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The Effect of Aquatic Exercise on the Peak Torque and Stability of Knee Joints of Elderly Women

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Abstract. [Purpose] The purpose of this study was to examine the effect of aquatic exercise using Taekwondo Poomsae motions on the peak torque and stability of elderly women's knee joints. [Subjects] The study subjects were conducted with 23 elderly women who were divided into an Aquatic Exercise Group (AEG, n=12) and a Control Group (CG, n=11). [Methods] The knee joint peak torque was assessed using an ISOMED 2000 (D&R GmbH, Germany) and the stability was analyzed using a Balance System SD (BIODEX, U.S.A). [Results] Based on the results of the analysis of changes in knee joint peak torque and stability, the AEG showed significant improvement in all items of knee joint peak torque (RFF, RFE, LFF, LFE) and stability (O, A/P, M/L) after the intervention compared to before the intervention, while the CG did not show any significant changes. [Conclusion] Aquatic exercises using Taekwondo Poomsae motions can be utilized as a new exercise program to help reinforce elderly women's muscular function and enhance their stability.
Key words: Aquatic exercise, Knee joint peak torque, Balance

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INTRODUCTION

Physical changes appearing in elderly persons include functional deterioration of the nervous system, changes in the musculoskeletal system's muscular metabolism ability and decreases in the size of muscle fibers and the number of fast muscle fibers. Naturally, these affect the balance control system and reduce stability[1–5)]. In particular, the weakening of lower extremity muscular functions is closely related to the maintenance of balance in elderly persons; it limits posture control and movements, while simultaneously increasing the risk of falls[6)]. In this respect, it is necessary to utilize exercise programs that consider the physical characteristics of elderly persons in order to improve their muscular function and ability to control posture.

Aquatic exercise is an exercise method that can overcome the problems of elderly persons who have physical restrictions and limitations, since aquatic exercise utilizes beneficial environmental elements. These include buoyancy, resistance, water depth, the speed of movement in water, water temperature and density, and since the exercises are performed under reduced gravity it has other effects such as reducing body fat, enhancing joint mobility, and improving muscular strength and endurance[7–9)]. The application of aquatic exercise for elderly persons does not require any special skills, and most exercises perform on the ground can be performed in water[10,11)]. Taekwondo Poomsae motions are composed of standing, steps for punching as well as kicking motions, and they can improve lower extremity health related to physical strength and reduce the incidence of falls as they reduce balance sway[12,13)]. This study examined the effects of Taekwondo Poomsae motions performed in water on knee joint peak torque and stability.

SUBJECTS AND METHODS

The subjects of this study were elderly women aged around 70. Based on prior health examinations and medical tests those with health risks were excluded. The purpose of the study and all experimental processes were explained to the subjects, and their voluntary agreement was received before they participated in the experiment. The age of the AEG subjects was 70.1 ± 2.32 years, their height was 150.7 ± 3.48 cm and their weight was 55.4 ± 6.51 kg. The age, height and weight of the CG were 70.63 ± 2.33 years, 149.44+4.16 cm and 57.9 ± 5.42 kg, respectively. The two groups did not have any statistically significant differences ($p<0.05$); thus, they were homogeneous.

The aquatic exercise program was conducted at the N Aquatic Rehabilitation Swimming Pool in Chonan, Korea. The indoor environment was maintained at a temperature of

Table 1. The aquatic exercise program

Order	Exercise
warm-up (10min)	Stretching, light walking
main exercise (40min)	Taekwondo Poomsae, Taegeuk chapters 1–3 5 times Taekwondo basic kick (front kick, left side kick, right side kick) 10 times, 3 set
cool-down (10min)	stretching, light walking

Table 2. The comparison of knee joint of peak torque in each group (unit: Nm)

Group	Muscle strength	Pre (Mean ± SD)	Post (Mean ± SD)
AEG	RKF*	26.54 ± 11.01	35.90 ± 10.54
	RKE*	58.53 ± 8.73	69.90 ± 12.67
	LKF*	26.08 ± 8.14	32.00 ± 8.78
	LKE*	51.25 ± 13.59	59.14 ± 15.91
CG	RKF	28.09 ± 12.11	30.27 ± 8.66
	RKE	55.62 ± 13.15	57.40 ± 19.03
	LKF	27.70 ± 7.54	27.50 ± 9.74
	LKE	58.33 ± 13.26	54.44 ± 18.76

* $p<0.05$; AEG: Aquatic exercise group; CG: Control group; RKF: right knee flexion, RKE: right knee extension; LKF: left knee flexion; LKE: left knee extension.

