

Effects of aquatic exercise on trunk flexibility, back muscle strength, and pain scale in chronic nonspecific low back pain patients

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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 and ease the physical movement of chronic low back pain patients.*

Objective : *This study is aimed to compare the change of trunk flexibility, back muscle strength and pain scale before (week 0) and immediately after aquatic exercise (week 6) in patients with chronic low back pain.*

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

Design : *Experimental research.*

Methodology : *The study was done on 48 subjects that were divided into two groups. The average age of the subjects in the experimental (n = 25) was 42.5 ± 3.5 years old, whereas that of the control group (n = 23) was 41.8 ± 2.6 years old. Subjects baseline characteristics as well as trunk flexibility, back muscle strength and pain scale were recorded before and immediately after the program.*

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- Results** : *The trunk flexibility, back muscle strength and VAS of the subjects in the control group were not significantly different after the program. In contrast, the subjects in the experimental group showed significantly increased of the scores of trunk flexibility ($p = 0.038$), and back muscle strength ($p = 0.045$). In addition, these abilities were significantly better than those of the control group ($p = 0.030$ for trunk flexibility and $p = 0.044$ for back muscle strength). On the contrary, the subjects in the control group had significantly greater VAS ($p = 0.031$) than that of the experimental group.*
- Conclusions** : *The results of this study imply effects of aquatic exercises on the improvement of trunk flexibility, back muscle strength and pain scale of patients with chronic low back pain.*
- Keywords** : *Aquatic exercise, Chronic low back pain, Muscle flexibility, Muscle strength, Pain scale.*

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ปรีดา อารยาวิชานนท์, จตุรัตน์ กนต์พิทยา. ผลของการออกกำลังกายในน้ำต่อความอ่อนตัว
ความแข็งแรงของกล้ามเนื้อหลังและระดับความปวดในผู้ป่วยปวดหลังเรื้อรัง. จุฬาลงกรณ์-
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- บทนำ** : การออกกำลังกายในน้ำเป็นการออกกำลังกายสำหรับผู้ที่ต้องการความ
แข็งแรง ความอ่อนและแรงดันของน้ำสามารถช่วยบรรเทาอาการปวด
และง่ายต่อการเคลื่อนไหวสำหรับผู้ป่วยปวดหลังเรื้อรัง ซึ่งผู้ป่วยกลุ่มนี้มี
วิธีการรักษาได้หลายรูปแบบนอกเหนือจากการรักษาด้วยยาแล้ว
การออกกำลังกายในน้ำเป็นอีกทางเลือกหนึ่งที่น่าสนใจนำมาใช้กับผู้ป่วย
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- รูปแบบการวิจัย** : การวิจัยเชิงทดลอง
- วิธีการศึกษา** : เป็นการศึกษาในผู้ป่วยปวดหลังเรื้อรังจำนวน 48 คน แบ่งเป็น 2 กลุ่ม
ได้แก่กลุ่มทดลองหรือกลุ่มออกกำลังกายในน้ำ จำนวน 25 คน อายุเฉลี่ย
 42.5 ± 3.5 ปี กลุ่มควบคุมหรือกลุ่มที่ไม่ได้ออกกำลังกายในน้ำ จำนวน
23 คน อายุเฉลี่ย 41.8 ± 2.6 ปี โดยอาสาสมัครทั้งหมดจะได้รับการวัด
ข้อมูลพื้นฐาน ความอ่อนตัว ความแข็งแรงของกล้ามเนื้อหลังและระดับ
ความเจ็บปวด ก่อนและหลังการออกกำลังกายในน้ำ 6 สัปดาห์
- ผลการศึกษา** : ความอ่อนตัว ความแข็งแรงของกล้ามเนื้อหลังและระดับความเจ็บปวด
ของกลุ่มควบคุมไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติเมื่อเสร็จสิ้น
โปรแกรม 6 สัปดาห์ ในทางตรงกันข้ามความอ่อนตัวและความแข็งแรง
ของกล้ามเนื้อหลังของกลุ่มทดลองก่อนและหลังสิ้นสุดโปรแกรมมีความ
แตกต่างอย่างมีนัยสำคัญทางสถิติ ($p = 0.038, 0.045$) ตามลำดับและ
เมื่อเปรียบเทียบตัวชี้วัดทั้งสองอย่างนี้พบว่า กลุ่มทดลองมีค่าความอ่อนตัว
ความแข็งแรงของกล้ามเนื้อหลังมากกว่ากลุ่มควบคุมอย่างมีนัยสำคัญ
ทางสถิติ ($p = 0.030, 0.044$) ตามลำดับ และอาสาสมัครในกลุ่มควบคุม
มีระดับความเจ็บปวดมากกว่ากลุ่มทดลองอย่างมีนัยสำคัญทางสถิติ
($p = 0.031$) ด้วยเช่นกัน

