นิพนธ์ต้นฉบับ • Original Article

ผลของการฝึกโปรแกรมพลัยโอเมตริกแบบประยุกต์ต่อความแข็งแรงและกำลังของกล้ามเนื้อในนักกีฬามวยไทยชาย

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The Effect of Applied Plyometric Training Program on Muscle Strength and Muscle Power in Male Thai Boxing Athletes

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หลักการและวัตถุประสงค์: ไทยบ๊อกซิ่งหรือมวยไทยเป็นศิลปวัฒธรรมการต่อสู้ประจำชาติไทย การชกมวยไทยจำเป็นต้องมีความแข็งแรง ความรวดเร็ว พลังแรงระเบิด และการเคลื่อนไหวที่มีประสิทธิภาพ ถึงจะประสบชัยชนะ การเสริมสร้างความแข็งแรงและพลังกล้ามเนื้อโดยวิธีการฝึกพลัยโอเมตริกในนักกีฬามวยไทยชายยังไม่มีผู้ใดทำการศึกษาวิจัยมาก่อน ดังนั้นวัตถุประสงค์ของการศึกษาครั้งนี้เพื่อศึกษาผลของการฝึกโปรแกรมพลัยโอเมตริกแบบประยุกต์ ต่อความแข็งแรงของกล้ามเนื้อและพลังกล้ามเนื้อในนักกีฬามวยไทยชาย

วิธีการศึกษา: อาสาสมัครนักกีฬามวยไทยชายจำนวน 33 ราย อายุระหว่าง 18 ถึง 25 ปี ถูกคัดเลือกแบบสุ่มให้เป็นกลุ่มควบคุม (16 ราย) และกลุ่มฝึกพลัยโอเมตริกแบบประยุกต์ (17 ราย) ในกลุ่มควบคุมจะถูกฝึกเฉพาะมวยไทยแบบปกติ 5 วัน/สัปดาห์ ขณะที่กลุ่มฝึกพลัยโอเมตริกแบบประยุกต์จะฝึกมวยไทยแบบปกติ 5 วันต่อสัปดาห์ ร่วมกับการฝึกโปรแกรมพลัยโอเมตริกแบบประยุกต์ 2 วันต่อสัปดาห์ 50 นาที /ครั้ง (10 นาที อบอุ่นร่างกาย 30 นาที ฝึกพลัยโอเมตริกแบบประยุกต์ ที่ระดับความหนักร้อยละ 85-100 ของอัตราการเต้นหัวใจสูงสุด 10 นาที คลายอุ่นกล้ามเนื้อ) ต่อเนื่องกันเป็นเวลา 12 สัปดาห์ อาสาสมัครจะถูกประเมินลักษณะพื้นฐาน การวัดขนาดของร่างกาย ความแข็งแรงของกล้ามเนื้อและพลังกล้ามเนื้อ ในการศึกษาครั้งนี้การทดสอบไอโซคิเนติกเป็น

Background and objective: Thai boxing or Muaythai is the cultural martial fighting art of Thailand. Thai boxing fight requires strength, speed, power explosive and powerful movements for an athlete to succeed. There is no study using plyometric training program for development of muscle strength and muscle power in male Thai boxing athletes. Therefore, the purpose of this study was to investigate the effect of applied plyometric training program on muscle strength and muscle power in male Thai boxing athletes.

Method: Thirty-Three participants of male Thai boxing athletes between the age of 18 to 25 years old were randomly assigned into two groups; control group (CG; n = 16) and applied plyometric training group (PTG; n = 17). The CG subjects were practiced normal Thai boxing training program (NTP) 5 days / week, add while the PTG subjects trained NTP 5 days / week with an applied plyometric exercise for 50 minutes / session (10 minutes warm up, 30 minutes applied plyometric exercise of 85-100 % HRmax and 10 minutes for cool down) 2 day/weeks continuously for 12 weeks. All subjects were investigated on their baseline characteristics, anthropometry, muscle strength and muscle power. In this study, isokinetic test was used to determine their muscle strength at speed 60° / sec and muscle power at speed 180° / sec in knee extension, shoulder abduction and elbow flexion (according

