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The Effect of Eight Weeks of Strength Training in the Water on the Pain and Muscle Strength in Postmenopausal Women with Knee Arthritis

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Pain

Abstract

Knee osteoarthritis prevalence is 60 to 90 percent among 65-year-old and older people, and it is one of the most important causes of pain and disability in the elderly, on which muscle weakness as a risk factor plays an important role. So far, muscle weakness and atrophy in patients with osteoarthritis was attributed to lack of muscle function, and it thought that patients have less mobility due to joint pain, and those joint muscles are used less. The aim of this study was to investigate the effect of eight weeks of strength training in water on pain, range of motion, and muscle strength in postmenopausal women with knee arthritis. A total of 30 postmenopausal women with knee osteoarthritis were purposefully selected and randomly divided into two groups of 15 individuals of strength training in water and control (no training) groups. The degree of pain was assessed with the use of VAS questionnaire, the range of motion with the use of goniometer, and the muscle strength with the use of dynamometer. The experimental group performed the strength training in water for eight weeks, three sessions of 1 hour in each week. The paired t-test was used for comparison within group and the independent t-test was used for comparison between groups ($P<0.05$). The pain ($P=0.001$) reduced about 35%, the range of motion increased about 21% ($P=0.001$), and the quadriceps muscle strength ($P=0.004$) increased about 70%, which significantly improved in the exercise group compared to the control group ($P\leq0.05$). The strength training program in water, had a positive effect on improving pain, range of motion, and quadriceps muscle strength in postmenopausal women with knee osteoarthritis, and it could be recommended as a safe and effective treatment for them.

1. Introduction

Knee osteoarthritis ('OA') with a prevalence of 60-90% is one of the most important factors of pain and disability in the elderly (1, 2), and (3). Muscle weakness, especially weakness in the quadriceps, has been addressed as an etiologic factor and one of the risk factors in the research literature (4-6). Also the destruction of articular cartilage as evenly along with bone growth (osteophytes), pain, joint stiffness, and decreased range of motion is involved in the joints. Effect of knee injury in exposure to arthritis may be partly related to muscle strength. Weakness and muscle atrophy can increase the risk of osteoarthritis progression (7). But is not well-known as a risk factor for OA nowadays (8). The role of the quadriceps muscle as a mediator in the incidence of knee OA is a common issue in researches (2, 9). Muscle is a major contributor to the stability and shock absorption in knee joint during motion. Clinically, quadriceps muscle weakness in patients with knee OA can always be seen (10). Studies have shown that stronger quadriceps muscle, reduces the risk of onset of symptomatic knee OA, and has also lower risk of progression of joint space narrowing and loss of cartilage in women (11). Muscles play an important role in the movement, balance, and prevention of abnormal movement of joints; a disorder of the sensory or movement nerves of a muscle can bring upon various symptoms and complications, followed by erosion of the bone in the bones under the cartilage would occurs. There is a link between knee pain and muscle weakness in osteoarthritis (Jamoto et al., 2007; Amin et al., 2009). Knee pain can reduce muscle strength (12). Knee osteoarthritis in women with decreased quadriceps strength was 1.6 times more than women that their quadriceps strength was in the upper third range, by the way this relationship has not been observed in men (13). The pain can also affect muscle strength and lead to decreased muscle strength (7). The results have shown that the exercise training in water program, can be considered as a safe and effective exercise in improving pain, function, and quality of life in elderly women with knee osteoarthritis (14). Arthritis is a chronic systemic disease that mainly affects the joints di arthyroid and its surrounding soft tissues which has owns the greatest causes of inflammation of the joints and their deformation. The resulting physical effects of the disease are numerous and among the most important, chronic pain, impairment of physical stimulation, deformity and fatigue can be named (15). In the knee osteoarthritis, the muscle strength around the involved joints is decreased (7). Patients with knee osteoarthritis, has also reduced muscle strength in the muscles around the hip. The relationship of knee osteoarthritis and muscle strength is complicated and differs depending on the disease location. So far, weakness and muscle atrophy in patients with OA was attributed to non-application of muscles and it was thought that patients have less mobility due to joint pain, and the involved joints muscles are less used and therefore atrophy and muscle weakness is created; but it does not apply in all cases, as there is muscle weakness often before the onset of osteoarthritis, which is recognizable (11).

