นิพนธ์ต้นฉบับ • Original Article

ผลของการฝึกออกกำลังกายยูชิโกมิร่วมกับการเพิ่มน้ำหนักที่แขนและขาต่อสมรรถภาพปอด และความแข็งแรงของกล้ามเนื้อหายใจในนักกีฬายูโดไทย

ณัฐวุฒิ โพธิ์ศรีแก้ว[1], ธัญดา สุทธิธรรม[2], อรพิน ผาสุริยวงษ์[2], ปรเมษฐ์ วงษ์พุทธิชัย[3]
[1]หลักสูตรวิทยาศาสตร์การออกกำลังกายและการกีฬา บัณฑิตวิทยาลัย มหาวิทยาลัยขอนแก่น
[2]ภาควิชาสรีรวิทยา คณะแพทยศาสตร์ มหาวิทยาลัยขอนแก่น
[3]ภาควิชาพลศึกษา คณะครุศาสตร์ มหาวิทยาลัยราชภัฏเพชรบูรณ์

Effects of Uchikomi Exercise Training with Hand and Leg Weight Load on Pulmonary Function and Respiratory Muscle Strength in Thai Judo Athletes

Nattawut Posrikaew[1], Tunda Suttitum[2], Orapin Pasurivong[2], Phoramate Wongputthichai[3]
[1]Doctor of Philosophy Program in Exercise and Sport Sciences, Graduate School, Khon Kaen University
[2]Department of Philosophy, Faculty of Medicine, Khon Kaen University
[3]Department of Physical Education, Faculty of Education, Phetchabun Rajabhat University

หลักการและวัตถุประสงค์: การแข่งขันกีฬายูโดใช้ระยะเวลาสั้นๆ แต่นักกีฬาจำเป็นต้องมีความทนทานและแข็งแรง โดยเฉพาะการใช้ออกซิเจนเพื่อไม่ให้เกิดอาการอ่อนล้าได้ง่ายและรวดเร็วจนกว่าจะจบการแข่งขัน การหารูปแบบใหม่ของการฝึกซ้อมเพื่อพัฒนาสมรรถภาพปอดและความแข็งแรงของกล้ามเนื้อหายใจให้นักกีฬายูโดของไทยมีความสามารถยืนระยะได้ตลอดการแข่งขันจึงเป็นสิ่งสำคัญอย่างยิ่ง วัตถุประสงค์ของการศึกษานี้เพื่อศึกษาผลของการฝึกยูชิโกมิ (Uchikomi) ร่วมกับการเพิ่มน้ำหนักที่แขนและขา ต่อสมรรถภาพปอดและความแข็งแรงของกล้ามเนื้อหายใจในนักกีฬายูโดไทย

วิธีการศึกษา: กลุ่มตัวอย่างเป็นอาสาสมัครนักกีฬายูโดไทย จำนวน 35 ราย ทั้งเพศชายและหญิงอายุระหว่าง 15-25 ปี การคัดเลือกแบบสุ่มให้จัดเข้ากลุ่มควบคุม 17 ราย และกลุ่มฝึกยูชิโกมิร่วมกับการเพิ่มน้ำหนักที่แขนและขา 18 ราย ในกลุ่มควบคุมฝึกตามโปรแกรมยูโดแบบปกติ 5 วัน/สัปดาห์ ขณะที่กลุ่มฝึกยูชิโกมิทำการฝึกยูโดแบบปกติ 2 วัน / สัปดาห์ และฝึกตามโปรแกรมยูชิโกมิร่วมกับการเพิ่มน้ำหนักที่แขนและขาวันละ 50 นาที (อบอุ่นร่างกาย 10 นาที ฝึกยูชิโกมิร่วมกับการเพิ่มน้ำหนักที่แขนและขา 30 นาที ที่ระดับความหนักร้อยละ 60-80 ของอัตราการเต้นของหัวใจสูงสุด และคลายอุ่น 10 นาที) ฝึก 3 วัน/สัปดาห์ใช้ระยะเวลา 12 สัปดาห์ติดต่อกัน

Background and Objectives: In Judo competition, it uses a short time. But Judo athletes need to have endurance and strength especially in using oxygen consumption for protection their fatigue easily and quickly until it has finished the competition. It is the most necessary to find the new model of exercise training to develop pulmonary function and respiratory muscle strength for maintenance endurance competition in Thai Judo athletes. The aim of this study was to study effects of Uchikomi with hand and leg weight load program (UTP) on pulmonary function and respiratory muscle strength in Thai Judo athletes.

Methods: Thirty-five participants of both male and female Thai Judo athletes aged between 15-25 years old were randomly assigned into two groups; control group (CG; n= 17) and Uchikomi training group (UTG; n= 18). The CG subjects were practiced normal Judo training program (NJTP) 5 days / week, while the UTG subjects trained NJTP 2 days / week including with Uchikomi with hand and leg weight load program (UTP) 50 minutes/session (10 minutes warm up, 30 minutes UTP exercise 60-80% of HRmax, 10 minutes cool down) 3 days/week. Both groups were exercised in consecutive 12 weeks and investigated of baseline characteristics, anthropometry, pulmonary function both static lung volume and dynamic lung volume

และได้รับการประเมินลักษณะข้อมูลพื้นฐาน วัดสัดส่วนของร่างกาย ทดสอบสมรรถภาพปอด โดยวัดปริมาตรความจุปอด และอัตราการไหลของอากาศในปอด ทดสอบความแข็งแรงของกล้ามเนื้อหายใจโดยวัดปริมาตรการหายใจเข้าสูงสุดขณะหายใจปกติ (PImaxFRC) วัดอัตราการหายใจเข้าสูงสุด (PImaxRV) วัดอัตราการหายใจออกสูงสุด (PEmax) และวัดอัตราการหายใจเข้าสูงสุดโดยใช้จมูก (Pnsn) ในช่วงก่อนการฝึก (สัปดาห์ที่ 1) ระหว่างการฝึก (สัปดาห์ที่ 7) และหลังการฝึก (สัปดาห์ที่ 14) โดยทำการเปรียบเทียบภายในกลุ่ม และระหว่างกลุ่มของกลุ่มควบคุม และกลุ่มฝึกยูชิโกมิร่วมกับการเพิ่มน้ำหนักที่แขนและขา

