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Effects of aquatic exercise on pulmonary function in healthy Thai subjects

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Background : *Aquatic exercise is an important exercise for people who want to be strong. The warmth and pressure of the water may further assist pain relief, swelling reduction, and ease the physical movement. However, in Thailand no researcher has studied the effects of aquatic exercise on pulmonary function.*

Objective : *This study is aimed to compare the forced vital capacity (FVC) and forced expiratory in one second (FEV_1) before (week 0), and immediately after the completion of the aquatic exercise program (week 6) in healthy Thai subjects.*

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

Design : *Experimental Study.*

Method : *Forty-four subjects were divided into two groups. The average age of the control group or no aquatic exercise (n = 22) was 43.1 ± 9.8 years of age, while that of the experimental group or aquatic exercise group (n = 22) was 46.1 ± 11.4 years. Both groups had their baseline characteristics, FVC and FEV_1 before (0 week) and immediately after aquatic exercise program was completed (6 weeks).*

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Results : *FVC of control group before and after were 1.9 ± 0.4 and 1.8 ± 0.4 liters and FEV_1 before and after were 1.5 ± 0.3 and 1.5 ± 0.2 liters, respectively. FVC and FEV_1 of the control group were insignificantly different, when the results of the before and immediately after program completion were compared. FVC of experimental group before and after were 1.9 ± 0.4 and 2.1 ± 0.3 liters and FEV_1 before and after were 1.5 ± 0.5 and 1.7 ± 0.5 liters, respectively. Nevertheless, after the program was completed, the experimental group had significantly greater FVC ($p = 0.025$) and FEV_1 ($p = 0.031$) than the corresponding control group. In addition, the results showed significant differences ($p = 0.039$; $p = 0.031$) in FVC and FEV_1 between before and after 6 weeks of aquatic exercise.*

Conclusion : *In conclusion, the results of this study imply effects of aquatic exercise on the improvement of lung capacity. Thus, it may be applied in individuals with restrictive pulmonary conditions. However, the study was conducted in normal subjects. Therefore, further study on effects of aquatic exercise in patients with restrictive pulmonary conditions is valuable. In addition, the study on effects of aquatic exercise on pulmonary function of different genders may expand the results of aquatic exercise.*

Keywords : *Aquatic exercise, pulmonary function, forced vital capacity, forced expiratory in one second.*

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บทนำ : *การออกกำลังกายในน้ำเป็นการออกกำลังกายที่สำคัญสำหรับผู้ที่ต้องการสร้างเสริมสุขภาพให้แข็งแรง ความอุ่นและแรงดันของน้ำจะช่วยลดความเจ็บปวด การบวมและทำให้การเคลื่อนไหวดีขึ้น แต่การศึกษาผลของการออกกำลังกายในน้ำต่อสมรรถภาพปอดนั้นยังไม่มีรายงานการวิจัยใด ๆ*

วัตถุประสงค์ : *งานวิจัยนี้ต้องการศึกษาเปรียบเทียบการเปลี่ยนแปลงค่าปริมาตรอากาศทั้งหมดขณะหายใจออกเร็วและแรงเต็มที่ และปริมาตรอากาศที่หายใจออกในช่วง 1 วินาทีแรกของการหายใจออกอย่างเร็วและแรงเต็มที่ ขณะก่อนและหลังการออกกำลังกายในน้ำ 6 สัปดาห์ในคนไทย*

สถานที่ที่ทำการศึกษา : *คณะเทคนิคการแพทย์ มหาวิทยาลัยขอนแก่น*

รูปแบบการวิจัย : *การวิจัยเชิงทดลอง*

วิธีการศึกษา : *เป็นการศึกษาในคนไทยสุขภาพดีจำนวน 44 คน แบ่งเป็น 2 กลุ่ม ได้แก่ กลุ่มควบคุมหรือกลุ่มที่ไม่ได้ออกกำลังกายในน้ำ จำนวน 22 คน อายุเฉลี่ย 43.1 $\pm$ 9.8 ปี และกลุ่มทดลองหรือกลุ่มออกกำลังกายในน้ำจำนวน 22 คน อายุเฉลี่ย 46.1 $\pm$ 11.4 ปี โดยอาสาสมัครทั้งหมดจะได้รับการวัดข้อมูลพื้นฐาน ปริมาตรอากาศทั้งหมดขณะหายใจออกเร็วและแรงเต็มที่ และปริมาตรอากาศที่หายใจออกในช่วง 1 วินาทีแรกของการหายใจออกอย่างเร็วและแรงเต็มที่ ขณะก่อนและหลังการออกกำลังกายในน้ำ 6 สัปดาห์*