In longitudinal studies of before and during postmenopausal in American women a decreased level of Hydroxyestrone and estradiol serum was found in their urine which is a predictor of the knee OA (16). Several treatments such as laser therapy, massage therapy, and aquatic exercise were compared to each other and it was concluded that aquatic exercise has a greater role in reducing back pain and improving quality of life (17). Exercise in water has also special benefits for those who have little physical work capacity or those with physical problem. Also, many researches, including Maher (2004), showed the effects of strength training in water on the recovery and treatment of diseases (Maher, 2004). Since, the effects of strength training in water is not thoroughly studied yet, so the purpose of this study is to respond the question of whether eight weeks of strength training in water is effective on the pain and muscle strength in postmenopausal women with knee arthritis?

2. Material & Method

This is a quasi-experimental and causal-comparative research. The subjects are purposefully selected with regard to the entry and exit criteria of the research, and the effect of eight weeks of strength training in water on pain, range of motion, and muscle strength of the quadriceps muscles of the postmenopausal women with knee arthritis was assessed.

2.1 Statistical population

The population of this study, was postmenopausal women, 45 to 60 years of age with knee osteoarthritis of the city of Shiraz.

2.2 The sample and the method of selection

Based on the research entry criteria, a group of 30 postmenopausal women, 45 to 60 years old, with knee joint osteoarthritis, whose disease was confirmed by orthopedic physician were selected from the population, and were randomly divided into two groups of 15 individuals of strength training in water and control (no exercise) groups.

2.3 Criteria for entry to and exit from the research

2.3.1 Inclusion criteria for the study

- Lack of activity in the past two years.
- Lack of articular injection drug use in the last quarter.
- Having at least five in pain intensity score based on Visual analog scale.
- Having aged 45 to 60 years.
- Lack of back pain.
- Lack of any communicable, skin, and transmittable by water diseases.
- Voluntary consent of the subject to participate in research.
- Lack of any surgery history on the spine or lower extremities, having history of serious spine damage and ligament or meniscus injury in the past year.
- Lack of any visible musculoskeletal disorders on the lower extremity such as Genuvarum, Genuvalgum, and ankle pronation.
- Lack of use of medications that affect the central nervous system such as sedatives on test day.

2.3.2 Exclusion criteria for the study

- Osteoarthritis of the hip joint
- Rheumatoid arthritis
- Lack of consent for continued cooperation.
- Pain in any part of the body during the test so that the person is not able to cooperate.
- Researcher recognition that the person does not cooperate properly during the test period.

2.4 Equipment and tools used in research

- Tape
- Scale
- VAS questionnaire to determine the degree of knee pain
- Goniometer to measure the range of motion of the knee.
- Dynamometer to measure muscle strength
- Resistance training protocol

2.5 *Assessing pain intensity*

Visual Analog Scale is a 10 cm horizontal line, which has the term of without pain at the left end, and the term of "maximum imaginable pain" at the right end. In other words, this scale is a 10 cm horizontal bar with one end of zero (no pain) and the other end of 10 (most severe pain). The patients were asked to point to the somewhere in the 10 cm line according to numbers that indicate the degree of pain at the two ends. Then using a ruler, the distance from this point to the point of zero was measured and the value obtained was considered a patient's pain (Rajabi, 2013).

2.6 Measuring the range of motion of the knee

A metal goniometer was used to measure the range of motion of the knee. Favorable condition for measurement with goniometer is in the way that it is placed beside the joint or on the joint with little contact between the skin and goniometer. To measure the range of motion of the knee, the subject lies on his back and bends his thigh and knee and then performs knee extension. To do this, the goniometer axis is placed on the femoral epicondyle and the fixed arm was placed parallel to the large bumps hips, and the mobile arms was placed parallel to the outer ankle. Then the angle of flexion-extension mode is recorded (6).

2.7 Measuring the strength of the quadriceps muscles

Hand dynamometer was used to measure muscle strength. Each test was repeated three times, and each person was asked to perform the move with maximum power. Each contraction was hold for 5 seconds and the maximum strength observed was recorded. Before conducting the study, the repeatability of the measurement of isometric muscle strength by hand dynamometer was done on volunteers, which had a good repeatability (ICC in 0.85 – 0.96). To measure the strength of the quadriceps muscle, the subject sat on chair while the knee and hip was on 90 degrees' flexion. To test the quadriceps, muscle the dynamometer was placed 2 cm proximal to the ankle on the shin of a person. The subject was asked to straighten his knee against resistance (18).

