

# The Effect of Aquatic Training on Kinematic Walking Patterns of Elderly Women

Khadijeh Irandoust, Morteza Taheri

Department of Sport Sciences, Faculty of Social Sciences, Imam Khomeini International University, Qazvin, Iran

ORCID:

Khadijeh Irandoust: <https://orcid.org/0000-0001-5839-9753>

## Abstract

**Aims:** The aim of this study was to evaluate the effects of an aquatic training course on the kinematic walking patterns of elderly women. **Materials and Methods:** Thirty elderly women aged 60–70, who had entry criteria for research, voluntarily entered the study process, of which nine women refused to continue cooperation. Participants were randomly assigned into control ( $n = 10$ ,  $63.2 \pm 3.1$ ) and experimental groups ( $n = 10$ , average age  $64.4 \pm 3.3$ ). The exercise program consisted of an 8 week of aquatic protocol, three sessions a week, and each session was performed for 60 min. The h/p/cosmos gait analyzer was used to evaluate the kinematic patterns of walking on the treadmill with the force plate, and the velocity variables (km/h), cadency (steps/min), step length (Cm), and step time (s) were measured in two stages of pretest and posttest. **Results:** The results suggested that aquatic training had a significant effect on the kinematic patterns of walking (walking speed, cadency, and length of step) in elderly women ( $P \leq 0.05$ ). **Conclusion:** Since walking patterns and walking quality have a significant effect on maintaining balance and functional independence in the elderly populations, any intervention that improves these patterns will have a significant effect on the balance of elderly people. Therefore, water resistance exercises can improve the walking patterns in elderly women.

**Keywords:** Aquatic exercises, elderly, gait analysis, kinematics

## INTRODUCTION

The excessive growth of the elderly population in recent years has led health policy-makers to seek solutions to increase the elderly's functional independency to minimize the costs of these age-related disorders and disease.<sup>[1-3]</sup> Decreasing changes in physiological and neurological systems during old age impair postural control and causes poor balance.<sup>[4,5]</sup> Along with these constraints, changes in the central nervous system impaired the information processing of the elderly, which can affect the psychological functioning, and thus disturb the motor control and balance.<sup>[6,7]</sup> Body composition changes such as increased body fat percentage and muscle tissue loss are factors that affect the parameters associated with motor control in the elderly.<sup>[5,8,9]</sup> In addition, changes in musculoskeletal structure, vestibular system, sensory system, and visual system impair elderly balance, which is one of the main causes of the fall in aging.<sup>[10]</sup> There is evidence to show that the improvement of various systems involved in maintaining body balance, such as vestibular system, visual, and sensory and motor systems,

can be enhanced by training interventions by which activated antigravity muscles and body balance improves.<sup>[4,11-13]</sup> Research evidence suggest that over 50% of the fall in elderly people occurs while walking, with poor physical fitness and muscle weakness are the main reasons for the fall. During stepping forward and walking, the center of gravity of the elderly fluctuates forward, left, and right, and the excessive intensity of these fluctuations will affect kinematic walking patterns such as step length, speed, and range of joints. This is because the implementation of any interventions that can improve these parameters will be effective. Therapeutic exercise has always been one of these effective interventions, followed by the health researchers. The elderly populations lack the ability to participate in all sports activities due to the greater vulnerability

**Address for correspondence:** Dr. Khadijeh Irandoust, Department of Sport Sciences, Faculty of Social Sciences, Imam Khomeini International University, Qazvin, Iran.  
E-mail: [parirandoust@gmail.com](mailto:parirandoust@gmail.com)

### Access this article online

Quick Response Code:



Website:  
<http://iahs.kaums.ac.ir>

DOI:  
10.4103/iahs.iahs\_1\_19

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

**For reprints contact:** [reprints@medknow.com](mailto:reprints@medknow.com)

**How to cite this article:** Irandoust K, Taheri M. The effect of aquatic training on kinematic walking patterns of elderly women. *Int Arch Health Sci* 2019;6:1-5.