ผลการศึกษา: พบว่า ข้อมูลพื้นฐานทางกายภาพและการวัดสัดส่วนของร่างกาย เปอร์เซ็นต์ร้อยละไขมันในร่างกาย, เส้นรอบเอว, เส้นรอบสะโพก และอัตราการเต้นของหัวใจ ในกลุ่มฝึกยูชิโกมิร่วมกับการเพิ่มน้ำหนักที่แขนและขา ลดลงอย่างมีนัยสำคัญทางสถิติ ในขณะที่กลุ่มควบคุมไม่พบความแตกต่างอย่างมีนัยสำคัญทางสถิติ ผลของการทดสอบสมรรถภาพปอดและความแข็งแรงของกล้ามเนื้อหายใจพบความแตกต่างที่เพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ ระหว่างสัปดาห์ที่ 1 เปรียบเทียบกับสัปดาห์ที่ 7 และ14, และ สัปดาห์ที่ 7 กับ 14 เมื่อเปรียบเทียบภายในกลุ่มฝึกยูชิโกมิ ในขณะที่กลุ่มควบคุมไม่พบความแตกต่างอย่างมีนัยสำคัญทางสถิติ

สรุป: การฝึกออกกำลังกายยูชิโกมิร่วมกับการเพิ่มน้ำหนักที่แขนและขาเป็นระยะเวลา 12 สัปดาห์ ติดต่อกัน มีผลเพิ่มสมรรถภาพปอด ทั้งปริมาตรความจุของปอด และอัตราการไหลของอากาศในปอด ตลอดจนเพิ่มความแข็งแรงของกล้ามเนื้อหายใจในนักกีฬายูโดไทย ดังนั้นโปรแกรมการฝึกออกกำลังกายยูชิโกมิร่วมกับการเพิ่มน้ำหนักที่แขนและขาจึงสามารถนำไปใช้เป็นการออกกำลังกายรูปแบบใหม่เพื่อพัฒนาสมรรถภาพทางกายในนักกีฬายูโดไทยได้

คำสำคัญ: นักกีฬายูโด, การฝึกออกกำลังกายยูชิโกมิ, สมรรถภาพปอด, ความแข็งแรงของกล้ามเนื้อหายใจ

and respiratory muscle strength test of maximal inspiratory pressure to exhale to function residual capacity (PImaxFRC), maximal inspiratory pressure to exhale to residual volume (PImaxRV), maximal expiratory pressure (PEmax) and stiff nasal inspiratory pressure (Pnsn) at pre-test period (week 1), mid-test period (week 7) and post-test period (week 14), consequently. All parameters were compared within and between groups of CG and UTG.

Results: The results of this study showed decrease significant difference in percentage of total body fat, waist circumference (WC), hip circumference (HC), and heart rate (HR) on data of baseline characteristics and anthropometry in UTG, comparison with no significant difference in CG. Parameters in pulmonary function test and respiratory muscle strength test (RMS) showed increase significant difference when they were compared between week 1 versus week 7 and 14 and week 7 versus week 14 within UTG. While, they showed no significant difference within CG.

Conclusions: Uchikomi exercise training with hand and leg weight load program (UTP) in consecutive 12 weeks can increase pulmonary function both static and dynamic lung volume and respiratory muscle strength in Thai Judo athletes. Therefore, this UTP can be used as a new exercise training model for improvement of physical performance especially in lung function and respiratory muscle strength in Thai Judo athletes.

Keywords: Thai Judo athletes, Uchikomi exercise training, lung function, respiratory muscle strength

ศรีนครินทร์เวชสาร 2561; 33(2): 136-44. • Srinagarind Med J 2018; 33(2): 136-44.

Introduction

Judo is a sport with its performance explanation is a complex task. It can be determined not only by several physical abilities, but also by technical, tactical and psychological aspects[1]. The main action desired by a Judoka during a Shiai (match in tournament) or Randori (sparring in which both participants practice attacking and defending) is the throwing of the opponent seeking scores that lead to winning[2]. In Judo competition, it uses a short time. But Judo athletes need to have endurance and strength especially in using oxygen consumption for protection their fatigue easily and quickly until it has finished the competition. During Judo competition, there exists some muscle fatigue of the athletes. This arises from inadequate practice of Judo athlete. It produces unpleasant results. Such situation drives the Judo athletes to demonstrate their abilities to hit the target, and the results are unsatisfied. Therefore, the researchers

are interested to establish a new training method by using Judo Uchikomi with hand and leg weight load program (UTP). Uchikomi technique repetition is a traditional exercise used by individual coach. It is particular throwing technique in Judo training for developing physical fitness. The practice of Uchikomi involves the application of throws to the culmination point. Instructors will typically have students perform the Uchikomi for a specified number of times prior to executing the total technique. Not much has been written on the subject of Uchikomi with regard to its benefits or lack thereof. This is probably due to the fact that the majority of the Judo community accepts the practice of Uchikomi as a beneficial adjunct to the development of the overall Judo skill. The common belief of the Judo community is simply that the practice of Uchikomi improves throwing skills[3].

However, in this study, the researchers invented the new model of Judo training by UTP. From the previous study, UTP athlete had never been used before in Judo athletes. It is the most necessary to find the new model of exercise training to develop physical performance especially pulmonary function and respiratory muscle strength in Thai Judo athletes. The aim of this study was to investigate the effect of UTP on pulmonary function and respiratory muscle strength in Thai Judo athletes.

Methodology

Study design and population

The design of this study was a quasi-experiment in human. Thirty-five Thai Judo athletes (both male and female) as healthy volunteer subjects were examined physical examination and complete the confidential health-screening questionnaire by a physician. Subjects aged between 15-25 years old with experience in Judo athletes at least 1 year and had participated in Judo competition. They were divided into two groups; control group (CG; n=17) and Uchikomi training group (UTG; n=18). The numbers of subjects were calculated according to previous study[4] and the calculation of sample size used the formula of nd = n/ (1-R); n = sample size calculated assuming no drop out, nd= sample size required with non-response, R= number of non-responses.

