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Acute effects of aquatic exercise on trunk flexibility and low back muscle strength in healthy Thai subjects

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Background : *Aquatic exercise can increase the degree of movements of various joints, resulting in nimbleness and flexibility. Previous studies were carried out on long-term programs of aquatic exercise. There has not been any research work on acute effects of aquatic exercise.*

Objectives : *To study the acute effects of aquatic exercise on the change of the trunk flexibility and strength of the lower back muscles of healthy subjects.*

Setting : *Faculty of Associate Medical Sciences, Khon Kaen University.*

Design : *Experimental research.*

Methodology : *Ninety-eight healthy Thai persons who were divided into two groups: control and experimental. The control group (n = 49) did not undergo aquatic exercise. The experimental group (n = 49) underwent aquatic exercise. The volunteers' trunk flexibility and the strength of lower back muscles were measured at 60 min before and after the exercise.*

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Results : *The values of trunk flexibility of the control group before and after the program were 2.7± 9.2 and 3.8 ± 8.8 centimeters (p = 0.061), whereas their strengths of the lower back muscles were 72.6 ± 26.2 and 72.1 ± 24.4 kilograms (p = 0.318). As for the experimental group, their trunk flexibilities before and after the program were measured at 3.4 ± 9.7 and 5.5 ± 9.0 centimeters (p = 0.000), whereas their strengths of the lower back muscles were 65.7 ± 20.3 and 67.9 ± 22.1 kilograms (p = 0.101).*

Conclusion : *Aquatic exercise could increase trunk flexibility but not the strength of the lower back muscles. The retention effect of trunk flexibility cannot be accurately stated, and it should be further investigated.*

Keywords : *Aquatic exercise, trunk flexibility, lower back muscle strength.*

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ทวีศักดิ์ จรรยาเจริญ, สุคนธรัตน์ สงวนรัมย์, ภัทราภรณ์ สารสุข, ภัทรวดี แก้วละมุล, ลักขณา มาทอ. ผลทันทีของการออกกำลังกายในน้ำต่อความอ่อนตัวและความแข็งแรงของกล้ามเนื้อหลังส่วนล่างในอาสาสมัครสุขภาพดี. จุฬาลงกรณ์เวชสาร 2555 ม.ค. – ก.พ.; 56(1): 51–60

บทนำ : *การออกกำลังกายในน้ำสามารถเพิ่มองศาการเคลื่อนไหวของข้อต่อต่าง ๆ ทำให้เคลื่อนไหวได้อย่างคล่องแคล่วมีความยืดหยุ่นสูง นอกจากนี้ยังไม่ทำให้เกิดการบาดเจ็บกล้ามเนื้อ เอ็น และข้อต่อ ซึ่งผลการศึกษาที่ผ่านมาจะเป็นการศึกษาผลของการออกกำลังกายในน้ำด้วยโปรแกรมระยะยาว และยังไม่มีงานวิจัยใดศึกษาผลทันทีของการออกกำลังกายในน้ำ*

วัตถุประสงค์ : *เพื่อศึกษาผลทันทีของการออกกำลังกายในน้ำต่อการเปลี่ยนแปลงของความอ่อนตัว ความแข็งแรงของกล้ามเนื้อหลังส่วนล่างของอาสาสมัครสุขภาพดี*

สถานที่ที่ทำการศึกษา : *คณะเทคนิคการแพทย์ มหาวิทยาลัยขอนแก่น*

รูปแบบการวิจัย : *การวิจัยเชิงทดลอง*

วิธีการศึกษา : *เป็นการศึกษาในคนไทยสุขภาพดีจำนวน 98 คน แบ่งเป็น 2 กลุ่ม ได้แก่ กลุ่มควบคุมหรือกลุ่มที่ไม่ได้ออกกำลังกายในน้ำจำนวน 49 คน กลุ่มทดลองหรือกลุ่มออกกำลังกายในน้ำจำนวน 49 คน โดยอาสาสมัครได้รับการวัดข้อมูลพื้นฐาน ความอ่อนตัวของร่างกาย ความแข็งแรงของกล้ามเนื้อหลังส่วนล่าง ขณะก่อนและหลังออกกำลังกายเป็นเวลา 60 นาที*

ผลการศึกษา : *ความอ่อนตัวของร่างกายของกลุ่มควบคุมก่อนและหลังสิ้นสุดโปรแกรมมีค่า 2.7 ± 9.2 และ 3.8 ± 8.8 เซนติเมตร (p = 0.061) และความแข็งแรงของกล้ามเนื้อหลังส่วนล่าง ก่อนและหลังสิ้นสุดโปรแกรมของกลุ่มควบคุมมีค่า 72.6 ± 26.2 และ 72.1 ± 24.4 กิโลกรัม (p = 0.318)*