เครื่องมือซึ่งถูกใช้ในการประเมินความแข็งแรงของกล้ามเนื้อที่ความเร็ว 60 องศาต่อวินาที และ พลังกล้ามเนื้อที่ความเร็ว 180 องศาต่อวินาที ในท่าเหยียดเข่า (Knee extension) ท่ายืนกางแขน (Shoulder abduction) และท่างอข้อศอก (Elbow flexion) ในข้างที่ถนัด (ตามคู่มือของ Primus RS) เปรียบเทียบผลระหว่างกลุ่มควบคุมและกลุ่มฝึกพลัยโอเมตริก ก่อนการฝึก (สัปดาห์ที่ 1) ระหว่างการฝึก (สัปดาห์ที่ 7) และหลังการฝึก (สัปดาห์ที่ 14) ตามลำดับ

ผลการศึกษา: การประเมินลักษณะพื้นฐานในกลุ่มควบคุมและกลุ่มฝึกพลัยโอเมตริกแบบประยุกต์ แสดงผลไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติของ อายุ น้ำหนักตัว ดัชนีมวลกาย ความดันเลือดและอัตราการเต้นของหัวใจ ผลการทดสอบไอโซคิเนติกในกลุ่มควบคุมไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ในขณะที่ผลการศึกษากลุ่มฝึกพลัยโอเมตริกแบบประยุกต์แสดงผลเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ ผลการทดสอบไอโซคิเนติกมีการเพิ่มขึ้นในสัปดาห์ที่ 14 ดังนี้ ร้อยละ 20.17 และ 35.12 ของท่าเหยียดเข่า ร้อยละ 30.82 และ 40.36 ของท่ายืนกางแขน ร้อยละ 29.35 และ 39.17 ของท่างอข้อศอก ที่ความเร็วกล้ามเนื้อหดตัว 60 องศาต่อวินาที และความเร็วกล้ามเนื้อหดตัว 180 องศาต่อวินาที ตามลำดับ ในกลุ่มฝึกพลัยโอเมตริก

สรุป: หลังจาก 12 สัปดาห์ของการฝึกโปรแกรมพลัยโอเมตริกแบบประยุกต์ สามารถพัฒนาสมรรถภาพทางกาย ความแข็งแรงของกล้ามเนื้อ และพลังกล้ามเนื้อในนักกีฬามวยไทยชายได้ ดังนั้นการฝึกนี้อาจใช้เป็นโปรแกรมการออกกำลังกายรูปแบบใหม่ที่มีผลต่อการพัฒนาสมรรถภาพทางกาย ความแข็งแรงของกล้ามเนื้อและพลังกล้ามเนื้อในนักกีฬามวยไทยได้

คำสำคัญ: นักกีฬามวยไทยชาย โปรแกรมการฝึกพลัยโอเมตริกแบบประยุกต์ ความแข็งแรงของกล้ามเนื้อ พลังกล้ามเนื้อ

to Primus RS manual). Comparative analysis of isokinetic parameters were assessed at pre - test period (week 1), mid - test period (week 7) and post - test period (week 14), consequently.

Results: Baseline characteristics of CG and PTG groups showned no significant differences in age, body weight (BW), body mass index (BMI), blood pressure (BP) and heart rate (HR). Data of isokinetic test in CG shown no significant differences, while the PTG's data shown increase significant differences. Isokinetic test data in week 14 shown the increase of leg extension by 20.17 % and 35.12 %, of shoulder abduction by 30.82 % and 40.36 %, of elbow flexion by 29.35 % and 39.17 %, at speed Con 60° and Con 180°, consequently in PTG group.

Conclusion: Applied plyometric training program could improve physical performance, muscle strength and muscle power after significantly 12 weeks of exercise program in male Thai boxing athletes. This could be a new model of exercise training program on development of physical performance, muscle strength and muscle power for male Thai boxing athletes.