Study protocol

CG was trained normal Judo training program (NJTP) 50 minutes/session (10 minutes/warm up, 30 minutes training NJTP 60-80% of HRmax, 10 minutes cool down) for 5 days/week. UTG was trained normal Judo training 2 days/week including with Uchikomi with hand and leg weight load program (UTP) 50 minutes/session (10 minutes warm up, 30 minutes UTP exercise 60-80% of HRmax, 10 minutes cool down) 3 days/week. Both groups were practiced for consecutive 12 weeks.

Baseline characteristics, pulmonary function test and respiratory muscle strength test were investigated at pre-test period (week 1), mid-test period (week 7) and post-test period (week 14), consequently. Vejvichakan Building at faculty of Medicine, Khon Kaen university and Judo Gym Building at Rajaphat Phetchabun university were places to be done the experiment in this study.

Parameter measurement

Subjects were investigated baseline characteristics, anthropometry, pulmonary function and respiratory muscle strength (RMS) test. Pulmonary function was assessed both static lung volume and dynamic lung volume. Respiratory muscle strength test was investigated maximal inspiratory pressure to exhale to function residual capacity (PImaxFRC), maximal inspiratory pressure to exhale to residual volume (PImaxRV), maximal expiratory pressure (PEmax) and stiff nasal inspiratory pressure (Pnsn).

Ethic approval

A standard informed consent including purpose, risks and benefits of this study were explained to each participant. The written informed consent from the participants were obtained before testing. The method of this study had been reviewed and approved by the Research Ethical Committee of Khon Kaen University Thailand (Research number HE581236).

Statistical Analyses

Data were expressed as mean ± standard deviation (SD). The STATA version 12.0 statistical software license of the faculty of Medicine, Khon Kaen university were used to perform the statistical analysis.

Independent sample t-test was used to compare differences in characteristics of all parameters between CG and UTG groups. An independent sample t-test was used to compare between groups and repeated measures ANOVA was used to compare within group on pulmonary function test and respiratory muscle strength test (RMS). P-value less than 0.05 was considered to be statistical significance.

Results

Baseline characteristics of subjects

Data of baseline characteristics and anthropometry showed no significant difference in age, body weight, height, body mass index (BMI), percentage of total body fat, waist circumference (WC), hip circumference (HC), waist to hip ratio (WHR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP) and heart rate (HR), when they were compared between CG and UTG groups at pre-test period (week 1). Parameters of baseline characteristics and anthropometry showed no significant difference when they were compared within CG at pre-test period (week 1) versus mid-test period (week 7) and post-test period (week 14), mid-test period (week 7) versus post-test period (week 14).

Comparative data of baseline characteristics and anthropometry within UTG group; Body weight (BW) and body mass index (BMI) decreased significant difference ($p<0.05$) from 62.56 ± 15.15 to 59.89 ± 13 kg (4.36 % difference) and 22.3 ± 4.06 to 21.39 ± 3.58 kg (4.16% difference), consequently, when they compared between week 1 and week 14 (Table 1). Percentage of total body fat showed decreased highly significant difference ($p<0.001$) at week 1 versus week 7 and 14, week 7 versus 14. Besides, WC showed decreased from 29.44 ± 4.08 to 28.89 ± 4.21 inches ($p<0.01$) and 29.44 ± 4.08 to 29.03 ± 4.1 inches ($p<0.05$) at week 1 versus 7 and 14, consequently. Data of WHR showed decrease significant difference ($p<0.05$) only at week 1 versus week 14 (Table 1).

Data of SBP, DBP and MAP showed decrease significant difference at $p<0.05$, $p<0.05$ and $p<0.01$ when they were compared at week 1 versus week 14, consequently. While, HR showed decrease highly significant difference ($p<0.001$) from 69 ± 5.85 to 65 ± 4.09 (beats/min) (5.97 % difference), from 69 ± 5.85 to 61 ± 4.58 (beats/min) (12.30 %) and from 65 ± 4.09 to 61 ± 4.58 (beats/min) (6.35 % difference) at week 1 versus 7 and 14, week 7 versus 14, consequently. Comparative data of HR between CG and UTG showed no significant difference at week 1, HR showed decrease high ($p<0.01$) and highly ($p<0.001$) from 72 ± 6.25 to 65 ± 4.09 (beats/min) (10.21 % d) at week 7 and from 70 ± 5.14 to 61 ± 4.58 (beats/min) (13.74 %) at week 14, consequently (Table 1).

Table 1 Comparative data of characteristics baseline and anthropometry within UTG group; (n= 18) at pre-test period (week 1), mid-test period (week 7) and post-test period (week 14).

Variables	Thai Judo athletes								
	Uchikomi training group (UTG; n =18)								
	Week 1	Week 7	% Difference	Week 1	Week 14	% Difference	Week 7	Week 14	% Difference
Age (years)	19.8 ± 1.26	19.8 ± 1.26	0	19.8 ± 1.26	19.8 ± 1.26	0	19.8 ± 1.26	19.8 ± 1.26	0
Body weight (kg)	62.56 ± 15.15	61.78 ± 13.62	-1.25	62.56 ± 15.15	59.89 ± 13.14 [a]	-4.36	61.78 ± 13.62	59.89 ± 13.14	-3.10
Height (cm)	167 ± 0.08	167 ± 0.08	0	167 ± 0.08	167 ± 0.08	0	167 ± 0.08	167 ± 0.08	0
BMI (kg/m^2)	22.3 ± 4.06	22.07 ± 3.67	+1.36	22.3 ± 4.06	21.39 ± 3.58[a]	-4.16	22.07 ± 3.67	21.39 ± 3.58	-3.12
Total body fat (%)	14.22 ± 3.71	11.62 ± 3.67.28[aaa]	-20.12	14.22 ± 3.71	9.52 ± 3.67 [aaa]	-39.59	11.62 ± 3.67.28	9.52 ± 3.67 [bbb]	-19.86
WC (Inch)	29.44 ± 4.08	28.89 ± 4.21 [aa]	-1.89	29.44 ± 4.08	29.03 ± 4.1 [a]	-1.40	28.89 ± 4.21	29.03 ± 4.1	+0.48
HC (Inch)	34.61 ± 3.5	33.61 ± 3.66 [aaa]	-2.93	34.61 ± 3.5	33.75 ± 3.66 [aa]	+2.51	33.61 ± 3.66	33.75 ± 3.66	+0.42
WHR	0.85 ± 0.05	0.86 ± 0.05	+1.17	0.85 ± 0.05	0.86 ± 0.06 [a]	+1.17	0.86 ± 0.05	0.86 ± 0.06	0
SBP (mmHg)	121 ± 5.6	120.39 ± 5.66	-0.83	121 ± 5.6	119.83 ± 4.19 [a]	-1.66	120.39 ± 5.66	119.83 ± 4.19	-0.84
DBP (mmHg)	78 ± 6.86	76 ± 5.32	-2.60	78 ± 6.86	76 ± 4.31 [a]	-2.60	76 ± 5.32	76 ± 4.31	0
MAP (mmHg)	92 ± 5.53	91 ± 4.39	-1.09	92 ± 5.53	90 ± 3.25 [aa]	+2.2	91 ± 4.39	90 ± 3.25	-1.10
HR (beats/min)	69 ± 5.85	65 ± 4.09 [aaa]	-5.97	69 ± 5.85	61 ± 4.58 [aaa]	-12.30	65 ± 4.09	61 ± 4.58 [bbb]	-6.35