ความอ่อนตัวของร่างกายของกลุ่มทดลองก่อนและหลังสิ้นสุดโปรแกรมมีค่า 3.4 ± 9.7 และ 5.5 ± 9.0 เซนติเมตร (p = 0.000) และความแข็งแรงของกล้ามเนื้อหลังส่วนล่าง ก่อนและหลังสิ้นสุดโปรแกรมของกลุ่มทดลองมีค่า 65.7 ± 20.3 และ 67.9 ± 22.1กิโลกรัม (p = 0.101)

วิจารณ์และสรุปผล : *การออกกำลังกายในน้ำมีแนวโน้มในการช่วยเพิ่มความอ่อนตัวของร่างกายแต่ไม่สามารถเพิ่มความแข็งแรงของกล้ามเนื้อหลังส่วนล่างได้ ซึ่งไม่สามารถบอกแน่ชัดเกี่ยวกับผลคงค้างของความอ่อนตัวของร่างกาย จึงเป็นแนวทางในการศึกษาต่อไปในอนาคต*

คำสำคัญ : *การออกกำลังกายในน้ำ, ความอ่อนตัวของร่างกาย, ความแข็งแรงของกล้ามเนื้อหลังส่วนล่าง.*

Our living requires activities through out the whole day, which vary from one person to another, depending on his or her living patterns and physical capacity to do the activities. Flexibility and muscle strength are two variables that may limit a person's physical ability to move and the nimbleness to conduct his or her daily activities.(1-3) The factors that cause reduction of flexibility include age, sex, living patterns, and each person's activities. The elderly usually experience lower flexibility than people of younger ages. When one gets older, their physical cells deteriorate.(3-5) Females are found to have more flexibility than males because of their physical structure, hip bones, and hormones.(2-4) The factors that most affect the flexibility are, however, the living patterns and the level of activities that can make the muscles and tendons around the joints become more flexible as the muscles are stretched while the angles of joints are increased. Muscle strength means the ability of muscle to contract. People with strong muscles will be able to conduct their daily activities well. The way to strengthen muscles is to practice by making the muscle work against resistance or weight.(3, 6-7)

Hence, flexibility and muscle strength are important elements behind our movements performed on various daily activities. A study of many research works indicates that aquatic exercise has a positive effect on the increase of flexibility and strength of muscles and joints. It can increase the efficiency of pulmonary function, heart and blood circulation just like other aerobic exercises.(8-10)

Colado JC *et al.*(1) conducted a study on the effect of exercise in water with resistant force on health and the strength of menopause women during a period of 24 weeks. They concluded that aquatic exercise can improve cardiovascular health and physical capacity of the subjects.

Ide MR *et al.*(2) compared the effects of aquatic exercise with no aquatic exercise on inspiratory muscle strength of 81 healthy elderly persons from the age of 60-65 years. The researchers concluded that aquatic respiratory exercise increased the strength of inspiratory muscles of healthy elderly. Still, both aquatic and non-aquatic exercises did not affect expiratory muscle strength.

Tsourlou T *et al.*(3) studied the effects of the 24-hour aquatic exercise on the muscle strength of 22 healthy female elderly women. The volunteers were divided into 2 groups; 12 in the experimental group, and 10 in the control. The results indicated that the experimental groups scored higher in leg muscle strength whereas their lean body mass reduced at 3.4%. There was no change recorded in the control group.

Wang TJ *et al.*(4) conducted a study on the impact of aquatic exercise on flexibility, strength and aerobic fitness in 38 patients with osteoarthritis of the hips or knee joints. The results showed that aquatic exercise assisted the increase of knee strength and aerobic fitness, but did not have any effect on the self-reported physical function and pain. It was concluded that their program did not affect pain. There was no difference found during weeks 6 and 12. It was noted that the sampling was done randomly, resulting in good distribution and impartiality in data collection. The intervention program was designed with detailed instructions and posts, and the variables to be recorded were clearly stated. Hence, their efficiency in data analysis was high. Nevertheless, limitations were found in in-and-out sample screening at the beginning, which was done based on disease, age, medication and aquatic exercise, and regularity of exercise.

There are many other studies on the impact of aquatic exercise on flexibility and strength that were carried out in the long term. Volunteers quoted in the literature were foreigners, who were normally different from Thai people in many aspects such as heredity, build, physiology, eating habits, daily life patterns, etc. There has not been any research on acute effects of aquatic exercise, which will be the present-day alternative for people who do not have time to work out. The researchers, therefore, hypothesize that aquatic exercise has acute effect on flexibility and strength in healthy volunteers.