Keywords: Male Thai boxing athletes, Applied plyometric training program, Muscle strength, Muscle power

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Introduction

Plyometrics, also known as "jump training or plyos" is an exercise to be produced fast and powerful movement. It is trained as an exercise in which muscles exert maximum force in short intervals of time, with the goal of increasing power or speed - strength. This plyometric exercise involve improves on strength, elasticity and innervations of muscle surrounding tissues.[1] Plyometric exercise also uses explosive movement to develop muscle power, the ability to generate large amount of force quickly.[2] Thai boxing or Muaythai is the cultural martial art of Thailand for a long time. It requires strength, speed, explosive and powerful movements for athletes to succeed in their competition.[3] Isokinetic test was one method of maximum strength and power testing. Isokinetic test machine could control speed of movement while it was testing. As your torque changed, it produced the movement and the machine would adjust its resistance to keep the speed of movement.[4] This exercise is used in testing in many

researches on muscle strength and muscle power as a clinical research tool. It had high validity and reliability in assessment process. Therefore, isokinetic test was also used for investigating muscle strength and muscle power in this experiment. In this study, it assessed knee extension for quadriceps and most muscles used in kicking and knee striking. Shoulder abduction and elbow flexion used for assessed biceps and deltoid muscle in punching and elbow striking.

Methodology

Study design and population

The design of this study was a quasi-experiment in human. Thirty-three male Thai boxing athletes were divided randomly into control group (CG; n=16) and applied plyometric training group (PTG, n=17). All volunteered Thai boxing subjects were males, between the age of 18 to 25 with experiences at least 1 year in Thai boxing competition. They were healthy and received physical examination by a physician. Number of subjects were calculated according to a previous study[5] and the calculation of sample size uses the formula of nd = n / (1-R); n = sample size calculated assuming no drop out, nd= sample size required with non-response, R = a number of non-responses.

Study protocol

All subjects in CG and PTG groups trained normal program or routine Thai boxing training program (NTP) for five days per week continuously for 12 weeks (Table 1). While in PTG, the subjects practiced additional training of applied plyometric training program (PTP) 50 minutes/session (10 minutes warm up, 30 minutes applied plyometric exercise of 85-100 % HRmax and 10 minutes for cool down) 2 days / week in period of twelve weeks (Table 2). All subjects also maintained their normal lifestyles on their eating and working habits. Baseline characteristics were investigated at pre - test period (week 1) and post - test period (week 14), both in CG and PTG. All parameters of isokinetic test were assessed at pre - test period (week 1), mid - test period (week 7) and post - test period (week 14), consequently. This study was experimented at Vejvichakarn Building, faculty of Medicine, Khon Kaen university and Rajaphat Phetchabun university, Thailand.

Table 1 Schedule of normal Thai boxing training program in CG and PTG groups for five days / week

Monday	Tuesday	Wednesday	Thursday
- Warm up 10 min	- Warm up 10 min	- Warm up 10 min	- Warm up 10 min
- Shadow Thai boxing 5 min	- Shadow Thai boxing 5 min	- Recreation game 30 min	- Shadow Thai boxing 5 min
- Punch and kick sand bag 10 min	- Punch and kick pad 10 min	- Cool down 10 min	- Punch and kick pad 10 min
- Punch and kick pad 10 min	- Sparing Thai boxing 15 min		- Closed battle training 15 min
- Sit up 90 repetition	- Sit up 90 repetition		- Sit up 90 repetition
- Push up 60 repetition	- Push up 60 repetition		- Push up 60 repetition
- Cool down 10 min	- Cool down 10 min		- Cool down 10 min
Thursday	**Friday**	**Saturday**	**Sunday**
- Warm up 10 min	- Warm up 20 min	- Rest and Recovery	- Rest and Recovery
- Shadow Thai boxing 5 min	- Shadow Thai boxing 5 min		
- Punch and kick pad 10 min	- Punch and kick sand bag 10		
- Closed battle training 15 min	min		
- Sit up 90 repetition	- Sparing Thai boxing 15 min		
- Push up 60 repetition	- Sit up 90 repetition		
- Cool down 10 min	- Push up 60 repetition		
	- Cool down 10 min		

Table 2 Schedule of applied plyometric training program (PTP) in PTG group for two days / week

Day 1: Tuesday	Day 2: Thursday
- Warm up 10 minutes	- Warm up 10 minutes
- Applied plyometric training program 30 minutes	- Applied plyometric training program 30 minutes
1.1 Plyometric squat jump 3 sets x 8 - 10 reps	2.1 Lateral High Hops 3 sets x 8 - 10 reps
1.2 Over back toss 3 sets x 8 - 10 reps	2.2 Plyometric push up 3 sets x 8 - 10 reps
1.3 Lateral barrier jumps 3 sets x 8 - 10 reps	2.3 Zig zag jumps 3 sets x 8 - 10 reps
1.4 Side throws 3 sets x 8 - 10 reps	2.4 Slams 3 sets x 8 - 10 reps
- Cool down 10 minutes	- Cool down 10 minutes