วิจารณ์และสรุปผล : การออกกำลังกายในน้ำ สามารถเพิ่มความอ่อนตัว ความแข็งแรงของกล้ามเนื้อหลังและลดระดับความเจ็บปวด ชะงักก่อนและหลังการออกกำลังกายในน้ำ 6 สัปดาห์ในผู้ป่วยปวดหลังเรื้อรังแก่อาสาสมัครได้

คำสำคัญ : การออกกำลังกายในน้ำ, ปวดหลังเรื้อรัง, ความอ่อนตัวของกล้ามเนื้อ, ความแข็งแรงของกล้ามเนื้อ, ระดับความปวด.

Chronic nonspecific low back pain (CNLBP) or common low back pain indicates that no precise structure has been identified causing the pain. CNLBP has become a major public health problem worldwide. This is the most common type of back pain. About 19 in 20 cases of acute (sudden onset) low back pain are classed as non-specific. This is the type of back pain that most people will have at some point in their life. It is called non-specific because it is usually not clear what is actually causing the pain. In other words, there is no specific problem or disease that can be identified as to the cause of the pain. The severity of the pain can vary from mild to severe.⁽¹⁾

CNLBP is prevalent, clinically complex, and imposes a huge financial burden on the patient and their families. Most patients are treated by primary care physicians or specialists. There are many factors causing CNLBP which can be decreased by several treatments. A major gap exists in the evidence for interventions that are currently recommended in clinical practice guidelines for the treatment of subacute low back pain.⁽¹⁾

Aquatic exercise is a term encompassing a range of therapeutic and exercise activities carried out in heated pools by a variety of providers.⁽²⁾ Aquatic exercise incorporates individual assessment, evidence-based practice, and clinical reasoning skills to devise treatment plans based on the principles of hydrostatics and hydrodynamics and the physiological effects of immersion.⁽³⁾ Effects of aquatic exercise offer several benefits compared to with land-based physical therapy for people with chronic low back pain.^(4,5) Buoyancy reduces across-joints loads 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 to increase resistance, and percentage of body weight borne across the lower limbs can be decreased or progressed in proportion to the depth of immersion. Furthermore, the warmth and pressure of the water may also reduce pain, swelling, and provide ease of movement. Weight bearing tactile and thermal stimulation as well as the initial effect of the movement can lead to relaxation.^(2, 3-5)

Aquatic exercise can reduce pain and encourage emotional improvement⁽⁶⁾ and can improve the respiratory muscle strength of a healthy person.⁽⁷⁾ Aquatic exercise may be one of the most useful modes of exercise for a patient with low back pain.⁽⁸⁾ At workloads sufficient to induce an aerobic training response, and yet safe for patients with CNLBP, rating of perceived exertion (RPE) is an accurate predictor of exercise intensity. At lower intensities, back and leg pain may exert a mediating influence.⁽⁹⁾

The variety offered, exercise that has a positive effect on patients with chronic low back pain, appears to be slightly effective in decreasing pain and improving function⁽¹⁰⁾, and results are largely maintained at the follow-up. Strengthening is a common component of exercise programs; However, the role of exercise co-interventions must not be overlooked. More high quality trials are needed to accurately assess the role of supervision and follow-up, together with the use of more appropriate outcome measures.⁽¹¹⁾

Although aquatic exercise is widely used in general practice, there are only a few studies related to CNLBP regarding flexibility, strength and pain scale of back. Thus, the purpose of this study was to

compare the change in trunk flexibility, back muscle strength and pain scale before (week 0) and immediately after aquatic exercise was completed (week 6) in CNLBP.

Methods

Forty-four subjects (42 women, 6 men) with CNLBP were divided into 2 groups. The average age of the subjects in the experimental or aquatic exercise group ($n = 25$; 23 women, 2 men) was 42.5 ± 3.5 years old, and that of the control group or non-aquatic exercise ($n = 23$; 19 women, 4 men) was 41.8 ± 2.6 years old. The baseline characteristics and outcomes of the study were collected before and immediately after the completion of the program, i.e. trunk flexibility, back muscle strength and pain scale.