of being injured compared to young people, as there is a high probability of musculoskeletal injuries.<sup>[14-16]</sup> Therefore, it is necessary to have preventive exercise strategies for them, which create the most training benefits for them. In this regard, water therapy and water rehabilitation exercises are one of the methods that has always been considered by researchers for their effectiveness. The reasons for the suitability of this training method are the physical characteristics of this exercise method, such as flotation and hydrostatic pressure, and allow the elderly to exercise without stress from weight-bearing. For example, static and floating pressure acts as a robust force, which exercises in the water work better than in dry conditions as a supportive force. On the other hand, due to hydrostatic pressure during immersion in water, the same resistance is introduced to all muscle groups, which increases the sense of movement and improves body awareness.<sup>[11,17]</sup> The pattern of stepping and walking skills is one of the most important activities in the elderly's functional autonomy. The most reports of elderly functional disability have been reported due to the lack of autonomy in walking in men and women.<sup>[18]</sup> Therefore, the identification of aging age factors and limitation of walking and effective methods for delaying the occurrence of these problems have always been considered by researchers. Sadeghi *et al.* (2002), in their research, stated that increasing age and reaching to elderly age affect the patterns of muscle contraction in the lower limbs of the elderly, which can lead to changes in patterns of stepping.<sup>[19]</sup> Changes in the walking biomechanical pattern and parameters such as step length and speed can disrupt the phase of balance and establishment on the ground in the elderly, which reduces the level of motor control. Muscle weakness in the hip, knee, and ankle muscles are destructive changes that increase the probability of falling during walking in the elderly.<sup>[20]</sup>

Researchers have shown that consolidation of each of the factors involved in balancing and walking such as sensory system (atrial and deep) and motor system (strength and flexibility) can be a suitable strategy in the treatment and prevention of walking problems and elderly balance, and ultimately, decrease their fall.<sup>[21,22]</sup> As one of the challenges in setting up training programs to improve the walking of the elderly, creating a safe and low-risk environment is still influential.<sup>[23]</sup> Exercise in water in recent years has been used to improve the level of physical fitness and rehabilitation of elderly people. However, in spite of the potential benefits of water rehabilitation, few studies have focused on the effect of water exercise on the kinematic indices of stepping patterns. Therefore, in this study, the researcher is trying to investigate the effect of aquatic training on kinematic walking patterns of elderly women.

## MATERIALS AND METHODS

### Subjects

The present research method is a semi-experimental with pretest/posttest and control group design. Thirty of the elderly women aged 60–70 years who had entry criteria were voluntarily enrolled in the study, of which nine were

discontinued. The participants were selected based on convenience sampling method, and the sample size was calculated based on Equation 1:

$$n = \frac{(\sigma_1^2 + \sigma_2^2) (Z_{1-\frac{\alpha}{2}} + Z_{1-\beta})^2}{d^2}$$

They were randomly assigned into control ( $n = 10$ ; age:  $63.2 \pm 3.1$  years) and experimental groups ( $n = 11$ , age:  $64.4 \pm 3.3$  years). The criteria for entry into the study were regular inactivity in the past 6 months, no cardiovascular problems, and lacking the physical and orthopedic problems that impaired the walking functioning and attending training sessions and testing. Any problem that prevented the attendance of training sessions was considered as an exclusionary criterion. The control group did their regular activities during the experiment and had no organized exercise as per the experimental group.

### Procedure

The exercise program consisted of 8 weeks of resistance training in water, three sessions per week, and each session lasted for 60 min. The h/p/cosmos gait way instrument was used to evaluate the kinematic patterns of walking on a treadmill with the force plate (HP Cosmos, Germany). The time and place variables, including walk speed (km/h), cadency (Step/min), step length (cm), and step time(s), were measured in two stages of pretest and posttest. To control the effect of physical properties on the test results, the body composition analyzer (in body 320, made in Korea) was used. Paired *t*-test was used to compare intragroup changes, and independent *t*-test was used to compare walking patterns between two groups at a significant level of 0.05. As shown in Table 1, the aerobic exercise program was run for 60 min, 8 weeks, and three sessions a week. Before starting the training protocol in the pretest session, the research variables were measured in the base state. The exercise program was performed as follows: the proposed training protocol is to warm up for 15 min (stretching movements in all joints and warming up major muscle groups; walking forward, back, sides, heel, and toe and juggling in the water); exercise for 30 min (weight transfer from front to back, rotation around a square, foot-balancing exercise, standing on one leg [every 20 s pause], weight transfer from one side to the other side, step by side, squat, curling hamstring, hip adducting, foot of a one-leg bike, pendulum training, moving the elbow to the opposite knee in the standing position, and exercising the pendulum of the hands); and return to baseline for 15 min (tensile training, deep breathing, and buoyancy exercises). Inferential statistics of dependent *t*-test was used to compare intragroup changes, and independent *t*-test was used to compare the balance indices between the two groups after 8 weeks at a statistically significant level of 0.05.

