Volland, Weber, Dowe, & Rogers, 1985).

3. "Chair Stand test" - test for measuring the strength of the lower limbs.

Description: From sitting on a chair, with the forearms crossed at the level of the wrists and the palms resting on the chest, the participant must stand up and sit again. Thus, the

subject must perform as many liftings and settlements as possible within 30 seconds. The chair will have a height of 43 cm. It can also be used as an indicator of functional capacity (Podsiadlo & Richardson, 1991; Rikli & Jones, Senior Fitness Test Manual-2nd Edition, 2012, pp. 47-49). Studies have shown that this test correlates well with other indicators of muscle strength in the lower limbs. If the subject was in the upright position (from the initial sitting position) when the time was up, the partial repetition is considered as a full repetition (Hallage, et al., 2010).

Quality of life assessment

5. Qualeffo-41 - Questionnaire for assessing the quality of life in women with osteopenia / osteoporosis

Description: QUALEFFO-41 questionnaire on quality of life in women with osteoporosis is a questionnaire developed by the "International Osteoporosis Foundation" consisting of 41 multiple-choice questions comprising seven groups of questions regarding: pain (5 questions), daily (4 questions), housework (5 questions), mobility (8 questions), leisure and social activities (7 questions), overall health (3 questions), mental function (9 questions). This questionnaire is clinically validated and translated into 24 languages, including Romanian and is the most used questionnaire currently in scientific studies to evaluate the quality of life in people with osteoporosis. All the answers to the questions are standardized, so for variant one one point is offered, for variant two answers two points are offered and so on. Exceptions are questions 33, 34, 35, 37, 39, 40 (which applies the inverse rule, variant one representing five points, option two representing four points, etc.). Thus, the lower the score obtained on this questionnaire, the higher the quality of life.

Evaluation of somatic indices

6. The height was measured with a wall Thalitometer, (model TANITA), the subject being barefoot, with his back to the wall, his gaze facing forward, his arms near his body, his heels fastened, the tips of his legs facing forward.

7. The weight of the subjects was measured using the electronic scale model TANITA BC-601, with a maximum capacity of 150 kilograms.

II.6. The intervention program

The training program was conducted for one year, twice a week and includes exercises to develop the strength of the main muscle groups at the lower and upper limbs, each training session lasting approximately 50 minutes, and the sessions took place. in the gymnasium of Ștefan cel Mare Suceava University - Faculty of Physical Education and Sport. The program was designed so that the exercises are performed mainly in the open kinematic chain, so as not to exaggerate pressure on the bones. Each training session consisted of several phases (see table 1):

A) Heating of the locomotive (7 '- 10') in which we used analytical exercises to warm the neck, upper limbs, trunk and lower limbs.

B) The intervention program (30 '- 35') in which we used exercises that targeted the muscles of the upper limbs, trunk and lower limbs. To prevent the onset of early muscle fatigue, the order of the exercises was designed so that the same muscle group would not work on two consecutive exercises, and the break between sets was between 1'30 " and 2 '. The subjects had a period of two weeks of familiarization with the physical exercises and of learning the correct technique of execution, and in these two weeks the intensity used was 40% of the 1RM with a number of 12 to 15 repetitions for each set. Subsequently, in the third week the intensity increased to 50% from 1RM, followed by the fourth week to use the specific method (6 x 50% from 1RM + 6 x 70% from 1RM).

C) Return of the body after effort (5 ') in which we used breathing exercises.

Table 1
Structure of the training session

Part	Duration	Content
Warm-up	7 – 10 minutes	Warm-up exercises for the trunk, lower and upper limbs
Intervention program	35 minutes	Exercises to develop the strength of the main muscle groups
Recovery after effort	5 minutes	Breathing exercises

Table 2
Exercises performed in session 1

Exercise	Volume and intensity	Rest
Seated Hip Abduction	2 sets: 6 x 70% + 6 x 50%	60-90''
Seated Machine Dip	2 sets: 6 x 70% + 6 x 50%	60-90''
Seated Back Extension	2 sets: 6 x 70% + 6 x 50%	60-90''
Standing Hip Flexion	2 sets: 6 x 70% + 6 x 50%	60-90''
Standing Hip Extension	2 sets: 6 x 70% + 6 x 50%	60-90''
Seated Hip Adduction	2 sets: 6 x 70% + 6 x 50%	60-90''

Table 3
Exercises performed in session 1

Exercise	Volume and intensity	Rest
Horizontal Leg Press[2]	2 sets: 6 x 70% + 6 x 50%	60-90''
Prone Hamstring Curls[2]	2 sets: 6 x 70% + 6 x 50%	60-90''
Seated Knee Extension[2]	2 sets: 6 x 70% + 6 x 50%	60-90''
Arms Horizontal Abduction	2 sets: 6 x 70% + 6 x 50%	60-90''
Bodyweight Squats[2]	2 sets: 20 reps.	60-90''
Scott Bench Biceps Curls[2]	2 sets: 6 x 70% + 6 x 50%	60-90''

II.7. Presentation, analysis and interpretation of the final results obtained in the preliminary research

In the experimental group, the weight of the subjects registered a significant decrease ($\Delta\%$ = -2.98%) after 12 months (M = 65.2, SD = 3.9) compared to the baseline (M = 67.2, SD = 3.7), (Z = - 2.06, p = .039, r = -0.92).

Within the control group, the weight of the subjects increased ($\Delta\%$ = 2.45%) at the end of the study (M = 66.8, SD = 7.4) compared to the baseline (Z = -1.63, p = .10, r = -0.73). Between the two groups, the difference was not significant after 12 months, (U = -0.31, p = .75, r = -0.10).

The height of the subjects in the experimental group showed a decrease ($\Delta\%$ = -0.12) at the end of the study (M = 159.8, SD = 6.0) compared to the initial moment (M = 160.0, SD = 6.0), (Z = -1.00, p = .32, r = -0.45).

There were no significant differences in the control group (Δ% = -0.13) at the end of the study (*M* = 156.2, *SD* = 4.8) compared to the initial test (*M* = 156.4, *SD* = 4.4), (*Z* = -1.00, *p* = .32, *r* = -0.45). Intergroup differences were not statistically significant (*U* = -1.27, *p* = .21, *r* = -0.40).

Body mass index decreased (Δ% = -2.67) in the experimental group at the end of the pilot study (*M* = 25.5, *SD* = 1.4) compared to the initial test (*M* = 26.2, *SD* = 1.3), (*Z* = -1.84, *p* = .066, *r* = -0.82) and an increase (Δ% = 2.70) within the control group (*M* = 27.4, *SD* = 2.6) compared to the baseline (*M* = 26.6, *SD* = 1.9)), (*Z* = -1.63, *p* = .10, *r* = -0.73), the differences were not significant at the end of the study between the two groups, (*U* = -1.36, *p* = .17, *r* = -0.43).

The mean bone mineral density from the total lumbar spine level increased (Δ% = 0.37%) within the experimental group at the end of the study (*M* = 0.814, *SD* = 0.003) compared to the baseline (*M* = 0.811, *SD* = 0.039), (*Z* = -1.22, *p* = .22, *r* = -0.55). The control group also showed an improvement (Δ% = 0.07%) at the end of the study (*M* = 0.819, *SD* = 0.030) compared to the baseline (*M* = 0.819, *SD* = 0.030), (*Z* = 1.00, *p* = 1.00 , *r* = 0.45), but the difference between the two groups did not differ significantly after 12 months, (*U* = -0.10, *p* = .92, *r* = -0.03).