ผลการศึกษา : *ปริมาตรอากาศทั้งหมดขณะหายใจออกเร็วและแรงเต็มที่ของกลุ่มควบคุมก่อนและหลังโปรแกรมมีค่า 1.9 $\pm$ 0.4 และ 1.8 $\pm$ 0.4 ลิตร และปริมาตรอากาศที่หายใจออกในช่วง 1 วินาทีแรกของการหายใจออกอย่างเร็วและแรงเต็มที่ก่อนและหลังโปรแกรม 1.5 $\pm$ 0.4 และ 1.8 $\pm$ 0.4 ลิตรตามลำดับ พบว่าปริมาตรอากาศทั้งหมดขณะหายใจออกเร็วและแรงเต็มที่และปริมาตรอากาศที่หายใจออกในช่วง 1 วินาทีแรกของการหายใจออกอย่างเร็วและแรงเต็มที่ของกลุ่มควบคุมไม่มี*

ความแตกต่างอย่างมีนัยสำคัญทางสถิติ ปริมาตรอากาศทั้งหมดขณะหายใจออกเร็วและแรงเต็มที่ ของกลุ่มทดลองก่อนและหลังโปรแกรมมีค่า 1.9 ± 0.4 และ 2.1 + 0.3 ลิตร และปริมาตรอากาศที่หายใจออกในช่วง 1 วินาทีแรกของการหายใจออกอย่างเร็วและแรงเต็มที่ก่อนและหลังโปรแกรม 1.5 ± 0.5 และ 1.7 ± 0.5 ลิตรตามลำดับ พบว่าขณะก่อนและหลังการออกกำลังกายในน้ำ 6 สัปดาห์มีความแตกต่างอย่างมีนัยสำคัญทางสถิติ (p = 0.039, p = 0.031) ตามลำดับ

วิจารณ์และสรุป : *ผลของการออกกำลังกายในน้ำสามารถเพิ่มสมรรถภาพปอดทั้งปริมาตรอากาศทั้งหมดขณะหายใจออกเร็วและแรงเต็มที่ และปริมาตรอากาศที่หายใจออกในช่วง 1 วินาทีแรกของการหายใจออกอย่างเร็วและแรงเต็มที่ ดังนั้นอาจบ่งบอกได้ว่าการออกกำลังกายในน้ำสามารถช่วยให้สมรรถภาพปอดของผู้ป่วยที่มีปัญหาภาวะการจำกัดปอดดีขึ้น อย่างไรก็ตาม การศึกษาครั้งนี้ทำการศึกษาในคนปกติ ดังนั้นในการศึกษาต่อไปในอนาคตยังคงต้องมีการศึกษาวิจัยในแง่ผลของการออกกำลังกายในน้ำในผู้ป่วยที่มีปัญหาภาวะการจำกัดปอด ตลอดจนศึกษาผลการออกกำลังกายในน้ำต่อสมรรถภาพปอดทั้งในเพศชายและเพศหญิงต่อไป*

คำสำคัญ : *การออกกำลังกายในน้ำ, สมรรถภาพปอด, ปริมาตรอากาศทั้งหมดขณะหายใจออกเร็วและแรงเต็มที่, ปริมาตรอากาศที่หายใจออกในช่วง 1 วินาทีแรกของการหายใจออกอย่างเร็วและแรงเต็มที่.*

Aquatic exercise is a term encompassing a range of therapeutic and exercise activities carried out in heated pools by a variety of providers. Aquatic exercise incorporates individual assessment, evidence-based practices, and clinical reasoning skills to devise treatment plans based on the principles of hydrostatics and hydrodynamics, and the physiological effects of immersion. Aquatic exercise offers several benefits over land-based physical therapy for people. Buoyancy reduces across-joints loading affected by pain and allows the performance of functional closed chain exercises which otherwise may be too difficult on land. Water turbulence can be used as a method of increasing resistance, and percentage of body weight borne across the lower limbs can be decreased or progressed in proportion to the depth of immersion. The warmth and pressure of the water may further assist pain relief, swelling reduction, and ease of physical movement. Weight bearing tactile and thermal stimulation as well as the initial effect of the movement can lead to relaxation.[1-5]

