

Changes in Postural Control after Aquatic Exercises Program in Ataxic Patients with Multiple Sclerosis

Hamid Mohammadi,¹ Mohsen Ghanbarzadeh,¹ Nastaran Majdinasab,² Masoud Nikbakht¹

¹ Department of Exercise Physiology, Faculty of Sport Sciences, Shahid Chamran University of Ahvaz, Ahvaz, Iran

² Department of Neurology, Faculty of Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

ABSTRACT

Purpose: The aim of this study is to change one of the primary impairments associated with multiple sclerosis, i.e. ataxia, in which there is insufficient postural control.

Materials and Methods: The current randomized controlled trial investigated the effects of aquatic exercise on postural control in MS ataxic patients. Thirty-two patients with multiple sclerosis with a degree of ataxia indications were selected and divided into two groups: exercise group (n=17, age, 39.12 ± 8.54) and control group (n=15, age, 33.4±15.16). The exercise group performed the exercise for 8 weeks, 3 sessions per week with 55% to 75% of maximum heart rate. Posture control by the force platform was measured before and after 24 sessions of aquatic exercises. Measurements of the center of pressure displacement included the anterior-posterior, medial-lateral directions, and sway velocity.

Results: Comparing the pre-test with the post-test, significant differences in patients' posture control (P = .001) was seen. There was no significant differences between the pre-test and the post-test in the control group, except for AP direction (P = .012).

Conclusion: The findings suggest that postural control in ataxic patients with multiple sclerosis can be affected by aquatic exercises. Further studies with a larger sample size are required to confirm these encouraging preliminary results; clinicians are recommended to consider aquatic exercises as a viable rehabilitation program for multiple sclerosis patients.

Keywords: aquatic exercises; ataxia; multiple sclerosis; postural control

AMHSR 2016;14:80-85
www.journals.ajaums.ac.ir

INTRODUCTION

Multiple Sclerosis (MS) is a disabling disease, which causes demyelination of the central nervous system and leads to a progressive neurologic dysfunction. The impairments are postural instability, balance deficits, ataxia, fatigue, pain, weakness, incoordination, sensory loss, abnormal tone, and visual and cognitive dysfunction.⁽¹⁾ The postural control is associated with various impairments.⁽²⁾ Therefore, interventions effectively improving the balance and mobility are important. Experiencing ataxia and tremor by 85% of individuals with MS, and as a result of ataxia, as well as experiencing impairments in function by 32% of people with MS have been reported.^(3,4) Ataxia is a neurological symptom

known for incoordination of voluntary movements, the most important manifestation of cerebellar disease.⁽⁵⁾ Since ataxia is resistant to medication, physical therapy is crucial.⁽⁶⁾ Perceiving insufficient postural control and incoordination of multi-joint movements are reported in ataxia patients.⁽⁷⁾

Analyzing ataxia, neglecting balance dysfunction, is not possible since clinical balance dysfunctions are caused by postural instability in postural control. Although incoordination is often conveyed through balance dysfunction and gait problems, in some cases, in-coordination of movements balance dysfunction does not exist while the balance dysfunction is observed.⁽⁸⁾ Life quality can be influenced by the loss or decline in postural

control and injuries because of falls,⁽⁹⁾ while postural control is affected via changing levels of resting muscle tension or muscle tone, strength and fatigue, specifically in individuals with MS.^(10,11) Muscle tone and natural elasticity of tendons, ligaments, and other tissues are the first responses to external perturbation of normal postural control.⁽¹²⁾ To investigate the possibilities of intervention and rehabilitation, it is required to study the mechanisms contributing to the postural control. Understanding the mechanisms leads to interventions that cause maintenance of postural control or improvement by rehabilitation.^(13,14)

In MS patients, postural control disorders have been investigated by both clinical and laboratory tools, clinical measurement of postural control includes Berg Balance Scale^(13,15) while laboratory assessment tools of postural control involve COP displacement.⁽¹⁶⁻²⁰⁾ Frzovic and colleagues revealed differences between MS patients and controls regarding the ability to maintain standing balance with feet apart, feet together, or in stride stance through clinical measures tools.⁽¹⁵⁾ Karst and colleagues demonstrated decreased COP displacement in MS patients compared with healthy controls.⁽¹⁶⁾ These studies show static balance and postural control measures allowed for discrimination between MS patients and healthy controls. Cameron and colleagues suggested the necessity of rehabilitation interventions in MS patients for improving postural control responses, based on findings, depicting MS patients' large and delayed postural sway compared with controls.⁽¹⁷⁾