Materials and Methods

Ninety-eight healthy subjects were divided into two groups: control and experimental. The average age of the women and men in the control or no aquatic exercise group (n = 49; 37 women, 12 men) was 20.5 ± 1.4 years old, whereas that of the subjects in experimental or aquatic exercise group (n = 49; 43 women, 6 men) was 21.8 ± 0.8 years old. Both groups had their baseline characteristics recorded, i.e. trunk flexibility and muscle strength of the lower back muscles before and immediately after the program was completed (60 minutes).

None of the subjects had previous history of surgery related to the cardiopulmonary system and musculoskeletal system as well as specific low back pain. They were refrained from any bronchodilator or medicine for at least 6 months prior to their participation. They did not have any respiratory diseases such as pneumonia, emphysema, infectious disease, fever or hypertension. No food or drink was allowed 1 hour before the test. The materials used in this study included a swimming pool, a_Dinamap 1846 SX for taking blood pressure and heart rate, a scale to measure weight and height, a stop watch for timing, a trunk flexometer for indicating back and hamstring flexibility (sit and reach) and a back-leg dynamometer for measuring back muscle strength with reference to the back-side muscles of the whole body.[9,10]

All subjects were informed about the nature and risks of the experimental procedures prior to participation in the study. The trial consisted of 60 minutes of exercise intervention. This study has been approved by the Human Studies Ethics Committee of Khon Kaen University, Khon Kaen it also conformed to the Declaration of Helsinki.

The study was designed as a randomized controlled trial in which subjects randomly received 60 minutes of aquatic exercise or no aquatic exercise by computerized random. Subjects were assessed immediately before and immediately after the completion of the program by researcher.

Subjects in the control group were given basic instruction on health education, stretching exercise on land, type of exercise similar to the aquatic exercise group and there was an immediate follow up after completing the 60-minute exercise.

The aquatic exercise group exercised for 60 minutes. Each session consisted of a 10-minute stretching and breathing control warm up in the pool, followed by a 40-minute aerobic training and a 10-minute cool down session undertaken at the end. These groups of subjects were also instructed by a physiotherapist in the hydrotherapy pool (water temperature was maintained at 28-31° Celsius, the standard leisure temperature use), with a maximum of 6 subjects per group.(1, 5, 9, 11-14) The detailed instructions of aquatic exercise program of Resende *et al.*(5) are as follows:

Phase I Warming up

Exercise 1: Neck flexion, extension, side flex and turn.

Exercise 2: Roll shoulders, roll forwards, backwards and shrug alternate shoulder.

Exercise 3: Let arms float on top of the water and stretch them from side to side.

Exercise 4: Holding on the float, turn round the feet from side to side-look around as you turn.

Exercise 5: Circle hips in both directions in the water.

Exercise 6: Facing the wall, hold onto the bar. With your feet touching the wall, let your hips drop away from the wall.

Exercise 7: Facing the wall, hold onto the bar; keep your hips close to the wall and let your upper body fall away from the wall.

Exercise 8: Holding onto the bar; stretch the triceps surae and iliopsoas muscles. Take a large step forward while maintaining the anterior knee in flexion, the posterior knee in extension, and feet in contact with the bottom of the pool.

Phase II Exercise program

Exercise 1: Holding onto a float, turn your body round from side to side. Progress by putting floats further into the water.

Exercise 2: Holding onto a float, push it down in front of you into the water.

Exercise 3: Holding onto two floats, push them down together or alternatively on either side of the body.

Exercise 4: Walking in circle hand in hand with sporadic changes of direction. Walking sideways, facing forwards and backwards, alternating the direction from clockwise to anticlockwise, three times in each kind of walk.

Exercise 5: Walking forwards, backwards and sideways.

Exercise 6: Walking with trunk rotation. Walking forwards moving hand to opposite knee in flexion alternately.

Exercise 7: Lying on the floats, press lower back into the water and hold for 10 seconds and then back to relax position.

Exercise 8: Lying on the floats, move your body against the water from side to side.

Exercise 9: Sitting on a stool, perform shoulder flexion and extension, while keeping the elbows in extension. Start with shoulder hyperextension and go until 90° flexion.

Exercise 10: Sitting on the stool, shoulder flexion at 90°, extend elbows. Start in adduction and go until 90° of horizontal adduction.

Exercise 11: Sitting on the stool, cycle legs forwards and backwards.

Exercise 12: Sitting on the stool, pump ankles.

Phase III: Cooling down (similar to the warm-up phase)

The experimental results included trunk flexibility and low back muscle strength before and immediately after the program was completed (60 minutes).

Statistical Analysis

The data were analyzed using SPSS for

Windows version 10. All data were expressed in mean ± SD. The baseline performances were compared by using the t-test for independent samples for the continuous variables. Student pair t-test was applied to compare the conditions before and after the intervention in each group. All outcome variables were normally distributed. A P-value of less than 0.05 was considered significant.