Data were presented as mean ± SD. Body mass index (BMI), waist circumference (WC), hip circumference (HC), waist to hip ratio (WHR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP) and heart rate (HR). All data were tested by repeated measures ANOVA.

[a], [aa], [aaa] Significant difference at $p<0.05$, $p<0.01$, $p<0.001$ at week 1 versus week 7 and 14.

[bbb] Significant difference at $p<0.001$ at week 7 versus week 14.

Pulmonary function test

In this study, pulmonary function test were assessed both static lung volume and dynamic lung volume. Parameters of pulmonary function such as tidal volume (TV), inspiratory reserve volume (IRV), expiratory reserve volume (ERV), vital capacity (VC), inspiratory capacity (IC), Force vital capacity (FVC), Force expiratory volume in the first second (FEV_1) and ratio of FEV_1/FVC were compared within CG and UTG groups at pre-test period (week 1), mid-test period (week 7) and post-test period (week 14). Results of pulmonary function showed no significant difference within CG group at week 1 versus week 7 and week 14 (Table 2). While, data of pulmonary function test within UTG group increased highly significant difference ($p<0.001$) of VC with 2.47 %, 4.89 % and 2.41 % difference, TV with 10.26 %, 20.06 % and 9.86 % difference, ERV with 12.01 %, 22.07 % and 10.13 % difference, IRV with 9.82 %, 19.27 % and 9.47 % difference and IC with 2.50 %, 4.94 % and 2.44 % difference, at week 1 versus week 7 and 14, week 7 and 14, consequently. In regard to data of dynamic lung volume they showed increase significant difference of FEV_1 with 4.89 %, 9.52 % and 4.65 % difference, and FVC with 4.52 %, 8.58 % and 4.07 % difference, at week 1 versus week 7 and 14, week 7 and 14, consequently (Table 3). Besides, comparative data of pulmonary function test were also assessed between CG and UTG groups at week 1, week 7 and week 14. They show increase significant difference of TV, IRV, ERV, VC, VC (% pred) and FEV_1/FVC at week 14. However, only data of TV and TRV showed increased significant difference at week 7 (Table 4).

Table 2 Comparative data of pulmonary function test within control group (CG; n= 17) at pre-test period (week 1), mid-test period (week 7) and post-test period (week 14).

Variables	Thai Judo athletes								
	Control group (CG; n =17)								
	Week 1	Week 7	% Difference	Week 1	Week 14	% Difference	Week 7	Week 14	% Difference
VC (L)	3.57 ± 0.44	3.39 ± 0.61	-5.17	3.57 ± 0.44	3.45 ± 0.35	-3.42	3.39 ± 0.61	3.45 ± 0.35	+1.75
VC (%pred)	94.29 ± 10.81	92.18 ± 9.91	-2.26	94.29 ± 10.81	92.35 ± 10.28	-2.08	92.18 ± 9.91	92.35 ± 10.28	+0.18
FVC (L)	3.79 ± 0.45	3.61 ± 0.61	-4.86	3.79 ± 0.45	3.67 ± 0.37	-3.22	3.61 ± 0.61	3.67 ± 0.37	+1.65
FVC (%pred)	97.29 ± 10.81	95.18 ± 9.91	-2.19	97.29 ± 10.81	95.35 ± 10.28	-2.01	95.18 ± 9.91	95.35 ± 10.28	+0.18
FEV_1 (L)	3.28 ± 0.41	3.12 ± 0.61	-5	3.28 ± 0.41	3.19 ± 0.35	-2.78	3.12 ± 0.61	3.19 ± 0.35	+2.22
FEV_1 (%pred)	100.59 ± 10.79	98.47 ± 9.92	-2.13	100.59 ± 10.79	99.06 ± 10.48	-1.53	98.47 ± 9.92	99.06 ± 10.48	+0.6
FEV_1/FVC (L)	0.88 ± 0.06	0.88 ± 0.24	0	0.88 ± 0.06	0.88 ± 0.09	0	0.88 ± 0.24	0.88 ± 0.09	0
FEV_1/FVC (%pred)	98.53 ± 10.75	96.41 ± 9.8	-2.18	98.53 ± 10.75	96.59 ± 10.14	-1.98	96.41 ± 9.8	96.59 ± 10.14	+0.19
ERV (L)	1.38 ± 0.13	1.28 ± 0.24	-7.52	1.38 ± 0.13	1.28 ± 0.14	-7.52	1.28 ± 0.24	1.28 ± 0.14	0
ERV (%pred)	92.71 ± 10.96	90.41 ± 10.11	-2.51	92.71 ± 10.96	90.47 ± 10.45	-2.45	90.41 ± 10.11	90.47 ± 10.45	+0.07
IC (L)	2.4 ± 0.67	2.28 ± 0.62	-5.13	2.4 ± 0.67	2.31 ± 0.66	-3.82	2.28 ± 0.62	2.31 ± 0.66	+1.31
IC (%pred)	94.18 ± 9.65	93.35 ± 9.07	-0.89	94.18 ± 9.65	92.53 ± 9.29	-1.77	93.35 ± 9.07	92.53 ± 9.29	-0.88
TV (L)	1.45 ± 0.07	1.36 ± 0.23	-6.41	1.45 ± 0.07	1.35 ± 0.12	-7.14	1.36 ± 0.23	1.35 ± 0.12	-0.74
IRV (L)	1.33 ± 0.15	1.25 ± 0.26	-6.20	1.33 ± 0.15	1.23 ± 0.16	-7.81	1.25 ± 0.26	1.23 ± 0.16	-1.61