Bone mineral density increased (Δ% = 1.54) in the femoral neck after 12 months (*M* = 0.669, *SD* = 0.073) compared to the initial moment (*M* = 0.688, *SD* = 0.082) in the experimental group, (*Z* = -1.21, *p* = .23, *r* = -0.54). The control group also showed an improvement (Δ% = 0.13) at the end of the study (*M* = 0.754, *SD* = 0.084) compared to the results from the beginning of the study (*M* = 0.753, *SD* = 0.086), (*Z* = - 0.14, *p* = .89, *r* = -0.06). The difference was not significant at the end of the study between the two groups, (*U* = -1.57, *p* = .12, *r* = -0.50).

At the trochanter level, density increased by 2.46% in the experimental group, (*Z* = -1.76, *p* = .078, *r* = -0.79) and decreased by 0.42% in the control group, (*Z* = -0.14, *p* = .89, *r* = -0.06), the difference was not significant between the two groups at the end of the pilot study, (*U* = -1.15, *p* = .25, *r* = -0.36).

In both groups, a decrease in density was observed at the intertrochanteric level, but the decrease was smaller (Δ% = -0.05) after 12 months (1.112 ± 0.081 vs. 1.111 ± 0.083) in the women who participated in the exercise program, (*Z* = 1.00, *p* = 1.00, *r* = 0.27). For the control group bone mineral density decreased (Δ% = -0.67) at the end of the study (1.126 ± 0.115 vs. 1.119 ± 0.115), (*Z* = -0.68, *p* = .50, *r* = -0.30). At the end of the study, the

difference between the two groups was not statistically significant (U = -0.52, p = .60, r = -0.16).

Within the experimental group, an increase (Δ% = 1.31) of the mineral density in the Ward's triangle was observed at the end of the study (M = 0.526, SD = 0.147) compared to the initial moment (M = 0.520, SD = 0.142), (Z = -0.67, p = .50, r = -0.30). Control group showed an improvement (Δ% = 0.30) at the end of the 12 months (M = 0.540, SD = 0.090) compared to the baseline (M = 0.539, SD = 0.091), (Z = -0.14, p = .89, r = -0.06). However, the difference between the two groups (at the end of the study) was statistically insignificant, (U = -0.10, p = .92, r = -0.03).

The average bone mineral density from the total femur level increased (Δ% = 0.68) within the experimental group at the end of the study (M = 0.924, SD = 0.092) compared to the initial test (M = 0.918, SD = 0.085), (Z = -1.10, p = .27, r = -0.49). In the case of the control group, a decrease of density (Δ% = -0.58) was observed at the end of the study (M = 0.955, SD = 0.083) compared to the initial moment (M = 0.961, SD = 0.085), (Z = -1.21, p = .23, r = -0.54), but the difference between the two groups was not significant at the end of the study (U = -0.52, p = .60, r = -0.16).

For the arm curl test, subjects in the experimental group showed an increase in performance (Δ% = 11%) at the end of the study (M = 22.2, SD = 0.8) compared to the initial test (M = 20, SD = 0.7), the difference being statistically significant (Z = -2.12, p = .034, r = -0.95). Within the control group, there was a decrease in performance (Δ% = -1.94%) after 12 months (M = 20.2, SD = 0.8) compared to the initial results (M = 20.6, SD = 1.1), but the decrease did not was statistically significant (Z = -1.41, p = .16, r = -0.63). The Mann-Whitney U test showed a significant difference between the two groups at the end of the study, (U = -2.46, p = .014, r = -0.78).

For the chair stand test, the group that participated in the exercise program had better results at the final test (M = 19.8, SD = 0.8) compared to the initial test (M = 18, SD = 0.7), being a 10% increase, statistically significant increase, (Z = -2.12, p = .034, r = -0.95). For the control group, the results were weaker at the final test (M = 17.6, SD = 1.7) compared to the initial one (M = 18, SD = 1.2), being a decrease of performances by -2.22%, a decrease which however, it was not statistically significant (Z = -1.41, p = .16, r = -0.63). However, between the two groups, the difference was significant at the end of the study (U = -2.27, p = .023, r = -0.72).

For the handgrip strength test (dominant hand) the experimental group showed a higher mean value (Δ% = 12%) after 12 months (M = 30.4, SD = 1.8) compared to the initial

average (M = 27.4, SD = 1.8), (Z = -2.06, p = .039, r = -0.92). In contrast, the group that did not take part in the exercise program showed a decrease (Δ% = -2.14%) at the end of the study (M = 27.4, SD = 2.1) compared to the initial moment (M = 28, SD = 2.7), the difference being not significant, (Z = -1.34, p = .18, r = -0.60). At the final test, the results were significantly different between the two groups, (U = -2.11, p = .035, r = -0.67).

For the same test, but for the non-dominant hand, the physically active group showed an improvement in the handgrip strength (Δ% = 10.53%) at the end of the 12 months (M = 29.4, SD = 1.7) compared to the initial test (M = = 26.6, SD = 2.2), the difference being statistically significant (Z = -2.04, p = .041, r = -0.91). The control group showed a decrease (Δ% = -3.65%) of the final average (M = 26.4, SD = 2.1) compared to the initial average (M = 27.4, SD = 2.7), a statistically significant difference (Z = -2.07) , p = .038, r = -0.93). At the end of the study, the difference between the two groups was significant (U = -2.11, p = .035, r = -0.67).

After the 12-month training program, the score on quality of life (initial-final evaluation) improved in the experimental group, compared with the control group on 4 of the 7 variables: pain, social activities, general health and mental function.

For the "pain" variable, the Wilcoxon test showed that the experimental group showed a significant improvement (Δ% = -50%) after 12 months (M = 33, SD = 2.7) compared with the initial values (M = 66, SD = 11.4), (Z = -2.02, p = .043, r = -0.90). The control group also showed an improvement (Δ% = -6.6%) after 12 months (M = 57, SD = 7.6) compared to the initial test (M = 61, SD = 11.9), but the difference was not significant, (Z = -0.96, p = .34, r = -0.43). The Mann-Whitney U test showed a significant difference between the experimental group (M = 33, SD = 2.7) and the control group (M = 57, SD = 7.6) at the end of the study (U = -2.66, p = .008 , r = -0.84).

For the variable "ADL", the experimental group showed an improvement (Δ% = -40%) after 12 months (M = 7.5, SD = 2.8) compared to the beginning of the study (M = 12.5, SD = 4.4), (Z = - 1.63, p = .10, r = -0.73). The control group increased (Δ% = 37.5%) after 12 months (M = 13.75, SD = 5.2) compared to the initial values (M = 10, SD = 3.4), but the difference was not significant (Z = -1.73, p = .083, r = -0.77). The difference between the experimental group (M = 7.5, SD = 2.8) and the control group (M = 13.75, SD = 5.2) was not significant at the end of the study (U = -1.93, p = .054, r = -0.61). .