### Ethical considerations

The research was approved by the local Ethical Committee of Imam Khomeini International University.

### Statistical analysis

Inferential statistics of dependent *t*-test was used to compare intragroup changes and independent *t*-test was used to compare the balance indices between the two groups after 8 weeks at a statistically significant level of 0.05.

### RESULTS

Data were normally distributed according to the Kolmogorov–Smirnov test ( $P \geq 0.05$ ). The descriptive data of kinematic patterns are shown in Table 2.

As shown in Table 3, The results of independent *t*-test showed that there was no significant difference in the walking speed of elderly women between the two groups in pretest ( $P = 0.50$ ). On the other hand, no significant difference was found in the posttest ( $P = 0.07$ ). The results of dependent *t*-test showed that aquatic training had a significant effect on walking speed in elderly women ( $P = 0.004$ ).

As shown in Table 4, there was no significant difference between the groups in walking cadency the pretest ( $P = 0.87$ ). However, there was a significant difference in the posttest ( $P = 0.01$ ). In addition, the results of dependent *t*-test showed that exercise grip had a significant improvement in walking cadency in posttest ( $P = 0.001$ ).

As shown in Table 5, there was no significant difference in step length between the groups in the pretest ( $P = 0.46$ ). However, there was a significant difference between the two groups exercise in the posttest ( $P = 0.02$ ). The results of dependent *t*-test showed that aquatic training had a significant effect on step length of elderly women ( $P = 0.001$ ).

### DISCUSSION

The improvement in kinematic variables of elderly (such as walking speed, cadency, and length) following aquatic training was well documented in the current research.

The purpose of this study was to determine the effect of water therapy training on the kinematic walking patterns of elderly women. The results showed that water therapy exercises as an appropriate treatment for improving the kinematic walking patterns of elderly people can be used, which lead to improved balance and increased functional autonomy. The results of this study are consistent with a research by Hinman *et al.* who showed that rehabilitation water therapy exercises led to an increase in muscular strength of the lower limb and improved balance and patterns of stepping, which resulted in increased motor function.<sup>[24]</sup> As shown in the research results, water therapy exercises improved the walking cadency in elderly women. As previously mentioned, increased stimulation of antigravity muscles by water therapy is one of the possible reasons for the conclusion that water therapy exercises can enhance the sensory information received from atrial, visual, and sensory and motor systems and systems involved in maintaining balance while walking.<sup>[25]</sup> The results showed that water exercises have significant effects on the step length of the elderly women. This finding can prove a better balance and stability of the elderly following the water therapy protocol, as the incremental step length increases the stability of the stepping. In justifying the results, it can be noted that the nature of the exercise protocol used in this study was to increase strength by applying resistance to lower limb muscles. In creating favorable conditions for effective walking, in addition to the equilibrium aspects of muscle groups, the extent of flexion, extension, abduction, and adduction muscle movements and lower limbs is important. Since in the elderly, reducing muscle strength reduces the length of the step, resistance exercises can increase the power of the lost and improve the length of the step. As observed, the speed of stepping in elderly women improved following the water therapy protocol. It should be noted that the length of the step and the cadency and the better rhythm of walking can lead to more speed in the elderly. Therefore, it is natural that with increasing rhythm and step length, the speed of the elderly will be improved. According to the studies, the length