Table 3 Comparative data of pulmonary function test within Uchikomi training group (UTG; n= 18) at pre-test period (week 1), mid-test period (week 7) and post-test period (week 14).

Variables	Thai Judo athletes								
	Uchikomi training group (UTG; n= 18)								
	Week 1	Week 7	% Difference	Week 1	Week 14	% Difference	Week 7	Week 14	% Difference
VC (L)	3.61 ± 0.79	3.77 ± 0.78^{aaa}	+4.34	3.61 ± 0.79	3.93 ± 0.78^{aaa}	+8.49	3.77 ± 0.78	3.93 ± 0.78^{bbb}	+4.16
VC (%pred)	95.44 ± 10.64	97.83 ± 10.56^{aaa}	+2.47	95.44 ± 10.64	100.22 ± 10.59^{aaa}	+4.89	97.83 ± 10.56	100.22 ± 10.59^{bbb}	+2.41
FVC (L)	3.68 ± 0.97	3.85 ± 0.97^{aaa}	+4.52	3.68 ± 0.97	4.01 ± 0.97^{aaa}	+8.58	3.85 ± 0.97	4.01 ± 0.97^{bbb}	+4.07
FVC (%pred)	97.83 ± 9.22	100.22 ± 8.88^{aaa}	+2.41	97.83 ± 9.22	102.61 ± 9.04^{aaa}	+2.80	100.22 ± 8.88	102.61 ± 9.04^{bbb}	+0.39
FEV_1 (L)	3.2 ± 0.99	3.36 ± 0.99^{aaa}	+4.89	3.2 ± 0.99	3.52 ± 0.99^{aaa}	+9.52	3.36 ± 0.99	3.52 ± 0.99^{bbb}	+4.65
FEV_1 (%pred)	98.06 ± 12.41	100.44 ± 12.52^{aaa}	+2.4	98.06 ± 12.41	102.83 ± 12.46^{aaa}	+4.75	100.44 ± 12.52	102.83 ± 12.46^{bbb}	+2.35
FEV_1/FVC (L)	0.86 ± 0.06	0.87 ± 0.07^{aa}	+1.15	0.86 ± 0.06	0.88 ± 0.06^{aaa}	+2.3	0.87 ± 0.07	0.88 ± 0.06^{b}	+1.14
FEV_1/FVC (%pred)	99.33 ± 8.24	101.72 ± 8.84^{aaa}	+2.38	99.33 ± 8.24	104.11 ± 8.53^{aaa}	+4.7	101.72 ± 8.84	104.11 ± 8.53^{bbb}	+2.32
ERV (L)	1.33 ± 0.56	1.5 ± 0.56^{aaa}	+12.01	1.33 ± 0.56	1.66 ± 0.56^{aaa}	+22.07	1.5 ± 0.56	1.66 ± 0.56^{bbb}	+10.13
ERV (%pred)	91.83 ± 10.75	94.22 ± 9.99^{aaa}	+2.57	91.83 ± 10.75	96.61 ± 10.59^{aaa}	+5.07	94.22 ± 9.99	96.61 ± 10.59^{bbb}	+2.50
IC (L)	2.48 ± 0.82	2.65 ± 0.82^{aaa}	+6.63	2.48 ± 0.82	2.81 ± 0.82^{aaa}	+12.48	2.65 ± 0.82	2.81 ± 0.82^{bbb}	+5.86
IC (%pred)	94.28 ± 10.95	96.67 ± 10.74^{aaa}	+2.50	94.28 ± 10.95	99.06 ± 10.84^{aaa}	+4.94	96.67 ± 10.74	99.06 ± 10.84^{bbb}	+2.44
TV (L)	1.48 ± 0.42	1.64 ± 0.42^{aaa}	+10.26	1.48 ± 0.42	1.81 ± 0.42^{aaa}	+20.06	1.64 ± 0.42	1.81 ± 0.42^{bbb}	+9.86
IRV (L)	1.55 ± 0.59	1.71 ± 0.59^{aaa}	+9.82	1.55 ± 0.59	1.88 ± 0.59^{aaa}	+19.27	1.71 ± 0.59	1.88 ± 0.59^{bbb}	+9.47

Data were presented as mean ± standard deviation (SD). VC; Vital Capacity, TV; Tidal Volume, FVC; Forced Vital Capacity, FEV_1; Forced Expiratory Volume in the first second, IRV; Inspiratory Reserve Volume, ERV; Expiratory Reserve Volume; IC; Inspiratory Capacity, % pred; % predicted value. All data were analyzed by using repeated measures ANOVA.

^{aaa} Highly significant difference at ($p<0.001$), at week 1 versus week 7 and 14.

^{bbb} Highly significant difference at ($p<0.001$), at week 7 versus week 14.

Table 4 Comparative data of pulmonary function test between control group (CG; n= 17) and Uchikomi training group (UTG; n= 18) at pre-test period (week 1), mid-test period (week 7) and post-test period (week 14).