None of the subjects had previous history of surgery relating to cardiopulmonary system and musculoskeletal system, as well as specific low back pain. They refrained from any bronchodilator or medicine for 6 months prior to their participation in this study. 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. Materials used in this study include a swimming pool, a Dinamap 1,846 SX for measuring blood pressure and heart rate, a scale to measure weight and height, a stop watch to record the time, a trunk flexometer for indicating back and hamstring flexibility (sit and reach)⁽¹²⁾ (Fig. 1), a back-leg dynamometer (Fig. 2) for measuring back muscle strength with reference to the back-side muscles of the whole body, and a visual analog scale (VAS) for measuring pain scale.⁽¹³⁾

All subjects were informed about the nature and risks of the experimental procedures prior to participation in the study. The trial consisted of a 6-week intervention period. This study has been approved by the Human Studies Ethics Committee 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 double blind randomized controlled trial in which subjects randomly received 6 weeks of aquatic exercise or no aquatic exercise. Subjects in both groups did not have some medicine, physiotherapy, acupuncture and others treatment.



Figure 1. Trunk flexometer for indicating back and hamstring flexibility (sit and reach).



Figure 2. Back-leg dynamometer for measuring back muscle strength.

Subjects in the control group were given basic instruction on health education, activity of daily living, 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 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 (Fig. 3). These groups of subjects were also instructed by physiotherapist in the hydrotherapy pool (the water temperature was at 28 - 31 degree Celcius, the standard leisure use temperature), with a maximum of 6 subjects per group.^(3,14-17) The detail instructions of aquatic exercise program Resende *et al*⁽¹⁵⁾ are as follows:

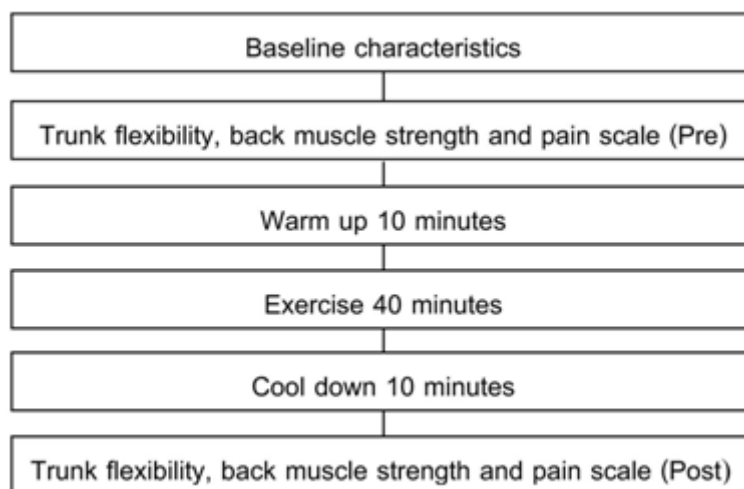


Figure 3. Methods of aquatic exercise group.

Phase I Warm up

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

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

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

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

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

Exercise 6: Facing the wall, holding onto the bar. With feet touching the wall, and letting hips drop away from the wall.

Exercise 7: Facing the wall, holding onto the bar, keeping hips close to the wall and then letting upper body fall away from the wall.

Exercise 8: Holding onto the bar, stretching the triceps surae and iliopsoas muscles; taking 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 the 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 the subject 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, followed by pressing lower back into the water and holding it for 10 seconds and then returning to relax position.

Exercise 8: Lying on the floats, move the 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, and pumping ankles.

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

The experimental results include trunk flexibility, back muscle strength and a VAS, graded from 0 to 10, with 0 being no pain and 10 being the worst imaginable pain.

Statistical Analysis

The data were analyzed using SPSS for Windows version 10. All data were expressed in means and SD. The baseline performances were compared by using the *t*-test for independent samples for the continuous variables. The one-way ANOVA was

applied to compare between the groups, with a between subject factor at 2 levels (the 2 groups). All outcome variables were normally distributed. A *P*-value of less than 0.05 was considered significant.

Results

There was no significant difference in the anthropometric and baseline characteristics between the groups (Table 1). The trunk flexibility, back muscle strength and VAS of subjects in the control group were not significantly different after the program (Table 2 - 4). In contrast, subjects in the experimental

group significantly increased the scores of trunk flexometer or trunk flexibility (*p* = 0.038) (95%CI 1.435 - 2.423), and the back muscle strength (*p* = 0.045) (95%CI 1.074 - 2.045). In addition, these abilities were significantly better than those of the control group (*p* = 0.030: 95%CI 1.349 - 2.012 for trunk flexibility and *p* = 0.044: 95%CI 1.449 - 1.945 for back muscle strength) (Table 2 - 3). On the contrary, after completing the program, the subjects in the control group had significantly more pain as measured by the VAS (*p* = 0.031) (95%CI (-1.572) -1.986) than that of the experimental group (Table 4).

Table 1. Anthropometric and baseline characteristics of subjects.