Although the experimental group showed an improvement (Δ% = -25%) regarding the variable "jobs around the house", the final results (M = 6, SD = 2.2) were not significantly different compared to the initial results (M = 8, SD = 2.7), (Z = -1.41, p = .10, r = -0.63). For

the same variable, the control group showed an increase (Δ% = 42.9%) at the end of the study (*M* = 10, *SD* = 3.5) compared to the initial test (*M* = 7, *SD* = 2.7), (*Z* = -1.13, *p* = .26, *r* = -0.50), but the difference between the two groups was not statistically significant (*U* = -1.85, *p* = .065, *r* = -0.59).

Both the experimental group and the control group had an improvement after 12 months regarding the variable "mobility", but the improvement was greater in the control group (Δ% = -12%), compared to the experimental group (Δ% = - 8.7%). However, the difference was not statistically significant either within the control group (*Z* = -1.34, *p* = .18, *r* = -0.60), nor within the experimental group (*Z* = -1.41, *p* = .16). , *r* = -0.63). The Mann-Whitney U test did not show a significant difference between the experimental group (*M* = 13.13, *SD* = 1.4) and the control group (*M* = 13.75, *SD* = 1.7) at the end of the study, (*U* = -0.66, *p* = .51 , *r* = -0.21).

Both groups showed an improvement after 12 months in the variable "social activities", but the improvement was more visible in the experimental group (Δ% = -26.1), compared to the control group (Δ% = -1.5). However, the difference was significant within the experimental group, (*Z* = -2.04, *p* = .041, *r* = -0.91), and statistically insignificant for the control group, (*Z* = -2.72, *p* = .79, *r* = 1.22). The Mann-Whitney U test showed a significant difference between the experimental group and the control group at the end of the study, (*U* = -2.68, *p* = .007, *r* = -0.85).

For the variable "general health perception", the Wilcoxon test showed that the experimental group showed an improvement (Δ% = -28.1%) after 12 months (*M* = 38.3, *SD* = 4.6) compared to the initial test (*M* = 53.3, *SD* = 4.6), (*Z* = -2.04, *p* = .041, *r* = -0.91). The control group had an increase in the level of symptoms (Δ% = 6.9%,) after 12 months (*M* = 51.7, *SD* = 9.1) compared to the initial values (*M* = 48.3, *SD* = 9.1), but the difference was not significant (*Z* = -0.27, *p* = .79, *r* = -0.12). At the end of the study, the difference was statistically significant between the two groups, (*U* = -2.41, *p* = .016, *r* = -0.76).

For the variable "mental function", the experimental group showed a significant improvement (Δ% = -33.7) at the end of the study (*M* = 35, *SD* = 7.8) compared with the initial values (*M* = 52.8, *SD* = 5.6), (*Z* = -2.02, *p* = .043, *r* = -0.90). The control group experienced a worsening of symptoms (Δ% = 4.6) at the end of the study (*M* = 50.6, *SD* = 9.7) compared to the initial test (*M* = 48.3, *SD* = 6.1), (*Z* = -0.73, p =. 47, *r* = -0.33). The Mann-Whitney U test indicated that there was a statistically significant difference between the experimental group and the control group after 12 months for this variable (35 ± 7.8 vs. 50.6 ± 9.7), (*U* = -2.13, *p* = .033, *r* = -0.67).

II.8. Preliminary research conclusions

As a result of the preliminary research, we managed to reach the following conclusions:

1. At the level of the spine both the T_{Total} score and the total bone mineral density registered an improvement within the experimental group (+ 1.85% vs. + 0.96% - T score and + 0.37% vs. +0.07 - bone density from the same level);

2. The bone density at the trohan level improved by almost 2.5 percent for the physically active group and presented a lower average with 0.42 percent compared to the initial moment within the control group;

3. Although the bone density decreased in both groups at the intertrochanteric level, the decrease was lower in the experimental group (-0.05% vs. -0.67%);

4. Even in the Ward's triangle, the increase was more significant in the experimental group (+ 1.31% vs. + 0.30%);

5. At the total level of the proximal femur, the subjects who participated in the resistance exercise program presented a higher average bone density (+ 0.68%) compared to a decrease in the control group (-0.58%);

6. For the physical performance tests, the subjects in the experimental group presented higher values at the end of the study for the arm curl test (+ 11% vs. -1.94%, p = .014, r = -0.78), chair stand test (+ 10% vs. -2.2%, p = .023, r = -0.72), handgrip strength test - dominant hand (+ 12% vs. -2.14%, p = .035, r = -0.67), handgrip strength test - non-dominant hand (+ 10.53% vs. -3.65%, p = .035, r = -0.67);

7. When assessing the quality of life, both groups showed an improvement in the variable "pain" but the decrease was much more evident in the experimental group (-50% vs. -6.6%, p = .008, r = -0.84) and the variable "social activities" (-26.1% vs. -1.5%, p = .007, r = -0.85); for "general health perception" the group that participated in the training program obtained better results (-28.1% vs. + 6.9%, p = .016, r = -0.76), and the same can be said for the variable "mental function" (-33.7% vs. +4.6, p = .033, r = -0.67);

8. The weight of women who participated in the exercise program decreased by 2.98 percent after 12 months, p = .039, r = -0.92, and for women in the control group, the average body weight increased by 2.45 percent. at the end of the study, p = .10, r = -0.73.

Conclusions 1, 2, 3, 4 and 5 confirm our research hypothesis that the training program will also contribute to the increase of bone density, as the results were better within the experimental group.

Conclusion 6 confirms the research hypothesis, namely that following the participation of postmenopausal osteopenia / osteoporosis women in the training program using the Bulgarian method by contrast […], muscular strength improvements can be obtained.

Conclusion 7 confirms the research hypothesis that following the participation of postmenopausal women with osteopenia / osteoporosis in the training program using the Bulgarian method by contrast […], quality of life improvements can be obtained. As there were no improvements in all the variables in the questionnaire, and the differences were not significant either in terms of bone mineral density at the level of the spine and femur, we consider that if we extend the research on a larger group of subjects, we will obtain some data that allow us to draw some final conclusions regarding the influence of the Bulgarian method by contrast on the quality of life.

PART III – EXPERIMENTAL STUDY ON THE INFLUENCE OF THE BULGARIAN METHOD BY CONTRAST ON THE QUALITY OF LIFE IN WOMEN WITH POSTMENOPAUSAL OSTEOPENIA / OSTEOPOROSIS

III.1. The purpose of the research

The purpose of this study is to establish the efficiency of the "Bulgarian (by contrast) method" and to verify the possibilities of applying this method as a preferential method in patients with osteopenia / osteoporosis.

III.2. Experimental research hypothesis

The results obtained on the 10 subjects included in the preliminary research, represent a scientific argument that allows us to extend the research on a larger group of

subjects. Thus, using the Bulgarian method (by contrast) in women with postmenopausal osteopenia / osteoporosis, improvements in muscle strength, bone mineral density and quality of life can be achieved.