In MS patients, however, the impact of exercise training on postural control and static balance is not confirmed, and further investigation is needed regarding the effect of aerobic, strength, and combined training on postural control.^(13,18-21) Cattaneo and colleagues showed no significant improvement in the balance after balance exercise training.⁽¹³⁾ Jessicand colleagues found the effect of supervised resistance training on improvement of postural control of MS patients.⁽¹⁸⁾ Cakt and colleagues reported that progressive resistance training may enhance the balance.⁽¹⁹⁾ Debolt and McCubbin found that postural control did not improve which was due to a home-based resistance training program. According to Romberg and colleagues, balance did not vary after six months of exercise training.⁽²⁰⁾ Ali Barbar and colleagues reported that aquatic exercise program improved balance in adults with MS.⁽²²⁾ The present study investigated the effect of aquatic exercise on postural control in ataxic patients with MS. Postural control was measured by evaluation of COP displacement during standing before and after the training. It was hypothesized that MS subjects show

significant changes in postural control measures after an 8-week aquatic exercise program⁽²³⁾.

MATERIALS AND METHODS

Subjects

Given that MS patients have been studied as a group, the condition of participation in the study was voluntary cooperation. Therefore, all eligible patients with multiple sclerosis from MS Association of Khuzestan Province, which has a record of over 127 females and 87 males, were called to action. Finally, thirty-two individuals with MS (10 males and 22 females) participated in the study with a degree of ataxia indications and a disease grade of (EDSS) 2.5 to 5, then the participants were randomly selected and divided into two groups of exercise ($n=17$, age, $39.12 \pm 8.54y$) and control group ($n=15$, age, $33.4 \pm 15.16y$). In all MS patients, the exercise group completed 8 weeks of aquatic exercises. The controls were selected matching the exercise group regarding age and gender. The control group completed only the pre-training postural control test and did not participate in the aquatic exercise program.

Patients were recruited through the MS Society. Inclusion criteria for MS patients and controls group included: 1) an Expanded Disability Status Scale (EDSS) score of 2.5–5,⁽²³⁾ 2) degree of ataxia indications, 3) no pregnancy, 4) age ranging 20 to 55 years, 5) no other neurological disorder, and 6) no current participation in a regular exercise program. (**Table 1**).

Important components of MS patients' assessment for the exercises in the pool included: 1) Determining the level of independence to walking, showering, dressing, and need for support, 2) Determining the safest methods for transportation during the exercises in the pool, 3) Determining weight-bearing capacity, 4) Identification of the type of pain in MS patients to be compared during or after the exercise, 5) Identification of the range of MS symptoms affecting a person's ability to engage in aquatic exercises, 6) Heat sensitivity and fatigue in MS patients to select the suitable pool temperature, appropriate training program duration, and estimation of rest periods and exercise intensity, and 7) Identification of people with bladder and bowel incontinence and urinary analysis test before pool entry to determine the person's suitability for aquatic exercise.⁽²⁴⁾

Postural Control Assessment

Postural control was measured using the force platform. The force platform measures 3-dimensional forces (F_x , F_y , F_z) and 3-dimensional moments (M_x , M_y ,

Mz) involved in postural control, which provide center of pressure, allowing postural sway and sway velocity to be measured. The current measurements of the velocity of the center of pressure included the anterior-posterior (AP), medial-lateral (ML) directions, and sway velocity. The patients stood on the force platform with the eyes open in the center of the laboratory with feet at approximately shoulder width apart. During the assessment, the patients were asked to stand on the platform for 30 seconds, and sampling frequency was set at 100 Hz.

Training Program

The pattern used for training protocol in this research is Erika Coxhead. Aquatic exercise for people with multiple sclerosis is MC practice (2009). The exercise group participants were asked to meet for 3 times a week for 8 weeks by 55% to 75% of maximum heart rate. The pool water temperature was set at 76° to 82° F. A swimming pool was used for aquatic exercise, named Rasha pool. Each session included a 10-minute warm-up, 30 minutes of the main exercise followed by a 5-minute cool-down. Noodles were used for buoyancy, balancing, and efficiency of water depth. The warm-up and cool-down programs included several types of walking (forwards, backwards, crosswise, and sideways). Exercises performed in this study included combination of stretching and relaxation, fitness, and balance training. Stretching involved stretching in lower and upper extremities. Fitness involved a variety of exercises which increased the work rate of the heart, lungs, and general fitness such as running and cycling in deep water, and jumping. Balance training included exercises reducing the dependence, and was performed when moving arm or leg against the resistance of water. The difficulty increased by reducing the base-of-support and performing balance exercises in deep water.⁽²⁴⁾

Data Analysis

COP displacements in AP and ML directions were measured using the component force data (Fx, Fy, and Fz) and sway velocity for each test. Descriptive statistics (means, SDs) were calculated for each COP parameter.