Parameter measurement

Subjects were investigated on their baseline characteristics, anthropometry and physical performance. In this study, muscle strength and muscle power would be determined by using isokinetic machine (Primus RS, model: PR 30, BTE technology USA). Isokinetic strength test (IST) was measured by the maximal (Peak torque) concentric (CON) and eccentric (ECC) of knee extension, shoulder abduction and elbow flexion (followed Primus RS manual). The pivotal point of the lever was visually aligned with the rotation axis of the knee, shoulder and elbow joint to maintain appropriate position during all evaluation process. It was evaluated muscle strength at angular velocities 60 degree / second and muscle power at angular velocities 180 degree / second between the range of 0 and 90 degrees.[6] Each angular velocities were taken five times (2 minutes rest) and 3 minutes rest before starting the position and the highest value obtained was used for further analyses.

Ethical approval

A standard informed consent including purpose, risks and benefits of this study were explained to each participant. Written informed consent were obtained from all subjects, after full explanation. Ethical approval has been obtained from the Research Ethical Committee of the university of Khon Kaen, Thailand (Research number HE 581237).

Statistical analysis

Statistical analyses were performed using STATA 12.0 (Statistical software license of Faculty of Medicine, Khon Kaen University). Data were expressed as mean ± standard deviation (SD). Independent sample t - test was used to compare differences in characteristics of all parameters between control and applied plyometric exercise groups. An independent sample t - test was used to compare between groups and repeated measures ANOVA was used to compare within group of physical performance, muscle strength and muscle power. And p - value less than 0.05 was considered to be statistically significant.

Results

Baseline characteristics

Baseline characteristics of volunteer subjects in both CG and PTG are summarized in Table 3. They are no significant difference in parameter in both CG and PTG at pre - test period (week 1).

Table 3 Baseline characteristics and anthropometry in male Thai boxing subjects in control group (CG; n = 16) and applied plyometric training group (PTG; n = 17) at pre - test period (week 1)

Variables	Male Thai boxing subjects	
	CG (n=16)	PTG (n=17)
Age (years)	21.50 ± 1.10	21.24 ± 1.15
Body weight (kg)	60.91 ± 4.86	59.25 ± 7.35
Height (cm)	170.44 ± 4.97	170.06 ± 5.06
BMI (kg/m^2)	21.01 ± 20	20.43 ± 1.69
Total body fat (%)	14.07 ± 4.23	14.96 ± 5.51
WC (inch)	29.06 ± 1.86	29.41 ± 2.94
HC (inch)	35 ± 2.13	35.18 ± 2.43
WHR	0.83 ± 0.03	0.84 ± 0.05
SBP (mmHg)	122.44 ± 3.98	120.82 ± 6.89
DBP (mmHg)	79.31 ± 3.79	76 ± 7.14
MAP (mmHg)	93.31 ± 4.48	90.94 ± 6.04
HR (beats/min)	64.63 ± 6.81	64.12 ± 7.94

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), heart rate (HR). Data were tested by independent sample t - test.

Isokinetic Test

Isokinetic test was assessed for muscle strength and muscle power. It was done following in manual at speed 60° / second and 180° / second. Data of isokinetic test shown significant difference in CG at pre - test period (week 1), mid - test period (week 7) and post - test period (week 14) as shown in Table 4 and Figure 1. While, isokinetic data were shown significant difference in PTG as shown in Table 5 and Figure 1, 2 and 3. In PTG, it show high ($p<0.01$) and highly ($p<0.001$) significant difference between week 1 versus week 7 and week 14. Isokinetic test at post - test period (week 14) were shown the increase of leg extension by 20.17 % and 35.12 %, of shoulder abduction by 30.82 % and 40.36 %, of biceps flexion by 29.35 % and 39.17 %, consequently.