Hinman RS (2006)[6] studied the aquatic physical therapy for hip and knee osteoarthritis. They concluded that aquatic physical therapy can improve physical function strength, and quality of life. Assis MR *et al*. (2006)[7] demonstrated that aquatic exercise can reduce pain and encourage emotional improvement. Ide MR (2005)[8] studied the effects of aquatic versus non-aquatic respiratory exercise program on the respiratory muscle strength in healthy aged persons. They concluded that aquatic respiratory exercise can improve the respiratory muscle strength of a healthy person. Ariyoshi M *et al*. (1999)[9] studied the efficacy of aquatic exercises on patients with low back pain. They suggested that exercises in water may be one of the most useful modes of exercise for a patient with low back pain.

Although aquatic exercise is widely used in general practice, there are no studies related to pulmonary function. Thus, the purpose of this study is to compare the forced vital capacity (FVC) and forced expiratory in one second (FEV_1) before (week 0) and immediately after aquatic exercise program was completed (week 6) in healthy Thai subjects.

Materials and Methods

In total, 44 healthy Thai subjects were recruited and divided into 2 groups: the experimental and the control groups. The average age of the experimental group or aquatic exercise group (n = 22) was 46.1 ± 11.4 years old, whereas that of the control group or no aquatic exercise (n = 22) was 43.1 ± 9.8 years old. The baseline characteristic data from both groups were collected, i.e. FVC and FEV_1, before and immediately after the program was completed.

None of the subjects had previous history of surgery related to the cardiopulmonary system and musculoskeletal system. They were refrained from any bronchodilator or medicine for 6 months, prior to their participation in this study. They do not have any respiratory disease such as pneumonia, emphysema, fever nor hypertension. No food nor drink was allowed 1 hour before the test. Materials used in this study included a swimming pool, a spirometer (Minato 505) for measuring lung function, a Dinamap 1846 SX for measuring blood pressure and heart rate, a scale to measure weight and height, and a stop watch for time

record. [10]

The control group did not attend any of the aquatic exercise program. However, these subjects were given basic instruction on health education, and there was an immediate follow up after the completion in the 6th week.

The aquatic exercise group exercised for 60 minutes, 3 times a week for 6 weeks, following the 1998 American College of Sports Medicine guidelines. Each session consisted of a 10-minute stretching warm up, followed by a 40-minute aerobic training and a 10-minute relaxation session. These groups of subjects were also instructed by a physiotherapist in the hydrotherapy pool (water temperature at 28 - 31^{O}C), with a maximum of 6 subjects per group.[2,11-12]

The experiment activities include simulated running in the deep end of the pool aided by a floating device that maintained the head above water. The subjects were instructed to exercise in the following positions: 1) an upright position with supine maintained in a neutral position; 2) running in place; 3) shoulder abduction-adduction-flexion-extension movements, with alternately flexion and extension movements in elbow; 4) abduction-adduction-flexion and extension movements in fingers; 5) lower limbs in a bicycling action; 6) hip abduction-adduction-flexion and extension movements, with alternately flexion and extension movements in knee; 7) ankle dorsiflexion-plantarflexion-eversion and inversion.[7,13]

All subjects were informed about the nature and risks of the experimental procedures before their participation consent were obtained. Before each experiment, all subjects were interviewed according to a health questionnaire, while their baseline characteristics, anthropometric measurements, back flexibility, back muscle strength, pain scale, heart rate and blood pressure were measured. The trial consisted of a 6-week intervention period. Subjects were assessed immediately before and immediately after the completion of the program. This study has been approved by the Ethics Committee on Human Experimentation of Khon Kaen University, Khon Kaen, and it also conformed to the standards set by the Declaration of Helsinki.

The study was designed as a randomized controlled trial in which the subjects randomly received 6 weeks of aquatic exercise.

Statistical analysis

All data were expressed in mean ± SD. To compare all statistical parameters between groups, one way ANOVA was used. To detect the differences between parameters represented by a single measurement, paired t-test was used. A P-value of less than 0.05 was considered significant.