Pre/post-test design was used for the experiment groups applying ANOVA. The paired t-tests were used to compare pre- and post-training outcomes in MS patients and independent t-tests to compare pre- and post-training results in MS patients and the control group. Statistical analysis was performed through SPSS 16.0 and R. The significance level was set at 0.05.

RESULTS

The present study planned to investigate the effects of aquatic exercise on postural control in ataxic patients with MS. The study was carried out on two groups (exercise and control). Demographical data are provided in **Table 1**. Pre- and post-test data, mean score, and standard deviations for the measures in the data analysis are presented (**Table 2**). The average COP displacement items scores in pre-test and post-test in both groups are shown in **Figure 1**. For each test of COP, the measure parameters (AP, ML directions, and sway velocity) of MS patients' post-training significantly decreased (P = .001), compared with the pre-training (P = .05) (**Table 2**). The difference between pre-test and post-test of the control group was not significant except for AP direction (AP direction, P = .012, ML direction, P = .103, and sway velocity, P = .113) (**Table 2**). The results confirm the role of aquatic exercise in decreasing COP displacement and improving posture control in ataxic patients with MS. Considering the lack of improvement in the control group, the improvement of the experiment group can be attributed to the effect of these exercises. Therefore, average COP velocity (A) and COP displacement (B and C) can be seen in anterior-posterior (AP) and medial-

Table 1. Subject demographics

| | Exercise group (n = 17) Mean±SD | Control group (n = 15) Mean±SD |
|-------------|------------------------------------|-----------------------------------|
| Age (yrs) | 39.12±8.54 | 33.4±15.16 |
| Gender | 11 Female / 6 Male | 11 Female / 4 Male |
| Height (cm) | 168.03±11.94 | 167.70±6.45 |
| Mass (kg) | 68.90±13.11 | 65.85±10.75 |
| EDSS* | 3.09±.85 | 3.05±.76 |

Abbreviations: EDSS, Expanded disability status scale.

Table 2. Summary of primary outcome measures at pre-testing and post-testing

| | Exercise group | | | Control group | | |
|----------------|----------------|-----------|------|---------------|-----------|------|
| | Pre-test | Post-test | P | Pre-test | Post-test | P |
| AP sway* | .72±.14 | .55±.14 | .001 | .61±.22 | .63±.22 | .012 |
| ML sway* | .46±.17 | .35±.13 | .001 | .42±.13 | .43±.14 | .103 |
| Velocity sway* | 1.5±.37 | 1.29±.34 | .001 | 1.93±.67 | 1.97±.69 | .113 |

*Significant difference between pre-test and post-test in exercise group and control group (P = .05).

lateral (ML) directions for the two exercise group and controls group in ataxic patients with multiple sclerosis (Figure 1).