2.8 Weighing

For the measurement of body weight, a digital scale marked Seca, made in Japan with measurement accuracy of 0.001 kg was used. The subjects were weighed while having only sport shirt and shorts without shoes.

2.9 Measuring height

In order to measure the height of the subjects, the height gauge device marked Seca, made in Japan with a measurement accuracy of 0.01 meter was used. To measure height, the subject stood without shoes, facing straight forward; then the leverage on top of the subject's head was lowered to touch the person's head, and the observed number was recorded as subject's height.

2.10 The form of background data collection

This form was used to record the background information of the subjects including height, weight, age, sport history, and exercise levels of the subjects (Appendix 2).

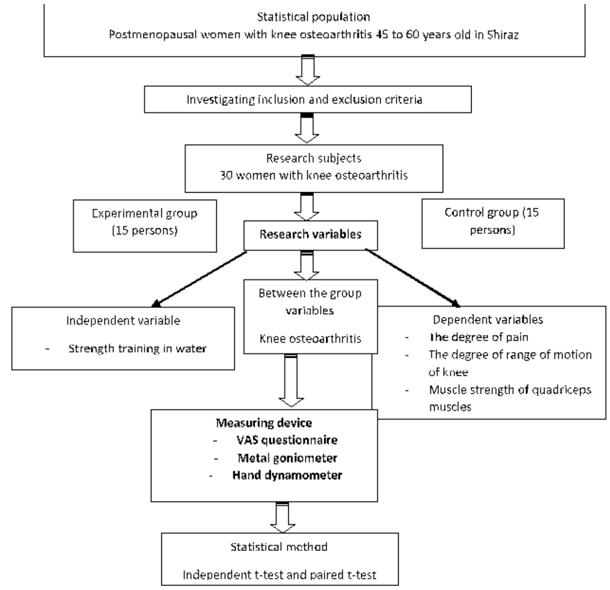

Figure 1. Outline of research project

2.11 The process of research measurements

Before measuring the variables, a summary of research design was explained to the subjects in the research introduction form, the initial screening of the subjects was performed based on inclusion and exclusion criteria of the study, and the people who were willing to cooperate, were given consent form. After identifying qualified individuals, the subjects visited the laboratory and the swimming pool according to the previously announced schedule in order to perform the test. Subjects had to meet the following requirements on the day of the test:

- Lack of activity in the past two years.
- Non-articular injection drug use in the last quarter.
- Having at least five in pain intensity score based on Visual Analog Scale.
- Aged 45 to 60 years.

On the day of the test, after filling the consent form by the subjects, their background information including height, weight, age, sport history, and sport major was recorded in the form of data collection.

In a general trend, on the day of the test, after measuring height, weight, and length of the subjects, both groups (control and experimental) were evaluated before the test, in a way that the degree of pain was evaluated with questionnaire of visual scale of pain, range of motion with goniometer, and quadriceps muscle strength with a hand dynamometer. After doing strength training in water by experimental group, subjects (control and experimental) were again evaluated in accordance with post-test to measure the degree of pain, range of motion, and quadriceps muscle strength.

2.12 The exercise protocol used

2.12.1 The training schedule characteristics (*Table1 1*)

- Training times were three times per week, and each session was one hour.
- Training sessions were hold in a pool with temperatures between 27-28 °C.
- Every move was done in three sets of 15 repetitions per set.
- Rest between sets was determined as 1 minute, and 30 seconds between each movement.
- The training with the above specifications, were verified with consultation of physiology professors.

2.13 Statistical methods

Finally, collecting the study information, the data related to the subjects' characteristics such as age, height, and weight, as well as variables in both descriptive and inferential statistics were analyzed by SPSS version 21, and the paired t-test was used for within-group comparison, an independent t-test was used to compare the results between the groups. Also, the significance level of 95% was considered throughout the study, with a smaller alpha, or equal to 0.50.

In this section, we first describe the characteristics of examined samples and variables; then inferential analyses of the research hypotheses will be carried out.

- With respect to the Sig obtained for the control group in the K-S test which is greater than 0.50, it could be said that the data are normally distributed, therefore we have permission to enter parametric statistics.
- With respect to the Sig obtained for the experimental group in the K-S test which is greater than 0.50, it could be said that the data are normally distributed, therefore we have permission to enter parametric statistics.