III.3. Experimental research objectives

The research objectives were as follows:

- Assessment of the degree of osteopenia / osteoporosis in the subjects included in the study;
- Formation of groups of subjects that can be included in the experimental study;
- Initial testing of subjects included in the study regarding bone mineral density, quality of life and muscle strength;
- Applying the training program on a larger group of subjects;
- Final testing of the subjects included in the study;
- Statistical data processing and interpretation;
- Elaboration of a work that reflects the final conclusions of the work;
- Formulation of recommendations.

III.4. Inclusion and exclusion criteria

Inclusion criteria:

- Subjects must be 49 years of age or older;
- Their history does not include hormone therapy;
- Subjects to receive treatment with alfacalcidol 0.5 µg / day;
- Subjects to present a total T score at the spine level between -1.5 and -3.

Exclusion criteria:

- Hormone therapy;
- Subjects following treatment other than alfacalcidol 0.5 µg / day;
- Tobacco consumption;
- Subjects who have been diagnosed with metabolic bone disease;

- Already participating in a program of intense physical exercises (once or twice a week);

- Has contraindications for intense physical exertion - high blood pressure, recent history of cardiac arrhythmias;

- Musculoskeletal problems that limit physical activity.

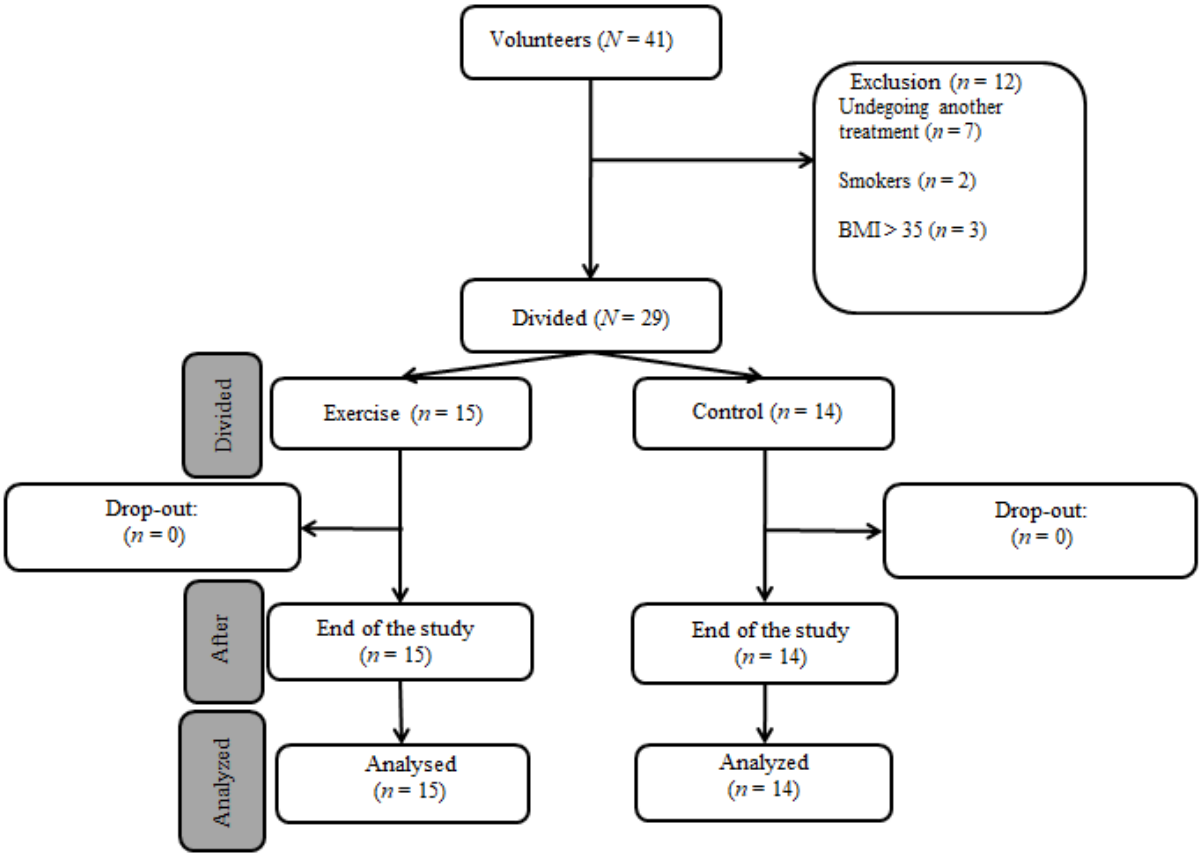

Figure 1. Flowchart of the study participants

III.5. The intervention program

The research was carried out on a batch of 29 subjects, in the gymnasium of the Faculty of Physical Education and Sport, "Stefan cel Mare" University Suceava, twice a week, the training lasting about 50 years. minutes. The measurements and the intervention program were carried out progressively, since not all subjects participated in the study starting with the same calendar date. Thus, as new cases of women with osteopenia / osteoporosis who wished to participate in the study appeared, they were subsequently included, the criteria being respected by all subjects. The training program was described in part II, together with the targeted muscles.

III.6. Presentation, analysis and interpretation of the final results obtained in the experimental study

In the experimental group, the weight of the subjects registered a significant decrease (Δ% = -1.93%) after 12 months (*M* = 64.5, *SD* = 7.9) compared to the initial test (*M* = 65.8, *SD* = 7.4), (t_{15} = 3.11, *df* = 14, *p* = .008, *d* = 0.80, 95% CI [0.39, 2.14]). Within the control group, the weight of the subjects increased (Δ% = 1.13%) at the end of the study (*M* = 63.9, *SD* = 7.6) compared to the initial time of the study (*M* = 63.2, *SD* = 7.5), but the increase was not statistically significant (t_{14} = -2.02, *df* = 13, *p* = .065, *d* = -0.50, 95% CI [0.05, -2.02]). At the end of the study, the average weight difference between the two groups was 0.61 kg, but the t test for independent samples showed that this difference is statistically insignificant, ($t_{15,14}$ = 0.21, *df* = 27, *p* = .84, *d* = 0.08, 95% CI [-5.31, 6.52]).

The height of the subjects in the experimental group showed a statistically insignificant decrease (Δ% = -0.12) at the end of the study (*M* = 160.8, *SD* = 6.3) compared to the initial time of the study (*M* = 161.0, *SD* = 6.3), (t_{15} = 1.87, *df* = 14, *p* = .082, *d* = 0.48, 95% CI [-0.03, 0.43]). In the control group there was a decrease of the mean height of the group by 0.1 cm (Δ% = -0.09), and the dependent *t*-test did not show significant differences at the end of the study (*M* = 157.5, *SD* = 4.6) compared to the initial test (*M* = 157.6, *SD* = 4.7), (t_{14} = 1.47, *df* = 13, *p* = .17, *d* = 0.40, 95% CI [-0.07, 0.35]). The *t* test for independent samples showed that at the end of the study, the difference between the two groups was not statistically significant, ($t_{15,14}$ = 1.60, *df* = 27, *p* = .12, *d* = 0.60, 95% CI [-0.93, 7.53]).