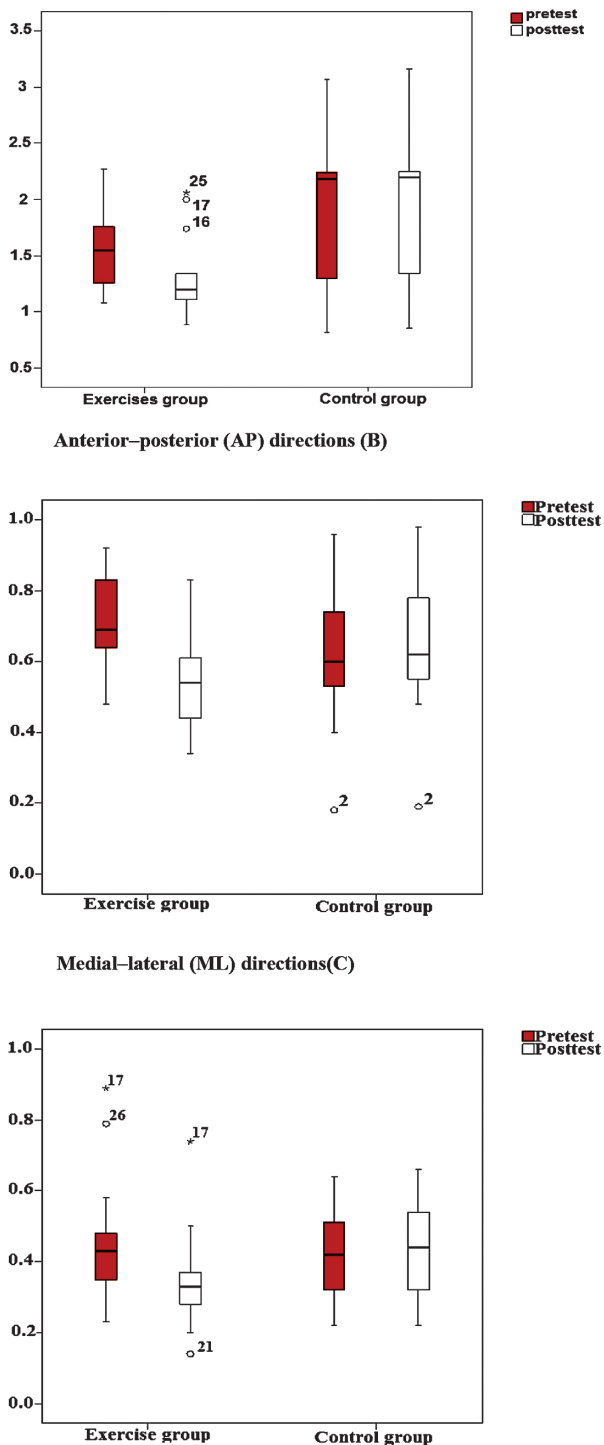


Figure 1. Average COP velocity (A) and COP displacement (B and C) in anterior–posterior (AP) and medial–lateral (ML) directions for the two exercise group and controls group in ataxic patients with multiple sclerosis

DISCUSSION

The present study evaluated the changes in postural control in ataxic patients with MS following an aquatic exercise program. It was hypothesized that there are differences between MS patients before and after aquatic exercise and aquatic exercise intervention brings about significant changes in the velocity of COP displacement in AP, ML directions, and sway velocity. Eight weeks of aquatic exercise reduced the amount of velocity of COP displacement in ataxic patients with MS compared with the control group before and after the aquatic exercise. This is in agreement with the hypothesis of the study and similar to the results obtained by other authors.^(18,19) Some studies used clinical assessment methods,^(13,15,25) and some others applied COP assessment techniques^(16,26) to evaluate postural control and static balance in MS patients. In most research studies, the effects of various exercise trainings on postural control and static balance of MS patients have been examined to improve these variables.^(13,18-20) However, the findings are not consistent with some other works, which is possibly due to various measurement tools and type of exercise training employed. The reduced velocity of COP displacement for MS patients indicates that training may improve postural control in these patients, and the velocity of COP displacement is different in MS patients and controls. The current findings showed significant changes following aquatic exercise compared with previous intervention studies which evaluated the effects of aerobic and resistance training on MS patients.

Cattaneo and colleagues examined changes in balance via Berg Balance Scale.⁽¹³⁾ Jessie and colleagues measured variations in postural control using sway variability and temporal structure of sway variability after 3 months of resistance training.⁽¹⁸⁾ DeBolt & McCubbin evaluated changes in sway velocity applying force platform for postural control measures after an 8-week home-based program,⁽²⁰⁾ while Romberg and colleagues evaluated changes in a clinical balance test after 6 months strength and aerobic exercise program.⁽²¹⁾

Previous studies used aerobic, strength, and combined training; however, the exercise program used in the current study was different because of water hydrostatic pressure and resistance. This study conducted exercises against water resistance, a property of resistance exercises for MS patients. It has been reported that increase in power improves the postural control of MS patients.^(18,19)

The patients continued to perform balance training. Perhaps, balance training in water, without the base-of-support and against water turbulence, improves

MS patients' balance. Cattaneo reported that balance rehabilitation is useful in reducing falls and improving balance in patients with MS.⁽¹³⁾

In this study, the patients lived in a new environment not experienced previously. Hence, leaving homes and taking part in sport societies and performing physical activities and exercises are other possibilities for the improvement of postural control MS patients. The levels of patients' physical activities were low due to muscle inactivity and inability to perform high-intensity exercises on the ground. None of the patients had taken part in a regular exercise program before the study. Thus, changes in physical fitness levels following aquatic exercises may possibly improve balance in MS patients. It has been reported that aquatic exercises improve MS patients' physical fitness levels.⁽²⁷⁾