Variables	Thai Judo athletes								
	Week 1			Weekk7			Week 14		
	CG	UTG	% Difference	CG	UTG	% Difference	CG	UTG	% Difference
VC (L)	3.57 ± 0.44	3.61 ± 0.79	+1.11	3.39 ± 0.61	3.77 ± 0.78	+10.61	3.45 ± 0.35	3.93 ± 0.78 [a]	+13
VC (%pred)	94.29 ± 10.81	95.44 ± 10.64	+1.21	92.18 ± 9.91	97.83 ± 10.56	+10.61	92.35 ± 10.28	100.22 ± 10.59[a]	+8.17
FVC (L)	3.79 ± 0.45	3.68 ± 0.97	-2.94	3.61 ± 0.61	3.85 ± 0.97	+6.43	3.67 ± 0.37	4.01 ± 0.97	+8.85
FVC (%pred)	97.29 ± 10.81	97.83 ± 9.22	+0.55	95.18 ± 9.91	100.22 ± 8.88	+5.16	95.35 ± 10.28	102.61 ± 9.04	+7.33
FEV_1 (L)	3.28 ± 0.41	3.2 ± 0.99	-2.47	3.12 ± 0.61	3.36 ± 0.99	+7.41	3.19 ± 0.35	3.52 ± 0.99	+9.83
FEV_1 (%pred)	100.59 ± 10.79	98.06 ± 12.41	-2.55	98.47 ± 9.92	100.44 ± 12.52	+1.98	99.06 ± 10.48	102.83 ± 12.46	+3.73
FEV_1/FVC (L)	0.88 ± 0.06	0.86 ± 0.06	-2.3	0.88 ± 0.24	0.87 ± 0.07	+1,14	0.88 ± 0.09	0.88 ± 0.06	0
FEV_1/FVC (%pred)	98.53 ± 10.75	99.33 ± 8.24	+0.81	96.41 ± 9.8	101.72 ± 8.84	+5.36	96.59 ± 10.14	104.11 ± 8.53[aa]	+7.49
ERV (L)	1.38 ± 0.13	1.33 ± 0.56	-3.69	1.28 ± 0.24	1.5 ± 0.56	+15.83	1.28 ± 0.14	1.66 ± 0.56 [aa]	+28.85
ERV (%pred)	92.71 ± 10.96	91.83 ± 10.75	-0.95	90.41 ± 10.11	94.22 ± 9.99	+4.13	90.47 ± 10.45	96.61 ± 10.59	+6.56
IC (L)	2.4 ± 0.67	2.48 ± 0.82	+3.28	2.28 ± 0.62	2.65 ± 0.82	+15.01	2.31 ± 0.66	2.81 ± 0.82 [a]	+19.53
IC (%pred)	94.18 ± 9.65	94.28 ± 10.95	+0.11	93.35 ± 9.07	96.67 ± 10.74	+3.49	92.53 ± 9.29	99.06 ± 10.84	+6.82
TV (L)	1.45 ± 0.07	1.48 ± 0.42	+2.05	1.36 ± 0.23	1.64 ± 0.42 [a]	+18.67	1.35 ± 0.12	1.81 ± 0.42 [aaa]	+29.11
IRV (L)	1.33 ± 0.15	1.55 ± 0.59	+15.28	1.25 ± 0.26	1.71 ± 0.59 [aa]	+31.08	1.23 ± 0.16	1.88 ± 0.59 [aaa]	+41.80

Data were presented as mean ± standard deviation (SD). VC; Vital Capacity, TV; Tidal Volume, FVC; Forced Vital Capacity, FEV_1; Forced Expiratory Volume in the first second, IRV; Inspiratory Reserve Volume, ERV; Expiratory Reserve Volume; IC; Inspiratory Capacity, % pred; % predicted value. All data were analyzed by independent sample t-test. Comparative between CG and UTG at week 1, week 7 and week 14.

[a, aa, aaa] Significant difference at $p<0.05$, $p<0.01$, $p<0.001$, consequently.

Respiratory muscle strength (RMS) test

Respiratory muscle strength (RMS) test and endurance is important as vital component of respiratory function. RMS assessed expiratory muscle strength (EMS) and inspiratory muscle strength (IMS) such as maximal inspiratory pressure to exhale to function residual capacity (PImaxFRC), maximal inspiratory pressure to exhale to residual volume (PImaxRV), maximal expiratory pressure (PE max) and stiff nasal inspiratory pressure (Pnsn) RMS showed no significant difference within CG group after 6 and 12 weeks with normal Judo training exercise (Table 5.1). While, PImaxFRC, PImaxRV, PEmax, Pnsn showed increase significant difference and increase percent of difference 13.99 %, 19.03 %, 14.14 % and 19.82 %, consequently within UTG group at week 1 versus 14. Besides, they showed increase significant difference at week 1 versus week 7 and 14 and week 7 versus week 14 (Table 5.2). However, those results showed increase in percent (%) of difference at week 14 more than week 7 when they were compared with week 1 in UTG group. All data were analyzed by repeated measures ANOVA.

All parameters of RMS were also assessed by comparison between CG and UTG group at week 1, 7 and 14. All data were tested by using independent sample t-test. They showed no significant difference at week 1, While, only PImaxFRC, PEmax and Pnsn showed increase significant differences in percent (%) of difference 13.53%, 10.98% and 17.34%, consequently at week 7. Beside, PImaxFRC, PImaxRV, PEmax, Pnsn showed increase significant difference in percent (%) of difference 12.79 %, 20.19 %, 14.71 % and 21.50 %, consequently at week 14 (Table 6). Thus, Uchikomi exercise training could improve respiratory muscle strength in progressively increasing exercise after 6 and 12 weeks in both male and female Thai Judo athletes.

Table 5.1 Comparative data of respiratory muscle strength test (RMS) within control group (CG; n= 17) at week 1, 7 and 14.

Variables	Thai Judo athletes								
	Control group (CG; n =17)								
	Week 1	Week 7	% Difference	Week 1	Week 14	% Difference	Week 7	Week 14	% Difference
PI max FRC ($cm.H_2o$)	108.47 ± 16.56	108.76 ± 16.47	+0.27	108.47 ± 16.56	109.53 ± 15.66	+0.97	108.76 ± 16.47	109.53 ± 15.66	+0.7
PI max RV ($cm.H_2o$)	113.53 ± 20.91	112.65 ± 20.43	-0.78	113.53 ± 20.91	114.59 ± 21.82	+0.93	112.65 ± 20.43	114.59 ± 21.82	+1.71
PE max ($cm.H_2o$)	118.29 ± 20.19	116.76 ± 20.52	-1.30	118.29 ± 20.19	118.76 ± 19.58	+0.4	116.76 ± 20.52	118.76 ± 19.58	+1.7
Pnsn (Snip) ($cm.H_2o$)	108.88 ± 21.51	107.76 ± 21.52	-1.03	108.88 ± 21.51	109.24 ± 21.13	+0.33	107.76 ± 21.52	109.24 ± 21.13	+1.36

Table 5.2 Comparative data of respiratory muscle strength test within Uchikomi training group (UTG; n= 18) at week 1, 7 and 14.