Table 4 Data of isokinetic test in CG group at pre - test period (week 1), mid - test period (week 7) and post - test period (week 14)

Position	Male Thai boxing subjects		
	CG (n=16)		
	Week 1	Week 7	Week 14
Knee extension (lbs)			
Con 60°	100.31 ± 13.42	101.56 ± 13.15	104.25 ± 12.10
Con 180°	83.13 ± 14.95	86.94 ± 16.01	85.75 ± 15.33
Ecc 60°	108.56 ± 14.65	109.56 ± 12.08	110.94 ± 11.29
Ecc 180°	106.75 ± 20.89	107.75 ± 20.68	110.38 ± 11.50
Shoulder abduction (lbs)			
Con 60°	28.75 ± 8.14	29.69 ± 6.09	29.63 ± 7.10
Con 180°	29.81 ± 8.87	32.13 ± 7.72	33.56 ± 8.63
Ecc 60°	36.94 ± 14.30	39.94 ± 12.87	37.63 ± 13.40
Ecc 180°	48.63 ± 27.14	53.63 ± 25.12	49.38 ± 25.72
Elbow flexion (lbs)			
Con 60°	34.31 ± 7.44	35.13 ± 5.46	34.26 ± 5.77
Con 180°	29.56 ± 8.89	30.63 ± 9.40	31.88 ± 9.32
Ecc 60°	43.44 ± 10.61	43.50 ± 9.25	43.00 ± 8.32
Ecc 180°	45.94 ± 14.74	49.13 ± 14.97	44.81 ± 13.70

Data were presented as mean ± SD. Con = concentric contraction, Ecc = eccentric contraction. All data were analyzed by repeated measures ANOVA.

No significant difference between week 1 versus week 7 and 14, week 7 versus week 14.

Table 5 Data of isokinetic test in PTG group at pre - test period (week 1), mid - test period (week 7) and post - test period (week 14)

Position	Male Thai boxing subjects		
	PTG (n=17)		
	Week 1	Week 7	Week 14
Knee extension (lbs)			
Con 60°	96.24 ± 12.51	105.59 ± 11.66 ^{aaa}	115.65 ± 7.84 $^{aaa\ bb}$
Con 180°	76.71 ± 19.97	96.82 ± 15.46 ^{aaa}	103.65 ± 14.45 ^{aaa}
Ecc 60°	110.06 ± 15.12	118.06 ± 12.70	123.82 ± 19.98 ^{aa}
Ecc 180°	107.82 ± 18.04	117.29 ± 10.67 ^{a}	122.82 ± 7.32 ^{aaa}
Shoulder abduction (lbs)			
Con 60°	24.82 ± 3.52	30.24 ± 5.80 ^{aaa}	32.47 ± 7.71 ^{aaa}
Con 180°	26.18 ± 4.25	30.71 ± 5.24 ^{aaa}	33.94 ± 6.09 ^{aaa}
Ecc 60°	34.41 ± 7.35	40.71 ± 8.99 ^{aa}	50.35 ± 11.95 $^{aaa\ bbb}$
Ecc 180°	42.53 ± 12.66	55.82 ± 17.81 ^{aaa}	70.47 ± 18.23 $^{aaa\ bbb}$
Elbow flexion (lbs)			
Con 60°	30.29 ± 5.47	34.47 ± 5.93 ^{a}	39.18 ± 6.30 $^{aaa\ b}$
Con 180°	26.12 ± 4.79	30.29 ± 8.12 ^{a}	36.35 ± 9.08 ^{aaa}
Ecc 60°	36.94 ± 8.35	42.76 ± 6.88 ^{aa}	45.18 ± 4.02 ^{aaa}
Ecc 180°	38.29 ± 8.84	44.06 ± 7.27 ^{aa}	46.47 ± 5.76 ^{aaa}

Data were presented as mean ± SD. Con = concentric contraction, Ecc = eccentric contraction. All data were analyzed by repeated measures ANOVA. Comparative data shown significant difference between week 1 versus week 7 and 14, week 7 versus week 14.