**Table 1: Exercise protocol**

Warm up (15 min)	Exercise protocol (30 min)	Cool down (15 min)
Stretching and locomotion movements	Weight transfer from front to back, rotation around a square, foot-balancing exercise, standing on one leg (every 20 s pause), weight transfer from one side to the other side, step by side, squat, curling hamstring, hip adducting, leg biking, pendulum training, moving the elbow to the opposite knee in the standing position, and exercising the pendulum of the hands	Stretching training, deep breathing, and buoyancy exercises

**Table 2: The mean kinematic variables of the research groups**

Group index	Mean ± SD			
	Control		Intervention of water therapy	
	Pretest	Posttest	Pretest	Posttest
Walking speed (km/h)	1.84±0.27	1.85±0.29	1.93±0.30	2.09±0.26
Cadency (step/min)	85.9±6.7	86.32±6.9	87.14±7.13	81.23±6.81
Step length (cm)	119.25±4.6	119.41±4.7	117.13±4.85	124.7±5.31

SD: Standard deviation

**Table 3: Walking speed of elderly women in both groups before and after intervention**

Variable	Test	Group	T	P	
Walking speed	Between difference (independent t-test)	Pretest	Exercise	0.67	0.5
		Posttest	Control	1.91	0.07
	Within difference (paired t-test)	Exercise	Pretest	-3.72	0.004
		Control	Posttest	-0.2	0.83

**Table 4: Walking cadency of elderly women in both groups before and after intervention**

Variable	Test	Group	T	P	
Walking cadency	Between difference (independent t-test)	Pretest	Exercise	-0.16	0.87
		Posttest	Control	-2.76	0.01
	Within difference (paired t-test)	Exercise	Pretest	8.12	0.001
		Control	Posttest	-1.13	0.28

**Table 5: Step length of elderly women in both groups before and after intervention**

Variable	Test	Group	T	P	
Step length	Between difference (independent t-test)	Pretest	Exercise	-0.74	0.46
		Posttest	Control	2.46	0.02
	Within difference (paired t-test)	Exercise	Pretest	-6.65	0.001
		Control	Posttest	-0.22	0.82

of a step decreases in elderly and the rate of decrease in women is more than men. One of the reasons for this issue refers to the body composition changes such as muscles atrophy and increased body fat percentage.<sup>[4,26]</sup> Therefore, the adoption of endurance programs to reduce body fat percentage, along with strength training to increase muscle, seems necessary. Since one of the challenges of setting up training programs is to promote the efficiency, the walking of the elderly, and to create a safe and low-risk environment that affects their motor and balance performance parameters, which ultimately will result in functional autonomy. Therefore, the present study training protocol can be used as a way to increase the walking patterns of elderly women. One of the limitations of this research was the low number of participants, which is recommended to

increase the number of people in future research in order to increase the generalizability of the research results. Controlling the psychological status of participants was the other limitation that should be monitored in future studies. On the other hand, it is suggested that the researchers compare the water therapy exercises with other training methods and examine the results in order to use the optimal pattern for elderly rehabilitation.

### CONCLUSION

Research in the field of kinematic functions for walking patterns in the elderly can shift the researchers' mind toward the more beneficiary strategies for elderly rehabilitation. As indicated in the research findings, water therapy exercises with resistance mode in nature, improve kinematic walking parameters.

### Acknowledgment

The authors would like to thank all the participants who helped us in this research.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