3. Results

A significant difference was observed in the degree of pain in the experimental group after eight weeks of strength training in water (P=0.007, t=9.33), so that the pain was reduced by 35%. But in the subjects of the control group, a significant difference was not observed (P=0.56, t=3.13). A significant difference was observed in the control and experimental groups (P=0.001, t=56.2).

A significant difference was observed in the degree of the range of flexion motion of the experimental group after eight weeks of strength training in water (P=0.027, t=3), so that the range of knee flexion was raised about 21%.

Table 1: The table of training protocol in water

Week	Program
1	To become familiar with water, standing on the toe/heel 3*8, abduction and adduction of the hip 3*8, high knee movement 3*10, tandem walking 3*10 steps, squat with knees bent 60 degrees 3*8
2	Standing on the toe/heel 3*10, abduction and adduction of the hip 3*10, high knee movement 3*12, tandem walking 3*12 steps, squat with knees bent 60 degrees 3*10
3	Standing on the toe/heel 3*12, abduction and adduction of the hip 3*12, high knee movement 3*15, tandem walking 3*15 steps, squat with knees bent 60 degrees 3*10
4	Slider movement (stretching laterally with one knee bent) 3*10, steppe touch movement 3*15, high knee movement 3*15, tandem walking 3*15 steps, squat with knees 60 degrees bent 3*15, walking with elastic 2*10, walking in circles 2*10 steps, stork standing (for each leg) 2*10 seconds
5	Slider movement (stretching laterally with one knee bent) 3*15, steppe touch movement 3*15, high knee movement 3*15, tandem walking 3*15 steps, squat with knees 60 degrees bent 3*15, walking with elastic 2*12, walking in circles 2*12 steps, stork standing (for each leg) 3*15 seconds
6	Slider movement (stretching laterally with one knee bent) 3*20, steppe touch movement 3*20, high knee movement 3*20, tandem walking 3*10 steps, squat with knees 60 degrees bent 3*20, walking with elastic 2*15, walking in circles 2*15 steps, stork standing (for each leg) 2*25 seconds
7	Slider movement (stretching laterally with one knee bent) 3*25, steppe touch movement 3*25, high knee movement 3*25, tandem walking 3*25 steps, squat with knees 60 degrees bent 3*25, walking with elastic 3*12, walking in circles 3*12 steps, stork standing (for each leg) 3*20 seconds
8	Slider movement (stretching laterally with one knee bent) 4*20, steppe touch movement 4*20, high knee movement 4*20, tandem walking 4*20 steps, squat with knees 60 degrees bent 4*20, walking with elastic 2*20, walking in circles 2*20 steps, stork standing (for each leg) 3*25 seconds