The body mass index decreased (Δ% = -1.79) within the experimental group at the end of the study (*M* = 24.9, *SD* = 2.4) compared to the initial test (*M* = 25.4, *SD* = 2.6), and the t test was dependent on demonstrated that the difference is statistically significant intra-group, (t_{15} = 2.71, *df* = 14, *p* = .017, *d* = 0.70, 95% CI [0.10, 0.81]), and within the control group there was an increase (Δ % = 1.27) statistically insignificant within the control group at the end of the study (*M* = 25.7, *SD* = 2.1) compared to the initial time of the study (*M* = 25.4, *SD* = 2.1), (t_{14} = -2.04, *df* = 13, *p* = .062, *d* = -0.55, 95% CI [-0.66, 0.02]), the differences being statistically insignificant at the end of the study between the two groups, ($t_{15,14}$ = -0.90, *df* = 27, *p* = .37, *d* = 0.34, 95% CI [-2.48, 0.96]).

Within the experimental group, bone mineral density at the lumbar spine L_1 increased (Δ% = 3.01%) after 12 months (*M* = 0.777, *SD* = 0.055) compared to the initial time (*M* = 0.754, *SD* = 0.057), however, the dependent *t* test did not show a significant difference (t_{15} = -1.90, *df* = 14, *p* = .079, *d* = -0.49, 95% CI [-0.048, 0.003]). Within the

control group there was a decrease (Δ% = -1.01%) of bone mineral density at the same level at the end of the study (*M* = 0.743, *SD* = 0.061) compared with the results at the beginning of the study (*M* = 0.750, *SD* = 0.072), (t_{14} = 1.17, *df* = 13, *p* = .26, *d* = 0.31, 95% CI [-0.006, 0.022]). Although, at the end of the study, the mean difference between the two groups was 0.034 g/cm^2 in favor of the experimental group, the t test for independent samples did not show a significant difference, ($t_{15,14}$ = 1.59, *df* = 27, *p* = .12 , *d* = 0.59, 95% CI [-0.010, 0.078]).

Bone mineral density at L_2 level increased (Δ% = 1.44%) within the experimental group at the end of the study compared to the initial time (0.791 ± 0.061 vs. 0.780 ± 0.050), the t test for paired samples demonstrating that the difference was not statistically significant (t_{15} = -1.24, *df* = 14, *p* = .24, *d* = -0.32, 95% CI [-0.031, 0.008]). Within the control group, there was a higher increase (Δ% = 1.70%), at the end of the research compared to the initial moment, but as with the experimental group, the increase was not statistically significant, (t_{14} = -1.74, *df* = 13, *p* = .11, *d* = -0.47, 95% CI [-0.029, 0.003]). Between the two groups, the t test for independent samples did not show a significant difference, ($t_{15,14}$ = 0.61, *df* = 27, *p* = .55, *d* = 0.23, 95% CI [-0.034, 0.063]), of an average difference between the two groups of 0.015 g/cm^2 in favor of the group that participated in the resistance exercise program.

In the lumbar spine L_3 the experimental group recorded an increase in bone mineral density by 2.55% at the end of the study (0.805 ± 0.057 vs. 0.785 ± 0.054), the *t* test for paired samples showing that the difference is almost statistically significant (t_{15} = -2.11 , *df* = 14, *p* = .053, *d* = -0.54, 95% CI [-0.040, 0.000]). At the same level, the control group recorded a decrease in bone mineral density at the end of the study by -1.29% compared to the initial results (0.776 ± 0.066 vs. 0.786 ± 0.064), but the difference was not statistically significant (t_{14} = 0.91, *df* = 13, *p* = .38, *d* = 0.24, 95% CI [-0.014, 0.034]). The difference was not statistically significant at the end of the study between the two groups ($t_{15,14}$ = 1.28, *df* = 27, *p* = .21, *d* = 0.47, 95% CI [-0.018, 0.076]), the experimental group recording a mean with 0.029 g/cm^2 higher than the control group.

Both groups registered a very close increase in value in the lumbar spine L_4: experimental group (Δ% = 0.68%), (t_{15} = -0.47, *df* = 14, *p* = .65, *d* = 0.12, 95% CI [- 0.030, 0.019]) and the control group (Δ% = 0.69%), (t_{14} = -0.51, *df* = 13, *p* = .62, *d* = -0.14, 95% CI [-0.027, 0.017]), but in in both cases the *t*-test for paired samples did not show a significant difference. At the end of the study, the *t* test for independent samples did not show a significant difference between the results of the two groups, ($t_{15,14}$ = 1.63, *df* = 27, *p* = .12, *d*

= 0.60, 95% CI [-0.010, 0.089]), the experimental group recording a higher average with 0.039 g/cm^2 compared to the control group.

The mean bone mineral density from the total lumbar spine level registered a statistically significant increase (Δ% = 1.82%) within the experimental group at the end of the study (*M* = 0.792, *SD* = 0.046) compared to the initial test (*M* = 0.778, *SD* = 0.042), (t_{15} = -2.68, *df* = 14, *p* = .018, *d* = -0.69, 95% CI [-0.025, -0.003]). The control group also improved (Δ% = 0.14%) at the end of the study (*M* = 0.763, *SD* = 0.059) compared to the initial time (*M* = 0.762, *SD* = 0.057), but the *t* test for paired samples did not showed a statistically significant difference, (t_{14} = -0.20, *df* = 13, *p* = .85, *d* = -0.05, 95% CI [-0.013, 0.011]). Although the experimental group had a higher increase compared to the control group, the difference was not significant at the end of the study on the total bone mineral density at the lumbar spine, ($t_{15,14}$ = 1.49, *df* = 27, *p* = .15, *d* = 0.55, 95% CI [-0.011, 0.069]), the average difference between the two groups being 0.029 g/cm^2 in favor of the experimental group.

Bone mineral density increased (Δ% = 2.15) in the femoral neck after 12 months (*M* = 0.696, *SD* = 0.071) compared to baseline (*M* = 0.681, *SD* = 0.069) in the experimental group, *t* test for paired samples showing that the improvement is statistically significant (t_{15} = -3.42, *df* = 14, *p* = .004, *d* = -0.88, 95% CI [-0.024, -0.005]). The control group also showed an improvement (Δ% = 0.32) at the end of the study (*M* = 0.686, *SD* = 0.069) compared to the initial results (*M* = 0.684, *SD* = 0.074), but the *t* test for paired samples did not showed a statistically significant difference, (t_{14} = -0.71, *df* = 13, *p* = .49, *d* = -0.19, 95% CI [-0.009, 0.004]), and the *t* test for independent samples showed that the difference did not was significant at the end of the study between the two groups, ($t_{15,14}$ = 0.40, *df* = 27, *p* = .69, *d* = 0.15, 95% CI [-0.043, 0.064]), the mean difference being 0.010 g/cm^2 in favor of the experimental group.

Bone mineral density at the trohan level recorded a statistically significant increase (Δ% = 4.15) within the experimental group at the end of the study compared to the initial time (0.618 ± 0.058 vs. 0.593 ± 0.056), (t_{15} = -7.52, *df* = 14 , *p* < .001, *d* = -1.94, 95% CI [-0.032, -0.018]). Also within the control group there was an improvement (Δ% = 0.87) of bone mineral density at the end of the study compared to the initial time, but the *t* test for paired samples did not show a statistically significant difference, (t_{14} = -1.74, *df* = 13, *p* = .11, *d* = -0.47, 95% CI [-0.012, 0.001]). At the end of the study, there was no statistically significant difference between the two groups ($t_{15,14}$ = 0.60, *df* = 27, *p* = .55, *d* = 0.22, 95% CI [-0.030, 0.055]), even if the group experimentally showed a higher average of 0.013 g/cm^2 compared to the control group.

