Comparison of the effects of aquatic exercise in shallow and deep water on Postural Control in elderly women with chronic knee Osteoarthritis

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Abstract: Knee osteoarthritis (OA) is related to poor balance and impairment of the proprioceptive system. Exercise in the water recommended for the rehabilitation of these patients. However, the depth of water influences some physiological and biomechanical factors. Hence, the objective of present study was to Comparison the effects of aquatic exercise in shallow and deep water on Postural Control in elderly women with chronic knee OA. 43 elderly women over 60 years old with knee OA on preferred foot voluntarily participated in present study. The RPE scale was used to measure and control the exercise intensity after each exercise session. Using Romberg test, the postural control was evaluated. Data were analyzed using Two Factor Repeated Measure ANOVAs and follow up tests included LSD and paired samples t test at p<0.05 significance level. The results showed that postural control improved significantly in shallow water group more than deep water group (p=0.02). We conclude that water exercise, especially shallow water is recommended to rehabilitate the patients suffering from knee OA.

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1.Introduction

Osteoarthritis is a widespread disease among patients over 60 years (Davis, Ettinger, Neuhaus, & Mallon, 1991; Felson et al., 1987; Hochberg, 1991). Knee OA is also the most common form of arthritis in the old adults especially in women (Felson DT, Naimark A, Anderson J, Kszis L, Castelli W, Meenan EF., 1987; Chaiammuay P, Darmawan J, Muirden KD., 1998). Knee OA associated with pain and stiffness of the joint, disability (Bruce ML, Peck B., 2005; Brosseau L, Pelland L, Wells G, et al., 2004; Foley A, Halbert J, Hewitt T, Crotty M., 2003), impairment of the proprioceptive system (Garsden LR, Bullock-Saxton JE,1999; Sharma L, Pai YC, Holtkamp K, Rymer WZ,1997) difficulties of the knee motion and postural control and then decline ability to perform simple daily activities(Kaufman, Hughes, Morrey, Morrey, & An, 2001; Mangione, Axen, & Haas, 1996). It has been demonstrated that the most falls in elderly people with knee OA are related to poor balance (Sturnieks DL, Tiedemann A, Chapman K, Munro B, Murray SM, Lord SR., 2004; Jones G, Nguyen T, Sambrook PN, Lord SR, Kelly PJ, Eisman JA., 1995).

Furthermore, lack of proprioceptive feedback due to knee injuries could lead to improper and/or overload to joints. In addition, a capsule injury not only cause distortion in transmission of afferent signal from joints, but also more importantly could lead to change in coding of afferent nerve signal to central nervous system. (Prentice, 2001)

Studies showed that various kind of exercise are important for balance improvement in knee OA patients (Messier SP, Royer TD, Craven TE, O'Toole ML, Burns R, Ettinger WH Jr.,2000; Wang TJ, Belza B, Thompson FE, Whitney JD, Bennet K.,2007). However, because of advantages of water, exercise in the water recommended for the rehabilitation of these patients(Cochrane T, Davey RC, Matthes Edwards SM., 2005; Foley A, Halbert J, Hewitt T, Crotty M., 2003). Yet, the depth of water influence some factors such as gravity, hydrostatic pressure and touching the floor of the pool in which makes some different biomechanical and physiological conditions for exercises in the water. Therefore, exercise in two different depth of water may have different effects on patient with knee OA. However, no study was found to comparison the effects of exercise in shallow and deep water on patients with knee OA. In the present study we investigate Comparison of the effects of aquatic exercise in shallow and deep water on Postural Control in chronic Osteoarthritis female elderly.

2. Material and Methods

Originally, 43 women elderly patients who had knee OA on preferred foot participated in present study. They were selected from among elderly patient who had been diagnosed with chronic degenerative OA that suffered over 8 months. Based on the preliminary examination and pretest, the subjects were divided by random matching into 3 homogeneous groups: 1) shallow- water exercise program (n=14, age: 62.41 ± 5.16 year, height: 154.92 ± 4.63 Cm, weight: 59.84 ± 10.45 kg, Body Mass Index (BMI): 25.71 ± 3.96 kg/m2, Body Fat Percentage (BFP): 30.69 ± 7.24), 2) deep- water exercise program (n=14, age: 63.11 ± 5.37 year; height: 155.22 ± 4.03 cm. weight: 61.03 ± 11.20 kg; BMI: 26.11 ± 4.09 kg/m2, BFP: 31.83 ± 6.88), and 3) control group (n=15, age: 63.41 ± 5.16 year; height: 154.85 ± 3.99 cm; weight: 60.13 ± 10.86 kg; BMI: 25.83 ± 4.21 kg/m2, BFP: 31.17 ± 7.55) without intervention.

Multifactor ANOVAs showed that there was no statistical significant between groups on BMI and BFP (wilks's Lambda=0.897, F (4, 78)=1.08, p=0.428). It means three groups are homogenous. The RPE (Rating of the Perceived Exertion) scale was used to measure and control the exercise intensity (Borg G., 1970).

It was evaluated after each exercise session. The Rating of the Perceived Exertion (RPE) was in range of 4 to 6 (from mild to severe). Postural control was evaluated using a One-Leg Balance with open eyes test (Romberg test). The participant stands on the preferred foot with knee OA while resting the hands at waist level and then raises the other foot approximately 10 cm off the floor. Balance is scored by the number of seconds for which the foot is kept raised or until balance is lost. Timing is terminated with touch the floor by the free foot, take hands away from the hips, move the support foot from the initial place, and hook the free foot behind the supporting foot (Rogers, M. E., Rogers, N. L., Takeshima, N., & Isam, M. M., 2003).