$^{a, aa, aaa}$ Significantly difference between week 1 versus week 7 and 14 at $p<0.05$, $p<0.01$ and $p<0.001$, consequently

$^{b, bb, bbb}$ Significantly difference between week 7 versus week 14 at $p<0.05$, $p<0.01$ and $p<0.001$, consequently

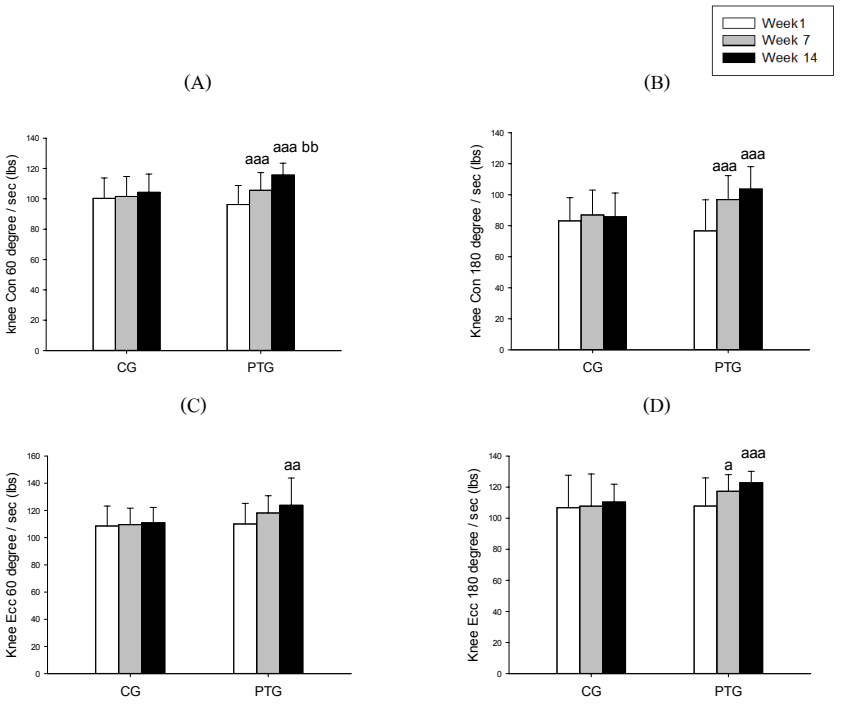

Figure 1 Data were presented as mean ± SD. (A) Knee concentric 60 degree / sec, (B) Knee concentric 180 degree / sec, (C) Knee eccentric 60 degree / sec, (D) Knee eccentric 180 degree / sec in control (CG) and applied plyometric training group (PTG) at week 1, 7 and week 14. All data were tested by repeated measures ANOVA.

$^{a, aa, aaa}$ Significantly difference between week 1 versus week 7 and week 14 at $p<0.05$, $p<0.01$ and $p<0.001$, consequently

^{bb} Significantly difference between week 7 versus week 14 at $p<0.01$

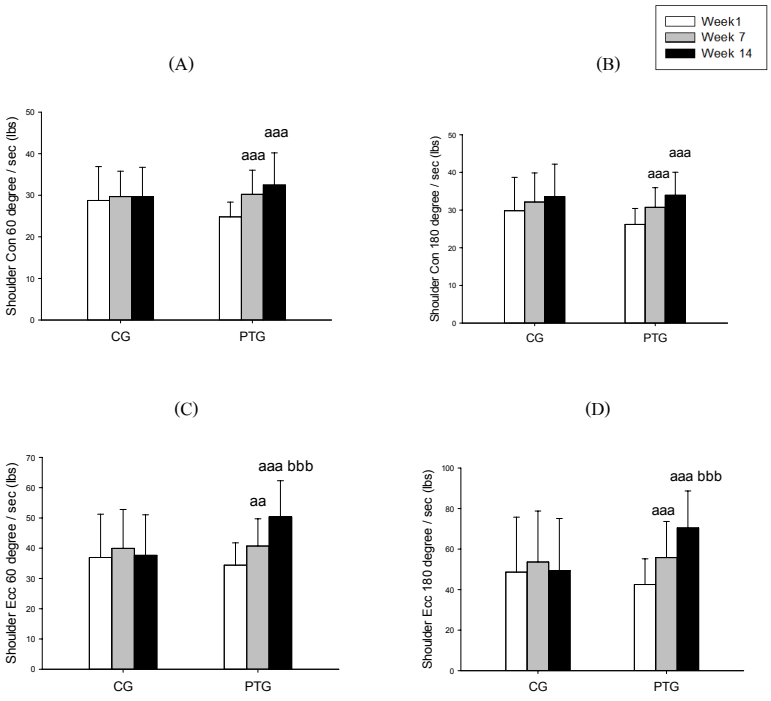

Figure 2 Data were presented as mean ± SD. (A) Shoulder concentric 60 degree / sec, (B) Shoulder concentric 180 degree / sec, (C) Shoulder eccentric 60 degree / sec, (D) Shoulder eccentric 180 degree / sec in control (CG) and applied plyometric training group (PTG) at week 1, 7 and week 14. All data were tested by repeated measures ANOVA.