Results

There was no significant difference in anthropometric and baseline characteristics between the two groups (Table 1). The trunk flexibility (p = 0.061) (95%CI (-1.820) - (-0.425)) and low back muscle strength (p = 0.318) (95%CI (-1.766) - (2.868)) of subjects in the control group were not significantly different after the program (Table 2, 3).

In contrast, subjects in the experimental group had significantly increased the scores of trunk flexometer or trunk flexibility (p = 0.000) (95%CI (-3.153)-(-1.043) (Table 2). On the other hand, low back muscles strength (p = 0.101) (95%CI (-5.425) - (1.180)) was not significantly different after the program (Table 3).

Table 1. Anthropometric and baseline characteristics of subjects.

Data/Groups	Control group n = 49	Experimental group n = 49
Age (years)	20.5 ± 1.4	21.8 ± 0.8
Weight (kg)	58.1 ± 12.6	52.8 ± 6.9
Height (cm)	163.0 ± 6.9	160.1 ± 6.5
BMI	21.8 ± 4.1	20.6 ± 2.3
Percent body fat	30.3 ± 8.4	32.1 ± 6.0
SBP (mmHg)	116.1 ± 12.3	108.8 ± 8.9
DBP (mmHg)	71.5 ± 9.9	67.2 ± 7.7
HR (beat/minute)	87.2 ± 11.1	84.5 ± 10.8

Note: BMI = body mass index, SBP = systolic blood pressure, DBP = diastolic blood pressure, HR = heart rate
Values are mean ± SD, kg; kilogram, cm; centrimetre

Table 2. Trunk flexibility in control (n = 49) and experimental groups (n = 49).

Group/Data	Before (cm)	After (cm)	95%CI	p-value
Control	2.7 ± 9.2	3.8 ± 8.8	(-1.820) - (-0.425)	0.061
Experimental	3.4 ± 9.7	5.5 ± 9.0*#	(-3.153) - (-1.043)	0.000

Note: Values are mean ± SD, cm; centrimetre, 95% CI; 95% confidence interval of the difference
*Significant differences from corresponding before period (p<0.05)
#Significant differences from corresponding control group (p<0.05)

Table 3. Back strength in control (n = 49) and experimental groups (n = 49).

Group/Data	Before (kg)	After (kg)	95%CI	p-value
Control	72.6 ± 26.2	72.1 ± 24.4	(-1.766) - (2.868)	0.318
Experimental	65.7 ± 20.3	67.9 ± 22.1	(-5.425) - (1.180)	0.101

Note: Values are mean ± SD, cm; centrimetre, 95% CI; 95% confidence interval of the difference

Discussion

This study compared the changes of trunk flexibility and low back muscle strength before and immediately after 60 minutes of aquatic exercise program in healthy Thai subjects. The study was conducted in one large general practice in Thailand. One of the strengths of this feasibility study lies in the inclusion of all healthy Thai subjects and the use of the local swimming pool. The water temperature was similar to that in previous studies.[5-7, 9, 13, 15-17]

In the present study, after the aquatic exercise, the experimental group had significantly greater trunk flexibility than before the aquatic exercise program. Similarly, after the program, the experimental group had significantly greater trunk flexibility than the control group. This may be explained by the effects of warm water and the buoyancy of water that enable back muscle relaxation and promote good elasticity in the back muscles.[5-7, 9, 13, 15-16]

However, the physical function and strength of the low back muscles cannot be improved by aquatic exercise, and because of the short duration, the resistance of water and training program cannot affect the strength of the back muscles.

The aquatic exercise in the experimental group had more significant flexibility and muscle strength, compared to the control group. This may be due to the trunk and back muscles being more active during aquatic exercise, to maintain correct body position, resulting in more effectiveness. [1-2, 17-18]

Nevertheless, the duration of aquatic exercise was completed in 60 minutes, which can have an effect on the trunk flexibility. This is correlated to the study of Hettinga *et al* [18] in terms of higher quality evidence of the effectiveness of exercise type for people who would like to improve their trunk flexibility after at least 60 minutes duration of exercise.

In conclusion, aquatic exercise could increase trunk flexibility among the volunteers because of the warmth of water and the buoyancy which resulted in free movements. Although trunk flexibility increased significantly, it did not make any clinical significance. The strengths of lower back muscle, before and after the intervention, did not denote significant difference. Since this research emphasizes short-term effects, the strength of muscle could not be increased. It may be explained that aquatic exercise could increase trunk flexibility but not the strength of the lower back muscles. The retention effect of trunk flexibility cannot be accurately stated and should be further investigated.

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