Within the group that participated in the weight training program, bone mineral density at the intertrochanteric level increased (Δ% = 1.25) at the end of the study (*M* = 1.018, *SD* = 0.059) compared to the initial results (*M* = 1.006, *SD* = 0.060), and the *t* test for paired samples showed that the improvement is statistically significant (t_{15} = -2.85, *df* = 14, *p* = .013, *d* = -0.74, 95% CI [-0.022, -0.003]). At the same level, within the control group, there was a decrease (Δ% = -0.19) of bone mineral density at the end of the study (*M* = 1.031, *SD* = 0.099) compared with the initial results (*M* = 1.033, *SD* = 0.115), however, the *t* test for paired samples did not show a significant difference, (t_{14} = 0.30, *df* = 13, *p* = .77, *d* = -0.74, 95% CI [-0.012, 0.016]). At the end of the study, the control group presented a higher average with 0.012 g/cm^2 of bone mineral density at the intertrochanteric level compared to the experimental group, but the t test for independent samples showed that the difference between the two groups was not statistically significant, ($t_{15,14}$ = -0.41, *df* = 27, *p* = .69, *d* = 0.15, 95% CI [-0.074, 0.049]).

Both groups have increased bone mineral density in Ward's triangle. Within the experimental group, an increase of 1.31% was observed at the end of the study (*M* = 0.513, *SD* = 0.096) compared to the initial moment (*M* = 0.504, *SD* = 0.099), the *t* test for paired samples showing that the improvement is statistically significant, (t_{15} = -2.35, *df* = 14, *p* = .034, *d* = -0.61, 95% CI [-0.018, -0.001]). And within the control group there was an increase of 1.11% at the end of the study (*M* = 0.509, *SD* = 0.121) compared to the initial results (*M* = 0.504, *SD* = 0.118), but the difference was not statistically significant (t_{14} = -1.56, *df* = 13, *p* = .14, *d* = -0.42, 95% CI [-0.013, -0.002]). Although, at the end of the study, the experimental group presented a higher average with 0.004 g/cm^2 of bone mineral density in Ward's triangle compared to the control group, the difference between the two groups was statistically insignificant, ($t_{15,14}$ = 0.11 , *df* = 27, *p* = .92, *d* = 0.04, 95% CI [-0.079, 0.087]).

At the end of the study, both the experimental group and the control group showed improvements in bone mineral density at the total femur level. However, the experimental group showed a statistically significant increase (Δ% = 2.35) compared to the initial results (0.866 ± 0.059 vs. 0.846 ± 0.056), (t_{15} = -4.71, *df* = 14, *p* < .001, *d* = -1.22, 95% CI [-0.029, -0.011]), while the control group registered a statistically insignificant increase (Δ% = 0.41) at the end of the study compared with the initial results (0.865 ± 0.074 vs. 0.861 ± 0.087), (t_{14} = -0.73, *df* = 13, *p* = .48, *d* = -0.20, 95% CI [-0.014, -0.007]). Although the experimental group showed a statistically significant increase, and at the end of the study the average bone mineral density at the total femur level was 0.002 g/cm^2 higher compared to the control group,

the *t* test for independent samples did not show a significant difference between the two groups, ($t_{15,14}$ = 0.06, *df* = 27, *p* = .95, *d* = 0.02, 95% CI [-0.049, 0.053]).

For the arm curl test, the experimental group recorded an increase in performance (Δ% = 8.83%) at the end of the study (*M* = 23.0, *SD* = 1.6) compared to the initial test (*M* = 21.1, *SD* = 1.8), the *t* test for paired samples showed that the difference was statistically significant (t_{15} = -20.55, *df* = 14, *p* < .001, *d* = -5.31, 95% CI [-2.06, -1.67]). Within the control group, there was a decrease in performance (Δ% = -1.02%) after 12 months (*M* = 20.8, *SD* = 1.8) compared to the initial results (*M* = 21.0, *SD* = 2.1), but the decrease did not was statistically significant (t_{14} = 1.15, *df* = 13, *p* = .27, *d* = 0.31, 95% CI [-0.19, 0.62]). The Mann-Whitney U test showed a significant difference between the two groups at the end of the study, (*U* = -2.80, *p* = .005, *r* = -0.52).

For the chair stand test, the group that participated in the exercise program had better results at the final test (*M* = 20.7, *SD* = 1.3) compared to the initial test (*M* = 18.4, *SD* = 1.1), with a performance increase of 12.32%, a statistically significant increase, (t_{15} = -19.18, *df* = 14, *p* <.001, *d* = -4.95, 95% CI [-2.52, -2.01]). For the control group, the results were weaker at the final test (*M* = 18.6, *SD* = 1.7) compared to the initial one (*M* = 18.9, *SD* = 1.9), being a decrease of performances by -1.14%, a decrease which however, it was not statistically significant (t_{14} = 1.00, *df* = 13, *p* = .34, *d* = 0.26, 95% CI [-0.25, 0.67]). At the end of the study, the difference between the two groups was 2.02 repetitions in favor of the experimental group, and the *t* test for independent samples showed that the difference is statistically significant ($t_{15,14}$ = 3.58, *df* = 27, *p* = .001, *d* = 1.33, 95% CI [0.86, 3.18]).

For the handgrip strength test (dominant hand) the experimental group presented a higher average value of 5.62% after 12 months (*M* = 31.3, *SD* = 4.4) compared to the initial average (*M* = 29.7, *SD* = 4.7), the test Wilcoxon showing that the difference is significant, (*Z* = -3.22, *p* = .001, *r* = -0.83). In contrast, the group that did not take part in the exercise program showed a decrease with -1.56% of the average punching force at the end of the study (*M* = 27.1, *SD* = 3.5) compared to the initial moment (*M* = 27.5, *SD* = 3.4), the nonparametric Wilcoxon test indicating that the difference was not statistically insignificant, (*Z* = -1.60, *p* = .11, *r* = -0.43). At the end of the study, the Mann-Whitney U test showed a significant difference between the two groups, in favor of the experimental group, (*U* = -2.87, *p* = .004, *r* = -0.53).

For the non-dominant hand, the experimental group showed an improvement in the clamping force (Δ% = 3.28%) at the end of the 12 months (*M* = 29.4, *SD* = 5.3) compared to the initial test (*M* = 28.5, *SD* = 5.6)), the Wilcoxon test showing that the difference is

statistically significant (Z = -2.81, p = .005, r = -0.73). The control group decreased (Δ% = -2.49%) of the final average (M = 25.1, SD = 3.5) compared to the initial average (M = 25.8, SD = 3.7), the same nonparametric Wilcoxon test showing that the difference is significant statistically, (Z = -2.71, p = .007, r = -0.72). At the end of the study, the mean difference between the two groups was 4.23 kgF in favor of the experimental group, and the t test for independent samples showed that the difference is significant, ($t_{15,14}$ = 2.53, df = 27, p = .018, d = 0.95, 95% CI [0.81, 7.71]).