Patients' self-report on reduction of fatigue and improvement of mobility due to aquatic exercise program is an explanation for the improvement in postural control in MS patients. Pariser and colleagues revealed the positive impact of aquatic exercise on improvement of mobility and reduction of fatigue in MS patients.⁽²⁷⁾

Aquatic exercise can improve balance via enhancing the joint range of motion, strength, and aerobic capacity. Toulotte and colleagues demonstrated that pain, changes in motion ranges, and muscle length and strength result in balance impairments.⁽²⁸⁾ Geytenbeek showed that aquatic exercise elevated the range of motion, pain, and muscle strength in MS patients.⁽²⁹⁾

The loss of proprioception was observed in both MS and ataxic patients. Rougier and colleagues showed that proprioception is important to maintain postural control in MS patients.⁽³⁰⁾ Therefore, improvement in postural control of MS patients after aquatic exercises results in improving proprioception. Risberg and colleagues demonstrated the improvement of proprioception via exercise training program.⁽³¹⁾

The patients had a degree of ataxia; probably, the aquatic exercises resulted in reduced ataxic movements in MS patients, thus changing the postural control. Armutlu and colleagues reported the efficiency of physical therapy and exercise training program on improving the performance of ataxic patients.⁽⁶⁾

Although the present study evaluated the effect of aquatic exercises on postural sway of ataxic patients with MS, there were some limitations. Measurement of ataxia changes was not performed to determine if the aquatic exercises were beneficial to heal ataxia in MS patients. Thus, it is not possible to conclude that the improvement in postural control is correlated with improvements of

ataxia in MS patients.

There was a significant difference between the pre-test and post-test in the control group in AP direction. Lack of any change and/or deterioration of patients' condition in the control group were due to the progressive and negative course of MS. In addition, warmer weather and its influence on fatigue of patients and more symptoms are other possible explanations for significant negative change in AP direction of the control group.

Further study is needed to determine the positive impact of aquatic exercises on the postural control of MS patients and the specific relationship between the decrease in ataxia of MS patients and the improvement in postural control.

CONCLUSIONS

The aquatic exercise program may have a significant and positive impact on the postural control of ataxic patients with MS. Further studies with a larger sample size are required to confirm these encouraging preliminary results; clinicians are recommended to consider aquatic exercises as a viable rehabilitation program for MS patients. However, if the exercise program and the sample size differs in future studies, some differences might be seen in the results of the study.

ACKNOWLEDGMENT

This article has been taken from master thesis of Department of Sport Physiology, Faculty of Sport Sciences, Shahid Chamran University of Ahvaz, Iran. So this work was supported in part by the MS Society of Khuzestan in Iran. The authors would like to thank the MS Society and its staff as well as the patients who volunteered to take part in the study.

CONFLICT OF INTEREST

None declared.

REFERENCES

1. Shapiro RT. Symptom Management in Multiple Sclerosis. 3rd ed. New York, NY: Demos Medical Publishing; 1998.
2. Peterka RJ. Sensorimotor integration in human postural control. *J Neurophysiol.* 2002;88:1097-1118.
3. Kesselring J. Long-term management and rehabilitation in multiple sclerosis. *Frontiers in multiple sclerosis.* London: Martin Duntiz; 1999, 243-52.
4. Weinschenker B, Issa M, Baskerville J. Long-term and short-term outcome of multiple sclerosis: a 3-year follow-up study. *Arch Neurol.* 1996;53:353-8.