### REFERENCES

- Noroozian M. The elderly population in Iran: An ever-growing concern in the health system. *Iran J Psychiatry Behav Sci* 2012;6:1-6.
- Amini M, Mirmoezzi M, Salmanpour M, Khorshidi D. Eight weeks of aerobic exercises improves the quality of life in healthy aged sedentary men. *Int J Sport Stud Health* 2018;1:e67514.
- Caballero B. The global epidemic of obesity: An overview. *Epidemiol Rev* 2007;29:1-5.
- Irاندوست K, Taheri M. The effects of aquatic exercise on body composition and nonspecific low back pain in elderly males. *J Phys Ther Sci* 2015;27:433-5.
- Naghavi N, Taheri M, Irاندوست K. Psychophysiological responses to cognitive and physical training in obese elderly. *Int J Sport Stud Health* 2018;1:e83935.
- Irاندوست K, Taheri M. The effect of Vitamin D supplement and indoor vs outdoor physical activity on depression of obese depressed women. *Asian J Sports Med* 2017;8:1-7.
- Raffaelli C, Milanese C, Lanza M, Zamparo P. Water-based training enhances both physical capacities and body composition in healthy young adult women. *Sport Sci Health* 2016;12:195-207.
- Taheri M, Irاندوست K. The effect of balance exercises and computerized cognitive training on psychomotor performance in elderly. *J Phys Ther Sci* 2017;29:2097-9.
- Taheri M. Effect of hydrotherapy on lower body strength and balance among elderly women. *J Phys Educ Res* 2015;2:19-26.
- Deshpande N, Metter EJ, Bandinelli S, Lauretani F, Windham BG, Ferrucci L. Psychological, physical and sensory correlates of fear of falling and consequent activity restriction in the elderly: The InCHIANTI Study. *Am J Phys Med Rehabil Assoc Acad Physiatrists* 2008;87:354.
- Depiazzi JE, Forbes RA, Gibson N, Smith NL, Wilson AC, Boyd RN, et al. The effect of aquatic high-intensity interval training on aerobic performance, strength and body composition in a non-athletic population: Systematic review and meta-analysis. *Clin Rehabil* 2018;33:157-70.
- Seghatoleslami A, Afif AH, Irاندوست K, Taheri M. The impact of pilates exercises on motor control of inactive middle-aged women. *Sleep Hypn* 2018;20:262-6.



13. Seghatoleslami A, Hemmati Afif A, Irandoust K, Taheri M. Effect of pilates exercises on motor performance and low back pain in elderly women with abdominal obesity. *Iran J Ageing* 2018;13:396-404.
14. Borowicz A, Zasadzka E, Gaczkowska A, Gawłowska O, Pawlaczyk M. Assessing gait and balance impairment in elderly residents of nursing homes. *J Phys Ther Sci* 2016;28:2486-90.
15. Pirker W, Katzenschlager R. Gait disorders in adults and the elderly: A clinical guide. *Wien Klin Wochenschr* 2017;129:81-95.
16. Irandoust K, Taheri M, Shavikloo J. The effect of water-based aerobic training on the dynamic balance and walking speed of obese elderly men with low back pain. *Sleep Hypn* 2018;20:233-40.
17. Colado JC, Borreani S, Pinto SS, Tella V, Martin F, Flandez J, *et al.* Neuromuscular responses during aquatic resistance exercise with different devices and depths. *J Strength Cond Res* 2013;27:3384-90.
18. Kozaki K. Fall risk and fracture. Aging and fall/fracture. *Clin Calcium* 2013;23:653-60.
19. Sadeghi H, Prince F, Zabjek KF, Sadeghi S, Labelle H. Knee flexors/ extensors in gait of elderly and young able-bodied men (II). *Knee* 2002;9:55-63.
20. Wewerka G, Wewerka G, Iglseider B. Measuring gait velocity in the elderly with a gait analysis system and a 10-meter walk test. A comparison. *Z Gerontol Geriatr* 2015;48:29-34.
21. Irandoust K, Taheri M. The impact of yoga and pilates exercises on older adults. *Sälmand* 2016;11:152-61.
22. Taheri M, Irandoust K, Seghatoleslami A, Rezaei M. The effect of yoga practice based on biorhythms theory on balance and selective attention of the elderly women. *Iran J Ageing* 2018;13:312-23.
23. Skelton DA, Dinan SM. Exercise for falls management: Rationale for an exercise programme aimed at reducing postural instability. *Physiother Theory Pract* 1999;15:105-20.
24. Hinman RS, Heywood SE, Day AR. Aquatic physical therapy for hip and knee osteoarthritis: Results of a single-blind randomized controlled trial. *Phys Ther* 2007;87:32-43.
25. Tsourlou T, Benik A, Dipla K, Zafeiridis A, Kellis S. The effects of a twenty-four-week aquatic training program on muscular strength performance in healthy elderly women. *J Strength Cond Res* 2006;20:811-8.
26. Nabilpour M, Mayhew J. Effect of peripheral heart action on body composition and blood pressure in women with high blood pressure. *Int J Sport Stud Health* 2018;1:e81874.