At the end of the study, both groups presented improvements to certain variables in the Qualleffo-41 questionnaire, but the improvements were much more evident within the group that participated in the resistance training program.

For the "pain" variable, the t test for paired samples showed that the experimental group showed a significant improvement (Δ% = -34.93%) after 12 months (M = 31.7, SD = 7.0) compared with the initial values (M = 48.7, SD = 17.0), (t_{15} = 4.54, df = 14, p < .001, d = 1.17, 95% CI [8.97, 25.03]). The control group also showed an improvement (Δ% = -6.34%) after 12 months (M = 47.5, SD = 8.0) compared to the initial test (M = 50.7, SD = 13.1), but the t test for paired samples was showed that the difference was not statistically significant (t_{14} = 1.26, df = 13, p = .23, d = 0.34, 95% CI [-2.29, 8.72]). At the end of the study, the average score in the experimental group was lower by 15.83 points (suggesting a better quality of life for this variable) compared to the control group ($t_{15,14}$ = -5.68, df = 27, p < .001, d = 2.10, 95% CI [-21.56, -10.11]).

For the variable "ADL", the experimental group showed an improvement (Δ% = -36.67%) after 12 months (M = 7.9, SD = 3.7) compared to the initial results (M = 12.5, SD = 6.7)), the nonparametric Wilcoxon test showing that the improvement is statistically significant (Z = -2.60, p = .009, r = -0.67). The control group increased (Δ% = 16%) after 12 months (M = 12.9, SD = 4.6) compared to the initial values (M = 11.2, SD = 4.4), but the difference was not statistically significant (Z = -1.27, p = .21, r = -0.34). The Mann-Whitney U test showed that the difference between the experimental group and the control group was significant at the end of the study (U = -2.97, p = .003, r = -0.55).

The experimental group showed an improvement (Δ% = -35.48%) regarding the variable "jobs around the house" at the end of the study (M = 6.7, SD = 2.4) compared to the initial results (M = 10.3, SD = 3.0), the Wilcoxon test showing that progress was statistically significant (Z = -3.32, p = .001, r = -0.86). For the same variable, the control group showed an increase (Δ% = 16.67%) at the end of the study (M = 10, SD = 3.9) compared to the initial test (M = 8.6, SD = 4.1), (Z = -1.63, p = .10, r = -0.44), and at the end of the study the

difference between the two groups was statistically significant (U = -2.39, p = .017, r = -0.44).

For the variable “mobility” the experimental group registered an improvement (Δ% = -10.38%) at the end of the study (M = 8.2, SD = 2.1), compared to the initial test (M = 9.2, SD = 2.8), but the nonparametric test Wilcoxon showed that the improvement was statistically insignificant, (Z = -0.86, p = .39, r = -0.22). Within the control group, the final mean was higher by 16.73% compared to the initial results for the same variable (10.9 ± 3.1 vs. 9.4 ± 2.5), and the nonparametric Wilcoxon test showed that the difference was statistically significant (Z = -2.25 , p = .024, r = -0.60). The Mann-Whitney U test showed that the difference between the two groups was statistically significant at the end of the study, (U = -2.47, p = .014, r = -0.46).

Both groups registered a statistically significant improvement at the end of the study on the variable "social activities"; thus, the experimental group showed an improvement of -9.13%, (Z = -2.66, p = .008, r = -0.69), compared with an improvement of -5.34% in the control group, (Z = -2.48, p = .013, r = -0.66). However, the Mann-Whitney U test showed that the difference between the two groups was not statistically significant at the end of the study (U = -1.53, p = .13, r = -0.28). For the variable " general health perception", the nonparametric Wilcoxon test showed that both the experimental group showed an improvement (Δ% = -40.78%) at the end of the study (M = 33.9, SD = 8.0) compared to the initial results (M = 57.2, SD = 9.9), (Z = -3.32, p = .001, r = -0.86), as well as the control group, which experienced an improvement in symptoms (Δ% = -12.25%) after 12 months (M = 51.2, SD = 10.3) compared to the initial values (M = 58.3, SD = 6.5), (Z = -2.04, p = .041, r = -0.55), for both groups the differences being statistically significant. At the end of the study, the difference was significant between the two groups, (U = -3.68, p < .001, r = -0.68). For the variable "mental function", the experimental group showed an improvement (Δ% = -35.62) at the end of the study (M = 29.4, SD = 5.1) compared with the initial values (M = 45.7, SD = 9.3), the t test for the samples pair showing that the improvement is statistically significant (t_{15} = 8.88, df = 14, p < .001, d = 2.29, 95% CI [12.36, 20.23]). The control group also improved the quality of life for this variable (Δ% = -9.0) at the end of the study (M = 38.1, SD = 7.3) compared to the initial test (M = 41.9, SD = 5.8), the t test for paired samples indicating that the improvement is statistically significant (t_{14} = 2.66, df = 13, p = .020, d = 0.71, 95% CI [0.71, 6.83]). The t test for independent samples recorded a significant difference between the two groups, ($t_{15,14}$ = -3.73, df = 27, p = .001, d = 1.38, 95% CI [-

13.41, -3.89]), the experimental group presenting an average score of 8.65 points lower (suggesting a better quality of life for this variable) compared to the control group.

III.7. Conclusions

Following the actual research I came to the following conclusions:

1. Women who participated in the exercise program recorded a statistically significant decrease in body weight (-1.93%, p = .008), while women who did not participate in the intervention program increased in weight (+1.13%, p = .065); also, the BMI of the subjects in the experimental group registered a significant decrease (-1.79%, p = .017), compared with an increase of the mean at the end of the study for the women in the control group (+1.27%, p = .062);

2. At the end of the study, the bone mineral density in the lumbar spine L_1 increased in the experimental group by 3.01% (p = .079), but decreased by -1.01% (p = .26) in the case of the control;

3. In the lumbar spine L_2, the control group had a higher increase in bone mineral density (+1.70%, p = .11), compared to the experimental group which showed an increase of only 1.44% (p = .24)

4. The control group had an average bone mineral density at the L_3 level with -1.29% lower at the end of the study (p = .38), while the experimental group had a higher average with 2.55% (p = .053);

5. Both groups showed an increase in bone mineral density close to the value at the end of the study, at level L_4: (+0.68%, p = .65 for the experimental group vs. +0.69%, p = .62 for the control group) ;

6. The group that participated in the exercise program registered a statistically significant increase (+1.82%, p = .018) regarding the total bone mineral density from the lumbar spine, while the group that did not participate in the exercise program resistance exercises increased by only 0.14% (p = .85);

7. Although there were no statistically significant inter-group differences in bone mineral density at the femur level, the experimental group recorded statistically significant increases in all areas of interest of the femur as follows: femoral neck (+2.15%, p = .004), trochanter (+4.15%, p < .001), intertrochanter (+1.25%, p = .013), Ward's triangle (+1.31%, p = .034) and the total bone mineral density (+2.35%, p < .001);

8. The group that received only vitamin D treatment also increased at the end of the study regarding bone mineral density from the same areas of interest of the femur except the intertrochanteric area, where the control group recorded a decrease by -0.19% (p = .77); in the other areas, the control group registered statistically insignificant increases as follows: femoral neck (+0.32%, p = .49), trochanter (+0.87%, p = .11), Ward's triangle (+1.11%, p = .14) and total bone mineral density (+0.41%, p = .48);