Variables	Thai Judo athletes								
	Uchikomi training group (UTG; n= 18)								
	Week 1	Week 7	% Difference	Week 1	Week 14	% Difference	Week 7	Week 14	% Difference
PI max FRC (cm.H_2o)	108.22 ± 15.46	117.72 ± 14.82^{aaa}	+8.41	108.22 ± 15.46	124.5 ± 12.44^{aaa}	+13.99	117.72 ± 14.82	124.5 ± 12.44^{bbb}	+5.6
PI max RV (cm.H_2o)	115.94 ± 20.36	129 ± 19.79^{aa}	+10.66	115.94 ± 20.36	140.33 ± 14.07^{aaa}	+19.03	129 ± 19.79	140.33 ± 14.07^{bb}	+8.41
PE max (cm.H_2o)	119.44 ± 19.24	130.33 ± 13.56^{aaa}	+8.72	119.44 ± 19.24	137.61 ± 13.97^{aaa}	+14.14	130.33 ± 13.56	137.61 ± 13.97^{b}	+5.43
Pnsn (Snip) (cm.H_2o)	111.11 ± 20.89	128.22 ± 14.91^{aaa}	+14.3	111.11 ± 20.89	135.56 ± 14.69^{aaa}	+19.82	128.22 ± 14.91	135.56 ± 14.69^{b}	+5.57

Data were presented as mean ± standard deviation (SD). PImaxFRC; Maximal inspiratory pressure to exhale to function residual capacity, PImaxRV; Maximal inspiratory pressure to exhale to residual volume, PEmax; Maximal expiratory pressure, Pnsn; Stiff nasal inspiratory pressure. All data were analyzed by repeated measures ANOVA.

^{aa},^{aaa} Significant difference at p<0.01, p<0.001, at week 1 versus 7 and 14, consequently.

^{b},^{bb},^{bbb} Significant difference at p<0.05, p<0.01, p<0.001, at week 7 versus 14, consequently.

Table 6 Comparative data of respiratory muscle strength test (RMS) between control group (CG; n= 17) and Uchikomi training group (UTG; n= 18) at pre-test period (week 1), mid-test period (week 7) and post-test period (week 14).

Variables	Thai Judo athletes								
	Week 1			Week 7			Week 14		
	CG	UTG	% Difference	CG	UTG	% Difference	CG	UTG	% Difference
PI max FRC (cm.H_2o)	108.47 ± 16.56	108.22 ± 15.46	-0.23	108.76 ± 16.47	117.72 ± 14.82	+7.91	109.53 ± 15.66	124.5 ± 12.44^{aa}	+12.79
PI max RV (cm.H_2o)	113.53 ± 20.91	115.94 ± 20.36	+2.10	112.65 ± 20.43	129 ± 19.79^{a}	+13.53	114.59 ± 21.82	140.33 ± 14.07^{aaa}	+20.19
PE max (cm.H_2o)	118.29 ± 20.19	119.44 ± 19.24	+0.97	116.76 ± 20.52	130.33 ± 13.56^{a}	+10.98	118.76 ± 19.58	137.61 ± 13.97^{aa}	+14.71

Data were presented as mean ± standard deviation (SD). PImaxFRC; Maximal inspiratory pressure to exhale to function residual capacity, PImaxRV; Maximal inspiratory pressure to exhale to residual volume, PEmax; Maximal expiratory pressure, Pnsn; Stiff nasal inspiratory pressure. All data were analyzed by independent sample t-test.

^{a},^{aa},^{aaa} Significant difference at p<0.05, p<0.01,p<0.001 at week 1, 7 and 14.

Discussion

Baseline characteristics and anthropometry

In this study, most of parameters in baseline characteristics and anthropometry such as body mass index (BMI), percentage of total body fat, waist circumference (WC), waist to hip ratio (WHR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP) and heart rate (HR) showed no significantly difference when they were compared between CG and UTG groups at pre-test period (week 1). While, the data of percentage of total body fat, WC and WHR blood pressure (BP) and HR showed decrease significant difference in UTG group after 12 weeks of UTP. They were co-confidence as the study of Marx et al.[5] and Chumvangvapee et al[6]. It was possible that they were showed decrease percentage of total body fat, waist circumference (WC), hip circumference (HC), and waist to hip ratio (WHR) due to the practice of continuous rotating the hips and waist. It could be built body muscle mass. In the similar study of post-exercise could change in blood pressure, heart rate and rate pressure product in endurance exercise and moderate intensity exercise.[7] They showed decrease in BP and HR due to regular and continuous exercise. It may be produce better physical health from stronger cardiovascular. Therefore, it was indicated that after 12 weeks of UTP could promote better baseline characteristics and anthropometry in Thai Judo athletes

Pulmonary function test following UTP

Pulmonary function test is a group of tests that it was measured breathing and how well the lungs are functioning. Spirometry measures airflow by measuring how much air exhale, and how quickly exhale, spirometry can evaluate a broad range of lung diseases. In a spirometry test, while you are sitting, you breathe into a mouthpiece that it is connected to an instrument called a spirometer. The spirometer records the amount and

the rate of air that you breathe in and out over a period of time. When standing, some numbers might be slightly different.[8] Judo is a dynamic, high-intensity, intermittent sport that requires complex skills and tactical excellence for success. A typical high-level Judo match lasts 3 minutes, with 20- to 30-second periods of activity and 5-10 seconds of interruption, while a significant portion of a match lasts 3-4 minutes[9] and it is very important to use lung capacity in the competition. From this study showed the increase in all parameters of pulmonary function in UTG group after Uchikomi training with hand and leg weight load program (UTP) in Judo athlete at week 7 and 14. It is co-confidence as the study of effects of endurance and resistance training on pulmonary function they found that results increased significantly on vital capacity (VC) and forced vital capacity (FVC) in resistance and endurance training group.[10] Moreover, effect of aerobic exercise and interval training can improved VC and IC in Women.[11] It is also co-confidence from the study of effects of high-intensity inspiratory muscle training in subjects who are healthy[12], they found that results increased on vital capacity (VC), total lung capacity, and exercise capacity at 8 weeks.