Results

There was no significant difference in anthropometric and baseline characteristics of both groups (Table 1). FVC of control group, before and after were 1.9 ± 0.4 and 1.8 ± 0.4 liters and FEV_1 before and after were 1.5 ± 0.3 and 1.5 ± 0.2 liters, respectively. FVC and FEV_1 of the control group were insignificantly different, when the results of the before and immediately after program completion were compared. FVC of experimental group, before and after were 1.9 ± 0.4 and 2.1 ± 0.3 liters and FEV_1 before and after were 1.5 ± 0.5 and 1.7 ± 0.5 liters, respectively.

Table 1. Anthropometric and baseline characteristics of subjects.

Data/Groups	Control group n = 22	Experimental group n = 22
Age (yr)	43.1 ± 9.8	46.1 ± 11.4
Height (cm)	155.2 ± 5.4	158.6 ± 4.6
Weight (kg)	56.5 ± 9.8	59.5 ± 7.6
BMI	23.9 ± 2.9	23.3 ± 1.5
Percent fat (%)	22.2 ± 4.6	23.3 ± 4.3
WHR	0.8 ± 0.1	0.8 ± 0.1
SBP (mmHg)	122.6 ± 18.5	119.2 ± 13.9
DBP (mmHg)	76.5 ± 10.1	79 ± 8.9
HR (beat/minute)	80.7 ± 10.7	78.8 ± 6.7

BMI = body mass index, WHR = Wait to hip ratio, SBP = systolic blood pressure, DBP = diastolic blood pressure, HR = heart rate, Values are mean ± SD

Nevertheless, after the program was completed, the experimental group had significantly greater FVC (p = 0.025) (95%CI 1.259 - 2.125) (Figure 1) and FEV_1 (p = 0.031) (95%CI 1.423 - 1.756) (Figure 2) than the corresponding control group.

Similarly, after aquatic exercise program was completed, the experimental group had significantly greater FVC (p = 0.039) (95%CI 1.633 - 2.124) (Figure 1) and FEV_1 (p = 0.031) (95%CI 1.411 - 1.754) (Figure 2) than the corresponding before the program.

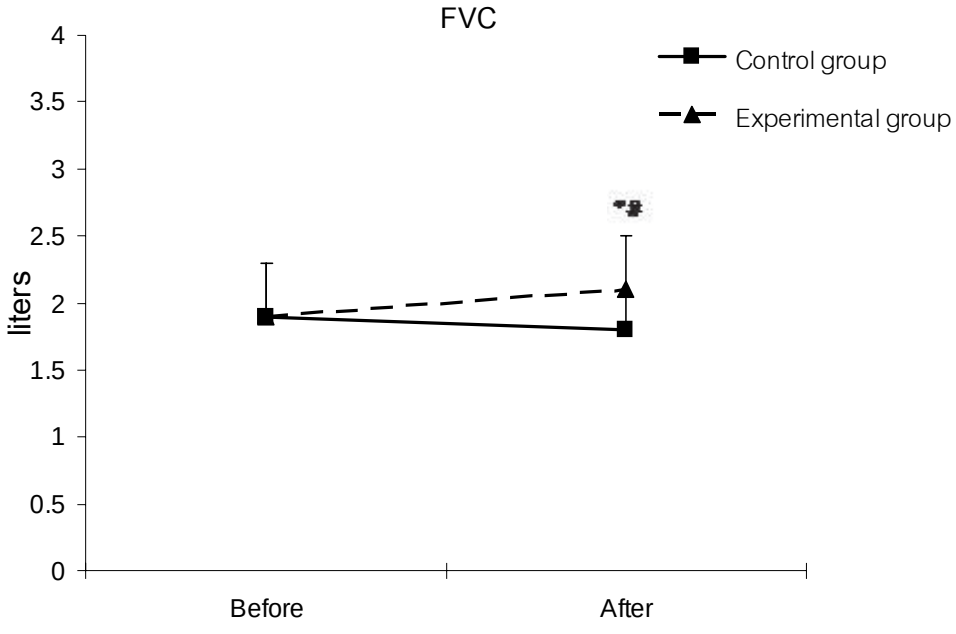

Figure 1. FVC in control (n = 22) and experimental groups (n = 22). Values are mean ± SD.
*Significantly different from corresponding before period (p <0.05)
#Significantly different from corresponding control group (p <0.05)