9. For the physical performance tests, the experimental group recorded statistically significant increases at the end of the study in all tests: arm curl test (+8.83%, p <.001), chiar stand test (+12.32%, p <.001).), handgrip strength test – dominant hand (+5.62%, p = .001) and the non-dominant hand (+3.28%, p = .005), compared to the control group that recorded decreases in physical performance: arm curl test (-1.02%, p = .27), chair stand test (-1.14%, p = .34), handgrip strengtht test - dominant hand (-1.56%, p = .11) and non-dominant (-2.49%, p = .007); between the two groups, the difference was statistically significant at the end of the study in all tests: arm curl test (p = .005, r = -0.52), chair stand test (p = .001, d = 1.33), handgrip strength test - dominant hand (p = .004, r = -0.52) and non-dominant hand (p = .018, d = 0.95);

10. The quality of life registered improvements at the end of the study within the experimental group, for all variables covered by the Qualleffo-41 questionnaire: "pain" (-34.93%, p < .001), "ADL" (-36.67%, p = .009), "jobs around the house" (-35.48%, p = .001), "mobility" (-10.38%, p = .39), "social activities" (-9.13%, p = .008), "general health perception" (-40.78%, p = .001) and "mental function" (-35.62%, p < .001);

11. The control group improved in four of the seven variables included in the Qualleffo-41 questionnaire, respectively in the variables "pain" (-6.34%, p = .23), "social activities" (-5.34%, p = .013), "general health perception" (-12.25%, p = .041) and "mental function" (-9%, p = .020), and for the other three variables, the control group recorded statistically insignificant increases in two of them, namely the variables "ADL" (+16%, p = .21) and "jobs around the house" (+16.67%, p =. 10), as well as a statistically significant increase regarding the variable "mobility" (+16.73%, p = .017), which suggests a poorer quality of life;

12. With the exception of the variable "social activities" (p = .13), where the inter-group difference was not statistically significant at the end of the study, in all the other six variables, the differences were statistically significant: "pain" (p < .001), "ADL" (p < .05), "jobs around the house" (p < .05), "mobility" (p < .05), "general health perception" (p < .001) and "mental function" (p < .05);

The experimental group showed much greater improvements compared to the control group, regarding the bone mineral density at the level of the spine and the femur, with two exceptions: lumbar spine L_2 and L_4. At the L_2 level, the control group recorded a higher increase (1.70%) compared to the experimental group (1.44%), and at the L_4 level, the control group recorded a greater increase of 1% compared to the experimental group (0.68%). vs. 0.69%). In all other areas of interest, the group that participated in the exercise program with resistance recorded much higher increases compared to the control group that only followed drug treatment. In the lumbar spine L_1, the experimental group increased by 3.01%, and the control group decreased by -1.01% in bone mineral density; at the L_3 level, the experimental group increased by 2.55% and the control group decreased by -1.29%. At the total level of the spine, the bone mineral density registered a significant increase at the end of the study in the experimental group (+1.82%) and a statistically insignificant increase in the control group (+0.14%). In the femur, the experimental group registered significant increases in all areas of interest compared to the control group: femoral neck (+2.15% vs. +0.32%), trochanter (+4.15% vs. +0.87%), intertrochanter (+1.25% vs. -0.19%), Ward's triangle (+1.31% vs. +1.11%) and bone mineral density at the femur (+2.35% vs. + 0.41%).

Even though both groups showed improvements in bone mineral density in the spine and femur, the increases were much higher in the experimental group, and conclusions 2, 3, 4, 5, 6, 7 and 8 support our hypothesis. according to which "by using the Bulgarian method (by contrast) in women with postmenopausal osteopenia / osteoporosis, improvements in bone mineral density can be obtained".

For the physical performance tests, the experimental group registered significant improvements in all the tests compared to the control group which registered a decrease of the performances in all the tests: arm curl test (+8.83% vs. -1.02%), chair stand test (+12.32% vs. -1.14%), handgrip strength test – dominant hand (+5.62% vs. -1.56) and handgrip strength test - non-dominant hand (+3.28% vs. -2.49%). The differences were significant both intra-group and inter-group, in favor of the group that participated in the resistance exercise program, and conclusion 9 reinforces our hypothesis that, "using the Bulgarian method (by contrast) in women with postmenopausal osteopenia / osteoporosis can improve muscle strength".

At the end of the study, the experimental group recorded statistically significant improvements in six of the seven variables of the Qualleffo-41 questionnaire, except for the variable "mobility", compared to the control group that recorded improvements in four of the seven variables. The differences regarding each variable were: "pain" (-34.93% vs. -6.34%), "ADL" (-36.67% vs. +16%), "jobs around the house" (-35.48% vs . +16.67%), "mobility" (-

10.38% vs. +16.73%), "social activities" (-9.13% vs. -5.34%), "general health perception" (-40.78% vs. -12.25%) and “mental function” (-35.62% vs. -9%). As can be seen, the control group registered improvements on pain variables, social activities, health status and mental function, whereas the group that participated in the twice weekly exercise program improved all variables. Thus, conclusions 10, 11 and 12 once again strengthen our hypothesis that "using the Bulgarian method (by contrast) in women with postmenopausal osteopenia / osteoporosis can be achieved with [...] and quality of life".

Although there were no significant inter-group differences in bone mineral density in the lumbar spine or femur, the results do not confirm the effectiveness of the method used, but suggest that the Bulgarian contrast method can be used as a viable alternative for patients. with postmenopausal osteopenia / osteoporosis.

In contrast, the improvements were superior in the experimental group to almost all areas of interest in the lumbar spine and femur. Moreover, if we include the results obtained in the motor tests, as well as in the evaluation of the quality of life, body weight and body mass index, this allows us to argue that the Bulgarian method by contrast can be used as a preferential method in the case in patients with postmenopausal osteopenia / osteoporosis.

III.8. Impact of the experimental study

No study used the Bulgarian method by contrast in postmenopausal women with osteopenia / osteoporosis, and this was an opportunity for us to test the effectiveness of this method, as well as its impact on bone mineral density, quality of life and motor performance for this category of women.

Therefore, if this training program affects the quality of life, positively or negatively, the bone mineral density or motor capacity of women with postmenopausal osteopenia / osteoporosis would be very important to know, because in both cases we can draw important conclusions: if the program produces effects positive could be used as a preferential method in postmenopausal osteopenia / osteoporosis; if it is proven that the program produces negative effects it is well known that in the future it will be avoided in the case of women with osteopenia or osteoporosis.

Following our research, we can say that the hypothesis has been confirmed, and this method could be used by women with postmenopausal osteopenia or osteoporosis, as practicing resistance exercises using the Bulgarian method by contrast leads to increased

density over a year. Bone minerals, in improving the quality of life and physical performance. Even if the growths are not so obvious in all areas of interest, from the level of the spine and the level of the femur, it should be noted that any increase is a gain, because with age the bone mineral density decreases. Moreover, the fact that progress is also being made in terms of physical performance and quality of life is an additional argument for which we believe that the Bulgarian method by contrast could be used successfully for this category of women.

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