5. Mariotti C, Fancellu R, Di Donato S. An overview of the patient with ataxia: *J Neurol*. 2005;252:511-8.
6. Armutlu K, Karabudak R, Nurlu G. Physiotherapy approaches in the treatment of ataxic multiple sclerosis: a pilot study. *Neurorehabil Neural Repair*. 2001;15:203-11.
7. DeSouza L. Multiple sclerosis: approaches to management. London: London Chapman & Hall; 1990.
8. Crutchfield CA, Shumway-Cook A, Horak FB. Balance and coordination training. Philadelphia: Lippincott company; 1990.
9. Cattaneo D. Risks of falls in subjects with multiple sclerosis. *Arch Phys Med Rehabil*. 2002;83:864-7.
10. Yahia A, Ghroubi S, Mhiri C, Elleuch MH. Relationship between muscular strength, gait and postural parameters in multiple sclerosis. *Ann Phys Rehabil Med*. 2011;54:144-55.
11. Schieppati M, Nardone A, Schmid M. Neck muscle fatigue affects postural control in man. *Neuroscience*. 2003;121(2):277-85. Erratum in: *Neuroscience*. 2004;128:665.
12. Latash ML. Neurophysiological Basis of Movement. Human Kinetics: Champaign, IL; 1998.
13. Cattaneo D. Effects of balance exercises on people with multiple sclerosis: a pilot study. *Clin Rehabil*. 2007;21:771-81.
14. Liu-Ambrose T, Katarynych LA, Ashe MC, Nagamatsu LS, Hsu CL. Dual-task gait performance among community-dwelling senior women: the role of balance confidence and executive functions. *J Gerontol A Biol Sci Med Sci*. 2009;64:975-82.
15. Frzovic D, Morris ME, Vowels L. Clinical tests of standing balance: performance of persons with multiple sclerosis. *Arch Phys Med Rehabil*. 2000;81:215-21.
16. Karst GM, Venema DM, Roehrs TG, Tyler AE. Center of pressure measures during standing tasks in minimally impaired persons with multiple sclerosis. *J Neurol Phys Ther*. 2005;29:170-80.
17. Cameron M., Horak FB, Herndon RR, Bourdette D. Imbalance in multiple sclerosis: A result of slowed spinal somatosensory conduction: *Somatosens Mot Res*. 2008;25:113-22
18. Jessie M, Huisinga MLF, Stergiou N. Supervised Resistance Training Results in Changes in Postural Control in Patients with Multiple Sclerosis. *Motor Contr*. 2012;16:50-63.
19. Kakt BD, Nacir B, Genc H, Saracoglu M, Karagoz A, Erdem HR. Cycling progressive resistance training for people with multiple sclerosis: A randomized controlled study. *Am J Phys Med Rehabil*. 2010;89:446-57.
20. DeBolt LS, McCubbin JA. The effects of home-based resistance exercise on balance, power, and mobility in adults with MS. *Phys Med Rehabil*. 2004;85:290-7.
21. Romberg A, Virtanen A, Ruutiainen J, Aunola S, Karppi SL, Vaara M. Effects of a 6-month exercise program on patients with multiple sclerosis: A randomized study. *Neurol*. 2004;63:2034-8.
22. Ali B, Reza B, Yaser G. The effect of aquatic exercise on balance of adult with multiple sclerosis. *Eur J Exp Biol*. 2014;4:38-43.
23. Kurtzke JF. Rating neurologic impairment in multiple sclerosis: An expanded disability- status scale (EDSS). *Neurol*. 1983;33:1444-52.
24. Erika Coxhead. Aquatic exercise for people with multiple sclerosis. Sydney: MS Practice; 2009, 1-8.
25. Giesser B, Beres-Jones J, Budovitch A, Herlihy E, Harkema S. Locomotor training using body weight support on a treadmill improves mobility in persons with multiple sclerosis: A pilot study. *Mult Scler*. 2007;13:224-31.
26. Chung LH, Remelius JG, Van Emmerik RE, Kent-Braun JA. Leg power asymmetry and postural control in women with multiple sclerosis. *Med Sci Sports Exerc*. 2008;40:1717-24.
27. Pariser G, Madras D, Weiss E. Outcomes of an aquatic exercise program including aerobic capacity, lactate threshold, and fatigue in two individuals with multiple sclerosis. *J Neural Phys Ther*. 2006;30:82-90.
28. Toulotte C, Thevenon A, Watelain E, Fabre C. Identification of healthy elderly fallers and non-fallers by gait analysis under dual-task conditions. *Clin Rehabil*. 2006;20:269-76.
29. Geytenbeek J. Evidence for effective hydrotherapy. *Physiotherapy*. 2002;88:514-29.
30. Rougier P, Faucher M, Cantalloube S, Lamotte D, Vinti M, Thoumie P. How proprioceptive impairments affect quiet standing in patients with multiple sclerosis. *Somatosens Mot Res*. 2007;24:41-51.
31. Risberg MA, Mørk M, Jenssen HK, et al. Design and implementation of a of neuro Muscular training program following anterior cruciate ligament reconstruction. *J Orthop Sports Phys Ther*. 2001;31:620-31.

Corresponding Author:

Mohsen Ghanbarzadeh, PhD

Department of Exercise Physiology, Faculty of Sport Sciences, Shahid Chamran University of Ahvaz, Ahvaz, Iran

Tel: +98 61 33738535

Cell: +98 9163096612

E-mail: ghanbarzadeh23@gmail.com

Received April 2016

Accepted May 2016