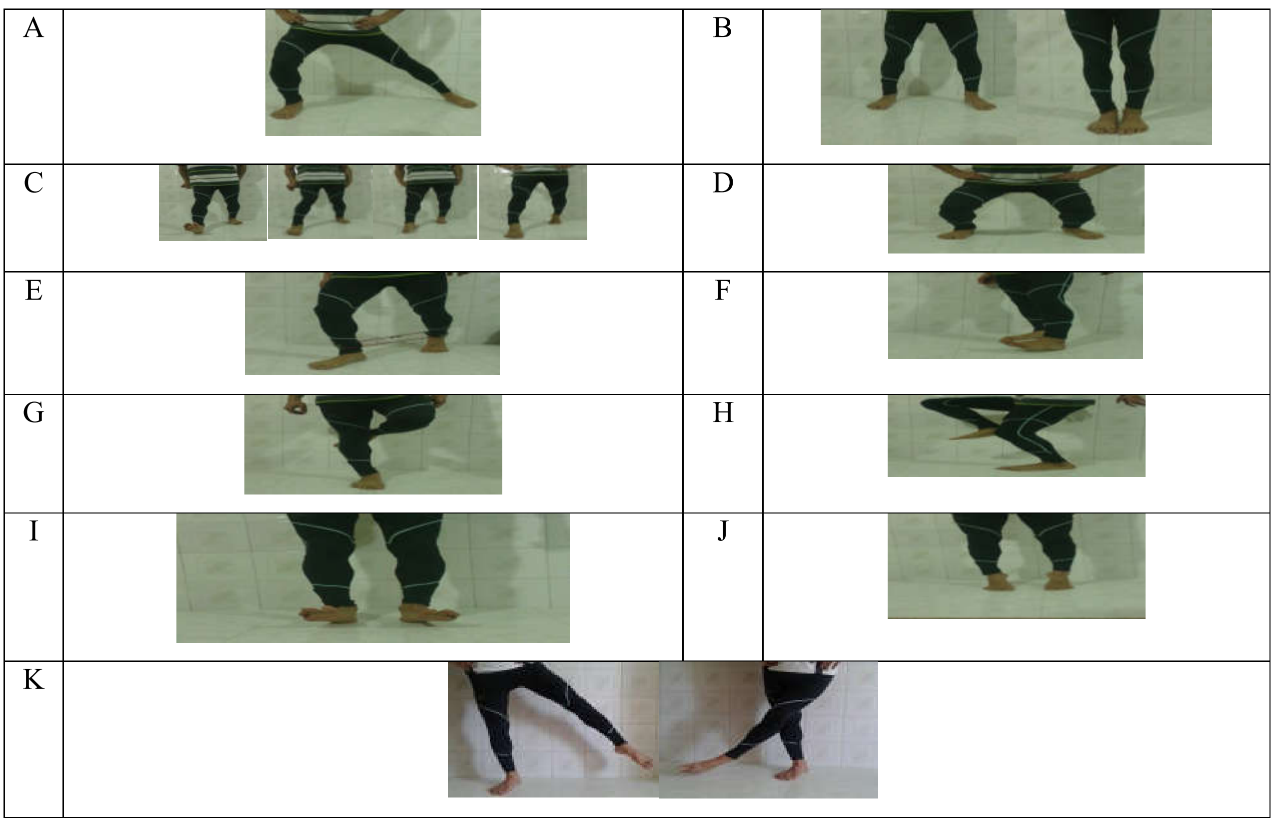

Figure 2. Training exercises protocol; A: Slider movement (stretching laterally with one knee bent), B: Steppe touch movement, C: Tandem walking, D: Squat with knees 60 degrees bent, E: Walking with elastic, F: Walking in circles, G: Stork standing, H: High knee movement, I: Standing on the heel, J: Standing on the toe, K: Abduction and adduction.

But in the case of the control group, no significant difference was observed (P=0.66, t=3.13).

A significant difference was observed in the degree of muscle strength of the quadriceps of the experimental group after eight weeks of strength training in water (P=0.007, t=2.23), so that the strength was raised about 70%. But in the case of the control group, no significant difference was observed (P=0.76, t=2.13). In general, a significant difference was observed between the control and experimental groups (P=0.004, t=2.2).

4. Discussion

The results showed that there was a significant difference in the degree of pain, after implementing the strength training in water, between the two groups of control and experimental. So that the degree of pain in postmenopausal women with osteoarthritis, has relieved after strength training. The results showed that the aquatic sport program is an appropriate treatment to improve pain in elderly women with knee osteoarthritis, which is consistent with studies by (19), in investigation of an exercise training course in water on people with knee osteoarthritis by BMI greater than 25 kilograms per square meter, and Wang et al. (2011), in investigating the comparison of the effect of an aquatic exercise course, and exercise on land on the patients with knee osteoarthritis (20), using a questionnaire KOOS, and silva (2008) in the investigation of the effects of hydrotherapy exercises versus common land exercises for the management of patients with knee osteoarthritis, using the WOMAC questionnaire (21), and Bartels et al. (2007) in the investigation of the effects of therapeutic exercises for the treatment of patients with knee osteoarthritis (22), and Foley et al. (2003) in the investigation of the effects of hydrotherapy on the degree of pain of patients suffering from knee osteoarthritis (23), using a WOMAC questionnaire, and (10) in the investigation of the effects of therapeutic of water on people with knee osteoarthritis. On the other side, it is inconsistent with the studies by Lund et al. (2008), and Wang et al. (2007), who did not observe a significant relationship in pain scores before and after hydrotherapy protocols (20, 24). The disparity of this study in pain, is probably because the Lund and Wang have used only a few types of exercise in them researches, even without the principle of overload. Among other reasons for the inconsistency in the results, differences in population and the number of samples, the used training protocols and method of assessing the variables, difference in the training course, equipment type, and gender could be mentioned. It is reported that pain is the most important symptom of osteoarthritis. Therefore, the main goal of any therapy method, is to reduce the clinical symptoms such as pain. Silva and colleagues believe that strengthening the hip muscles can improve the symptoms (21). Studies have shown that high cytokinin production in the body reduces the articular cartilage and joint diseases such as osteoarthritis. Physical activity reduces the production of cytokinin and thus reduces pain and increases performance (19). In addition, other factors that may be causing pain and loss of function, is muscle atrophy caused by inactivity (25). In a review, (22) showed that hydrotherapy can reduce pain in patients with knee osteoarthritis, which is caused by neuromuscular function related to the movement of the muscles around the knee (increased power, strength and endurance) (22).