Intervention

The water exercise program include one hour of exercises was performed three session per week on experimental groups (shallow water and deep water) underwent a 12 weeks period (figure 1).

Data Analysis

Data were analyzed using Two Factor Repeated Measure ANOVAs and follow up tests included LSD and paired samples t test at $p<0.05$ significance level.

3. Results

Table 1 shows the descriptive data of postural control in pretest and posttest of three groups.

Table1. The descriptive data of postural control (second) in pretest and posttest

Groups	Measurements		Percentage of changes
	Pretest	Posttest	
Shallow water	7.90± 6.29	9.83 ± 5.02	% 24.43↑*
Deep water	8.03± 6.54	9.36± 5.91	% 16.56↑*
Control	7.55 ± 8.11	7.38 ± 7.58	% 2.25↓

* Significant at p≤0.05

With regarding to the significant interaction between two independent variables, it used paired-sample T test for post hock comparison. As there is a significant main effect of depth of water, LSD test was used for multiple comparisons. Results show in table 2 and 3 respectively.

Table2. The results of paired t test for within groups' comparison of postural control

Groups	Mean difference Pretest-Posttest	T	df	p
Shallow water	-1.93	-11.73	13	<0.001*
Deep water	-1.33	-8.96	13	<0.001*
Control	0.17	0.230	14	0.856

* Significance at p<0.001

Table3. The results of LSD test for between groups comparison of postural control

Groups		Mean difference	Standard error	p
Shallow water	Deep water	0.47	0.21	0.02*
	Control	2.45	0.63	<0.001**
Deep water	Control	1.98	0.66	<0.001**

*significance at p≤0.05, ** significance at p≤0.001

4. Discussions

This study showed that a program of aquatic exercise in both shallow and deep water over a period of 12 weeks was effective in improving the postural control (open eyes position) in the elderly women with knee OA. However, the improvement of static balance was significantly higher in shallow water exercise group compared with the deep water exercise group. Numerous studies revealed that physical exercise in shallow water could lead to a improvement in static balance (e.g. Roth et al., 2006; Yennan et al., 2010; Geigle, Cheek, Gould, Hunt & Shafiq, 1997; Sadeghi & Alirezaei, 2007). However no significant study was found comparing different water depths. It seems that as liquid makes movements slow; the patient is given more time to control their moves. Therefore it is thought that the patient takes more advantage in water, especially patient with the lower body injuries, to regain balance and proprioception.

Extension in the reaction time (winter, 1996), as well as a safe environment in which there is little fear of falling down, enables the patient to regain their already lost proprioception. Also, it allows them (people unable to maintain balance) to get to understand their posture mistakes. (Simmons & Hansen, 1996).

Furthermore, touch stimulation, caused by turbulences of water while moving, as well as ongoing losing and regaining balance, provides a proper feedback which helps return the proprioception and balance (Sadeghi & Alirezaei, 2007).

On the other hand, the protective environment of water allows the elderly to independently maintain a straight posture (Era & Heikkinen, 1985; Geigle & et al., 1997). This may in turn lead in improvement of the elements which bring upon balance. In fact, sense of hydrostatic pressure of water all over the body creates a feeling of stability (Genuario & Vegaso, 1990; Thein & Brody, 1998) for the patient. Therefore, they keep doing exercises fearlessly in the water. Regarding the advantage of shallow to deep water on postural control, most probably due to patient's feet touching the floor and the close chain in shallow water, and consequent benefits for the patient to regain balance and somatosensory. Central nervous system intervention in keeping a proper posture is done in two domains. Firstly in sense organization (i.e. data collected from eyes, ears and the somatosensory system) and secondly in muscular coordination. For the first domain among adults a preferable source of data to control balance is the data coming from the somatosensory system (Understanding of movement caused by feet touching the floor).

Due to available support, all movements are made in a close chain in shallow water which leads to more stimulation in somatosensory information. Features of close chain include increase in joint pressure and joint coordination which in turn result in more stability, decrease acceleration, more resistance, proprioceptors stimulation and more dynamic stability all with weight tolerance. Therefore, it could be biomechanically suggested that exercises done in a close chain are more secure and can create forces and pressures which does less harm to tissues being recovered. Weight tolerance exercises increase joint pressure forces leading to more joint stability. It is also recommended that close chain exercises, specifically in lower body are more practical compared with open chain ones. That's because close chain exercises include weight bearing exercises which are similar to real life activities a person does on a regular basis. As for muscular coordination, movements are controlled by a central nervous system. The system coordinates the signals transmitted by mechanical receptors from the joint and muscles in motor chain. A well-balanced movement needs ongoing coordination of receptors, feedback and the data from the control center. Therefore a well-balanced weight bearing movement needs all joints to work in accordance with each other. Therefore, coordination exercises should be done in a close chain movement (shallow water with feet touching the floor). It seems that close chain exercises, using muscles in feet, ankle, knee and hip, create normal pressures and forces on joints which have more biomechanical advantages. Using multi-joint and multi-dimension movements, close chain exercises coordinate the proprioceptive feedback coming from pacinian corpuscle, ruffini end organ, golgi tendon apparatus (Prentice, 2001). Therefore, regarding the findings of the present study, water exercise, especially in shallow water is recommended to rehabilitate the already lost balance in patients suffering from knee OA.

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