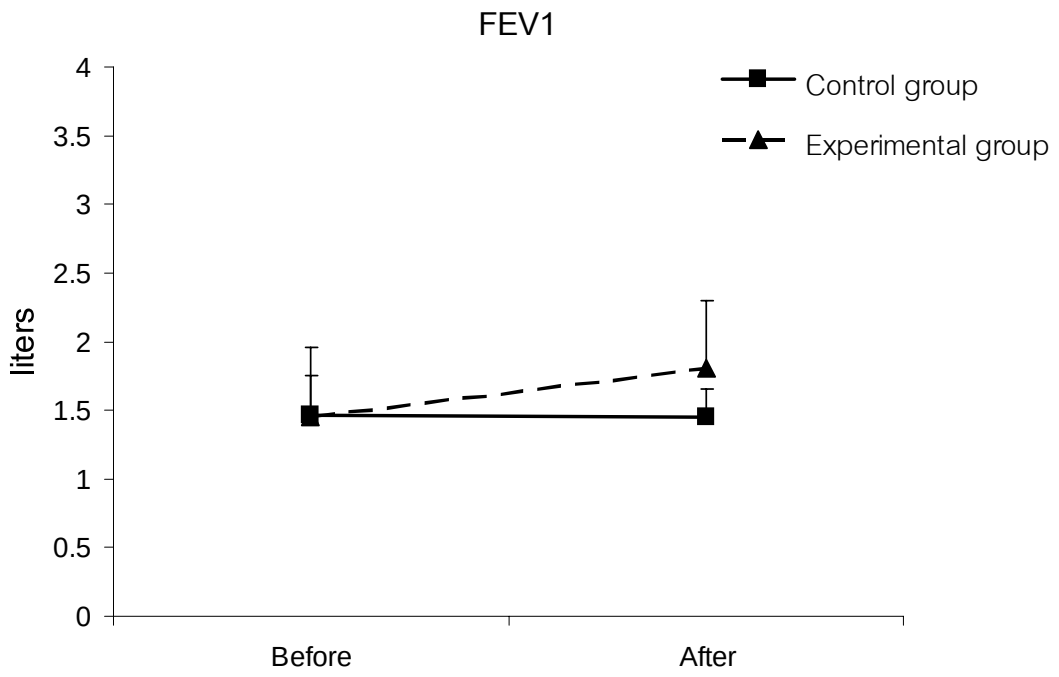

Figure 2. FEV_1 in control (n = 22) and experimental groups (n = 22). Values are mean ± SD.
FEV_1 = Forced expiratory volume in one second
*Significantly different from corresponding before period ($p < 0.05$)
#Significantly different from corresponding control group ($p < 0.05$)

Discussion

Aquatic exercise is a type of exercise which is safe for people who want to be healthy without any risk of injury.

This study compared FVC and FEV_1 before and immediately after the completion of aquatic exercise program in healthy Thai subjects. In this study, after the program was completed, the experimental group had significantly greater FVC and FEV_1 than the corresponding control group.

The long-term aquatic exercise can improve respiratory muscles strength. However, the type and pattern of the exercise in this study was designed to promote muscle endurance and strength. The water resistance can also encourage muscle work, particularly, the respiratory muscles.

The positions in the exercise in water promoted strength of the respiratory muscles during respiration. Finally, it can improve pulmonary function. The study showed that aquatic exercise has positive effects on pulmonary function of the subjects. We used a lower intensity exercise than the one used in the previous studies, but it is a continuous exercise, which can improve all muscles particularly, the respiratory muscles. Therefore, after the aquatic exercise program, FVC and FEV_1 was could be improved.[12 - 15]

Most experimental results showed improvements within six weeks, which is the minimal time compared to the previous studies due to the continuous exercise, position and type of exercise. We suggested that every program must consider

strategies to maintain the level of intensity and the continuous exercise pattern, in order to effectively influence the strength of respiratory muscle, which is the key to good pulmonary function where only a few researches had been conducted. However, aquatic exercise is a practical type of exercise for most individuals. Some individuals are limited to only simple physical tasks due to their disabilities, such as joint pain and arthritis, impeding their own weight bearing ability. Exercising in warm water is one of the beneficial programs for people or patients who would like to gain strength and maintain good health.

In conclusion, the results of this study imply effects of aquatic exercise on the improvement of lung capacity. Thus, it may be applied in individuals with restrictive pulmonary conditions. However, the study was conducted in normal subjects. Therefore, further study on effects of aquatic exercise in patients with restrictive pulmonary conditions is valuable. In addition, the study on effects of aquatic exercise on pulmonary function of different genders may expand the results of aquatic exercise.

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