Data/Groups	Control group n = 23	Experimental group n = 25
Age (years)	41.8 ± 2.6	42.5 ± 3.5
Weight (kg)	60.1 ± 5.8	62.1 ± 7.1
Height (cm)	165.4 ± 4.3	164.3 ± 4.7
BMI	22.5 ± 5.2	24.1 ± 3.4
Percent body fat	31.1 ± 4.7	31.4 ± 5.2
SBP (mmHg)	108.4 ± 10.1	109.7 ± 6.3
DBP (mmHg)	74.2 ± 7.6	77.1 ± 3.7
HR (beat/minute)	89.4 ± 9.7	82.1 ± 9.1

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

Table 2. Trunk flexibility in control (n = 23) and experimental groups (n = 25).

Group/Data	Before (cm)	After (cm)	Difference	95%CI	p-value
Control	7.3 ± 1.2	7.1 ± 1.1	-0.2	(-3.153)-(-1.043)	0.241
Experimental	8.2 ± 1.6	11.2 ± 2.1 [#]	3.0	(1.435)-(2.423)	0.038

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 = 23) and experimental groups (n = 25).

Group/Data	Before (kg)	After (kg)	Difference	95%CI	p-value
Control	37.5 ± 7.9	35.5 ± 7.3	-2.0	(-5.425)-(1.180)	0.423
Experimental	37.9 ± 6.1	44.8 ± 3.2* [#]	6.9	(1.074)-(2.045)	0.045

Note: Values are mean ± SD, kg; kilogram, 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 4. VAS in control (n = 23) and experimental groups (n = 25).

Group/Data	Before	After	Difference	95%CI	p-value
Control	5.2 ± 1.3	5.2 ± 0.7	0	(-1.766)-(2.868)	0.318
Experimental	5.3 ± 1.0	3.2 ± 0.3* [#]	-1.9	(-1.572)-(1.986)	0.031

Note: Values are mean ± SD, VAS; Visual analog scale, 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)

Discussion

This study compared the changes of trunk flexibility, back muscle strength and pain scale before and immediately after 6-week aquatic exercise program in subjects with CNLBP. 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 patients with CNLBP and use of the local swimming pool. The water temperature is the same as in previous studies.^(9,15,16,18 - 21)

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 of the back muscles.^(9,18-21) The long-term aquatic exercise could improve the elasticity and strength of the back muscles while controlling a proper position without pain of patients with chronic low back pain.^(22, 23)

Furthermore, the aquatic exercise program also promoted significantly greater back muscle strength than before the aquatic exercise in the experimental group. Resistance of water and training program can improve the strength of the back muscles. In the present study, the exercise pattern was designed to increase muscle strength and endurance. We therefore conclude that physical function and back muscle strength can be improved by aquatic exercise, which is in accordance with the studies of Ariyoshi *et al.*⁽⁸⁾ and Colado *et al.*⁽⁴⁾

The aquatic exercise in the experimental group had significantly more flexibility and muscle strength, compared to the control group. This may be due to the trunk and back muscles being more active during the aquatic exercise to maintain correct body position, resulting in more effectiveness.^(4, 24, 25)

On the other hand, VAS of subjects in the experimental group was significantly decreased after the program. Reasons underlying pain reduction may be due to several aspects relating to effects of aquatic exercise. Back muscles strength is associated with back pain severity in chronic low back pain. Stronger back muscles can help controlling body position in all activities, and can reduce the compressive force in the back. Aquatic exercise can reduce joint and muscle overload. It can also promote muscle relaxation, and VAS of subjects after aquatic exercise was decreased, due to absence of muscles injuries. Thus, it is possible that improvements in back muscle strength were partially responsible for the improvements in CNLBP observed in the present study. Therefore, it can decrease pain scale after aquatic exercise program. The possible mechanism underlying the observed improvements in flexibility, strength, and pain, may be improved recruitment of motor units, muscle hypertrophy, pain alleviation, or reduced intervertebral joints inflammation. Previous studies showing non-significant improvements in pain or functional outcomes have prescribed very low intensity exercise with short training and assessment periods.^(21,24,26) Accordingly, the acute effects of aquatic exercise should be further examined.

Nevertheless, the duration of aquatic exercise was within 6 weeks, which can have an effect on all parameters. This correlates to the study of

Hettinga *et al*⁽²⁷⁾, i.e., higher quality evidence of the effectiveness of exercise interventions for CNLBP of at least 6 weeks duration. Therefore, the present study's exercise duration was also 6 weeks, which was different from Barker *et al*⁽⁹⁾, which can be applied for treatment in physiotherapy programs. Aquatic exercise training improved trunk and back muscles flexibility and strength, and at the same time, decreased pain in patients with CNLBP.

In conclusion, the present study results indicate that a 6-week aquatic exercise program helps to improve trunk flexibility, back muscle strength and decrease pain in patients with CNLBP.

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