28~33 °C, humidity of 70~75 %, a water depth of 1.3 m, and water temperature of 27~28 °C. The aquatic exercises performed were Taekwondo motions, including Taegeuk chapters 1–3, and basic kicks (front kick, side kick and back kick). The intensity of the exercise was determined based on a rate of perceived exertion (RPE) of 11~13 (fairly light-somewhat hard) during weeks 1~6, and an RPE of 13~15 (somewhat hard-hard) during weeks 7~12. The frequency of the exercise was three times a week for 12 weeks, and the exercise time per session was 60 minutes. The exercise program is shown in Table 1.

An ISOMED 2000 (D&R GmbH, Germany) was used to measure maximum knee joint muscular strength (peak torque) and the measurement was done by measuring the extensor muscular strength and the flexor muscular strength of the left and right joints five times at 90°/sec. The stability was measured using a Balance System SD (BIODEX, U.S.A) and each study subject's ability to control their postures for 30 sec. was quantified by changes in foot position and ground reaction force in an unstable test in which the stability of the support plate was changed. The level of difficulty of the stability of the support plate was 2. The subject had to stand with a fixed foothold for 30 sec with her eyes closed during the measurement. To evaluate the stability, the measurement items used were Overall, Anterior/posterior and Medial/lateral indexes. The measured data were statistically analyzed using SPSS 13.0 Windows, and the paired t-tests was conducted to compare changes between before and after the intervention in each group. The significance level, α, was chosen as 0.05.

RESULTS

With regards to changes in knee joint peak torque, the AEG showed significant differences between before and after the intervention in all items, right knee flexion, right knee extension, left knee flexion and left knee extension ($p<0.05$), while the CG did not show any significant differences between before and after the exercise (Table 2).

Table 3. The comparison of stability in each groups (unit: score)

Group	Body sway	Pre (Mean±SD)	Post (Mean±SD)
AEG	O*	3.51 ± 1.01	2.10 ± 0.71
	A/P*	2.82 ± 1.30	1.73 ± 1.07
	M/L*	1.48 ± 1.11	0.62 ± 0.28
CG	O	3.88 ± 1.09	3.42 ± 1.80
	A/P	2.57 ± 1.19	2.60 ± 1.15
	M/L	1.30 ± 1.11	1.04 ± 0.51

*$p<0.05$; O: Overall, A/P: Anterior/Posterior index, M/L: Medial/Lateral index.

With regard to changes in stability, the AEG showed significant differences between before and after the application in all items, Overall, Anterior/posterior and Medial/lateral indexes ($p<0.05$), while the CG did not show any significant differences between before and after the intervention (Table 3).

DISCUSSION

A study by Winter indicated that as people aged, reflexes against external changes decreased due to overall physical strength decreases and physical sensory functional deterioration; thus, their stability decreased as aging progressed, causing fall-related risks to increase[14]. The present study conducted aquatic exercises using Taekwondo Poomsae motions with elderly women as subjects in order to improve their muscular function and stability.

The AEG showed significant improvement after the intervention compared before the intervention in all knee joint peak torque items ($p<0.05$). Dishman et al. stated that the effects of aquatic exercise were primarily due to water resistance, unlike exercise on the ground, and that environmental elements such as water depth, the speed of

movement underwater, the amount of force exerted in motions and water temperature cause an improvement in overall muscular function[15]. In particular, the continuous implementation of standing, steps and kicking motions in water greatly affected the movement of the body's weight and balance and were helpful in improving muscular and skeletal functions[16]. The results of our present study are in agreement with these previous studies, and we consider that the aquatic exercises performed in this study enhanced knee joint peak torque through the composite effect of the environmental characteristics of aquatic exercise and Taekwondo Poomsae motions.

The AEG showed significant improvement in all items of stability after the intervention compared before the intervention ($p<0.05$). Raymakers noted that the ability to control balance, which is essential when exercising, originates from muscular strength. This reinforces the fact that the improvement of muscular strength and muscular endurance positively affects the maintenance of balance and prevents falls. Moreover, an improvement in the ability to control balance was considered to be obtained through the training aimed at improving the somatic sense, vestibular sensation and proprioceptive sensational functions[17], and that the improvement of muscular strength was the result of muscular nerve adaptation and muscular responses, since muscular contractions in response to resistance increase the stimulation of the cerebral cortex making them the most effective promotion factor[18]. We consider the significant improvement in stability which was seen in the present study, was the result of improvement in knee joint muscular function and the balance control system. Our present results indicate that the performance of aquatic exercise using Taekwondo Poomsae motions improved knee joint peak torque and stability and they are supported, by the results of previous research suggesting the applicability of these exercises as a new exercise program for elderly women.

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