Given that one of the mechanisms of pain, is the presence of ischemia in the area of pain, followed by the secretion of enzymes of bradykinin, histamine, potassium and stimulation of pain in the tissue (18, 26), hydrotherapy is also a non-medical method which increases the blood supply to the muscles and increases blood circulation level, which leads to reap the triggers of pain and reduces pain and increases flexibility of muscles and joints and movements of bones and reduces muscle spasms in people, because the buoyancy of water, reduces compressive forces on painful joints and muscles, and allows them a more freely movement (27).

Improved muscle function by sport exercises, leads to further absorption of the forces imposed to the joint by muscles. Because lack of appropriate absorption of the forces imposed to the joint during the daily, sports, and leisure activities leads to tiny fractures in the sub-cartilage tissue which in turn, activates the secondary ossification centers. The process, results in thinning of the articular cartilage and increase of destruction of the articular cartilage. Then the increased sub-cartilage bone density, reduces the nature of shock absorption of tissue, increases pain degree, and reduces knee function and quality of life (13). So one of the reasons for pain relief can be reduced compressive forces on joints and absorption of articular forces by the resistance created in water.

The results of this study showed that a statistically significant difference was observed in the range of motion, after strength training in water, between the two control and experimental groups. So that the range of motion of the knee of the postmenopausal women with osteoarthritis, has improved after strength training. The results showed that the aquatic exercise program is an appropriate treatment to improve the range of motion of the knee in elderly women with knee osteoarthritis which is consistent with the studies by Fisher (1997) on patients with osteoarthritis of the hip that showed aquatic exercise led to increased joint range of motion (12), and also Kao (2012), which examined the effect of a three-month course of aquatic exercise on patients with osteoarthritis of the knee, which led to increased range of motion and improved motor function in individuals (28), and with the study by Wang et al. (2007), whose results showed increased ability to perform functional activities and range of motion of the hip and knee, of patients with osteoarthritis of the knee and thigh (20), as well as the study by (29) who reported that aquatic exercise in arthritis, leads to increased range of motion and reducing joint stiffness and increased ability to walk (12) as well as the study by Hinmin (2007), Foley et al. (2003), Wang et al. (2007), and Lee and colleagues (2006).

According to sensory and mechanical receptor activation by the strength training in water, it is clear that this kind of training, can directly affect brain activity. This shows the preparation of neurons of moving in a group of muscles and joints to make a move and its compatibility with the environmental context and also increased coordination and integration of motor units, co-contraction of partner muscles, and increased deterrence of opponent muscles, which eventually leads to improved neuromuscular responses, and thus may improve the range of motion. Changes may occur in electrical model of moving units, or in the moving frequency, or in the simultaneous involvement in the movement of the moving units, thereby increase the range of motion. Normally, internal feedback mechanisms (such as the Golgi tendon organ), inhibits the body's production of large stresses. However, when the body is exposed to high levels of stress due to strength training, the sensitivity of these organs may be reduced due to the process of automatic inhibit removal, and allow the person to approach the body's absolute maximum force production capacity. On the other hand, with more skilled nervous system in line with repeated practice, the muscle coordination is increased, and thus, facilitates the performance. On the other hand, the strength training used in the study, has probably led to increased range of motion, through imposing stress on the neuromuscular system.

5. Conclusion

Generally, the results showed that the strength training in water, has a positive impact on the improvement of pain, range of motion, and strength of quadriceps muscle in postmenopausal women with knee osteoarthritis.

Adding programs of strength training in water, to rehabilitation therapies for postmenopausal women with knee osteoarthritis, is recommended to ease restrictions caused by this condition. Therefore, coaches, occupational therapists, and sports physiotherapists are advised to schedule a training program and benefit the aquatic training advantages with respect to the needs of postmenopausal women with knee OA, as well as taking into account their abilities.

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