Respiratory muscle strength test after UTP

This study, we measured respiratory muscle strength (RMS) in expiratory and inspiratory muscle strength in Judo athletes, those parameters were measured the amount of air could inhale and exhale, as well the residual amount that remained in pulmonary. When respiratory volumes increased oxygen, they could deliver oxygen to cells more quickly. Thus presence of oxygen was more efficient in the body mechanism. In this study, we found that the results of in PImaxRV, PImaxFRC, PEmax and Pnsn were increased highly significant difference in Uchikomi training with hand and leg weight load program (UTP). Similarly respiratory muscle training could improve PImax FRC and strength of respiratory muscles by emphasizing trainings on specific muscles in university tennis players.[13] Therefore, moderate exercise could improve RMS. Studying periphery muscle strength through the peak torque of knee extensor, and RMS in 100 healthy subjects showed a positive correlation between both measures and the level physical activity, regardless of the subjects, sex and age.[14] According to this result, exercises might be recommended to improve RMS and respiratory muscle performance and aerobic capacity. It was corresponding the study of David et al.[15] Moreover, effect of inspiratory muscle training could improved both maximum inspiratory pressure and maximum expiratory pressure in basketball players.[16] In this study, subjects were exercised by using Uchikomi training with hand and leg weight load program (UTP) in UTG at moderate intensity (60-80% of HRmax) continuous 50 minutes. It might be possible that effective of respiratory mechanism could increase due to program training, it efficiency had enough to improve better healthy and physical fitness and RMS in Thai Judo athletes.

Conclusion

After 6 and 12 weeks of exercise training in Thai Judo athletes by using Uchikomi exercise training with hand and leg weight load program (UTP), it can improve baseline characteristics, anthropometry, pulmonary function test and respiratory muscle strength test in period of time in practice gradually. In regard to this Uchikomi exercise training program (UTP), it is the first study in Thai Judo athletes. Therefore, this knowledge and benefits of this study may be contributed to develop in research field of sport and exercise sciences. It may be applied to improve potentials in Thai Judo athletes.

Reference

1. Grzegorz Lech, Janusz Jaworski, Vladimir Lyakh, Robert Krawczyk. Effect of the level of coordinated motor abilities on performance in junior Judokas. J Hum Kinet 2011; 30: 153- 60.
2. Detanico D, Dal Pupo J, Franchini E, dos Santos SG. Relationship of aerobic and neuromuscular indexes with specific actions in Judo. Sci Sport 2012; 27: 16-22.
3. Elie A. Morrell, Hachidan. The Value of Uchikomi in the Development of Judo Skills. (online) 1995 June [cite June 9, 2017]. Available from: http://www.fightingart s.com/reading/article.php?id=729.

4. Franchini E, Takito MY, Bertuzzi RCM. Morphological, physiological and technical variables in high-level college Judoists. Arch Budo 2005; 1; 1-7.
5. Marx JO, Ratamess NA, Nindl BC, Gotshalk LA, Volek JS, Dohi K, et al. Low-volume circuit versus high-volume periodized resistance training in women. Med Sci Sport Exer 2001; 33: 635-43.
6. Chumvangvapee P, Suttitum T, Pasurivong O, Piwngern T. A new exercise model: Brisk walking with swaying hips and hand weight load exercise program and its effect on anthropometry, physical performance and cardiopulmonary function in obese Thai adults KKU Research Journal (Graduate Studies). 2016; 16: 63-74.
7. Pescatello LS, Franklin BA, Fagard R, Farquhar WB, Kelley GA, Ray CA; American College of Sports Medicine. American College of Sports Medicine position stand. Exercise and hypertension. Med Sci Sports Exerc 2004; 36: 533-53.
8. Gold WM, Koth LL. Pulmonary function testing. In: Broaddus VC, Mason RJ, Ernst JD, et al, editors. Murray and Nadel's Textbook of Respiratory Medicine. 6th ed. Philadelphia, PA: Elsevier Saunders; 2016: chap 25.
9. Degoutte F, Jouanel P, Filaire E. Energy demands during a Judo match and recovery. Brit J Sport Med 2003; 37: 245-9.
10. Maryam Khosravi, Seyed Morteza Tayebi, Hamed Safari. Single and concurrent effects of endurance and resistance training on pulmonary function. Iran J Basic Med Sci 2013; 16: 628-34.
11. Vahan Moradians, Alireza Rahimi, Seyed Ali Javad Moosavi. Effect of eight week aerobic, resistive, and interval exercise routines on respiratory parameters in non-athlete women. Tanaffos 2016; 15: 96-100.
12. Enright SJ, Unnithan VB, Heward C, Withnall L, Davies DH. Effect of high-intensity inspiratory muscle training on lung volumes, diaphragm thickness, and exercise capacity in subjects who are healthy. Phys Ther 2006; 86: 345-54.
13. Chung Yen WU, Ting Ya YANG, Pei Yi LO. Effects of respiratory muscle training on exercise performance in tennis players. Med Sport 2017; 70: 318-27.
14. Neder JA, Andreoni S, Peres C, Nery LE. Reference values for lung function tests: III. Carbon monoxide diffusing capacity (transfer factor). Braz j Med Biol Res 1999; 32: 729-37.
15. David A. Sonetti, Thomas J. Wetter, David F. Pegelow, Jerome A. Dempsey. Effects of respiratory muscle training versus placebo on endurance exercise performance Resp Physiol 2001; 127: 185-99.
16. Goosey Tolfrey V, Foden E, Perret C, Degens H. Effects of inspiratory muscle training on respiratory function and repetitive sprint performance in wheelchair basketball players. Br J Sports Med 2010; 44: 665-8.