[aa, aaa] Significantly difference between week 1 versus week 7 and 14 at $p<0.01$ and $p<0.001$, consequently

[bbb] Significantly difference between week 7 versus week 14 at $p<0.001$

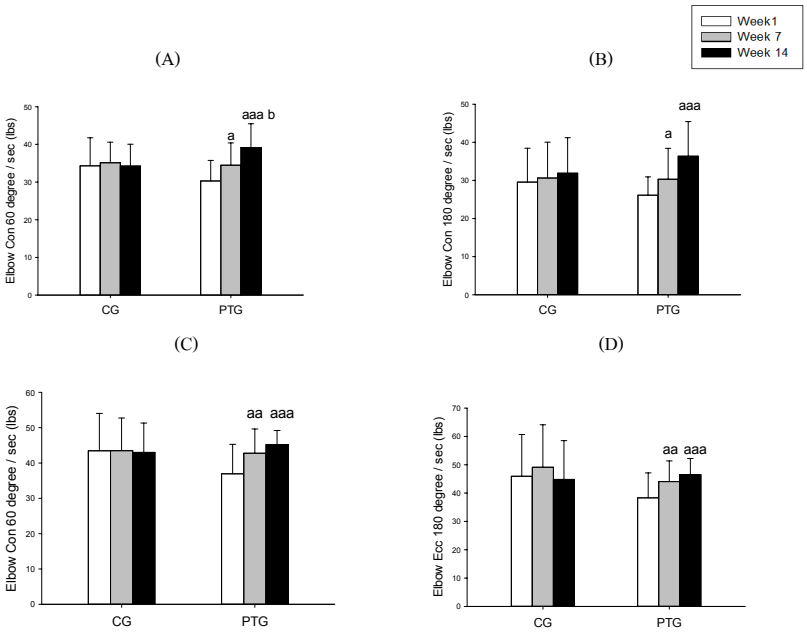

Figure 3 Data were presented as mean ± SD. (A) Elbow concentric 60 degree / sec, (B) Elbow concentric 180 degree / sec, (C) Elbow eccentric 60 degree / sec, (D) Elbow eccentric 180 degree / sec in control (CG) and applied plyometric training group (PTG) at week 1, 7 and week 14. All data were tested by repeated measures ANOVA.

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

[b] Significantly difference between week 7 versus week 14 at $p<0.05$

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) shown no significant difference when compared between CG and PTG groups at week 1 (pre - test period) and week 14 (post - test period). They were co-confidence as the study of Carey and Heathcock[7] and Goran and co worker.[8] Data of physical fitness test shown in the standard range of norm in Thai university athletes.[9]

Isokinetic test after applied plyometric training program

In this study researcher set up isokinetic machine test speed at 60 degree per second for testing muscle strength and 180 degree per second for testing muscle power in concentric and eccentric contraction test[6] on knee extension, shoulder abduction, elbow flexion. After Thai boxing athletes finished their training, the researcher found that PTP can increase all parameters in isokinetic test. There were increased in shoulder abduction in the range of 29.64 % to 65.69 %, elbow flexion in the range of 21.36 % to 39.17 % and knee extension in the range of 12.5 % to 35.12 %, consequently. Those were increased mostly in shoulder abduction, elbow flexion and knee extension, respectively. Therefore, the established model of PTP in this study might effectively improve muscle strength and muscle power of upper body more than lower body in knee extension from its effect on shoulder and elbow. Besides, we found that results in isokinetic test had also shown the increase of percentage of percent differences in shoulder abduction, elbow flexion and knee extension after 12 weeks of PTG more than 6 weeks. It was indicated that the improvement of muscle strength and muscle power shown increasing amount which corresponding to the training time in PTP. Thus, applied plyometric training program could increase muscle strength and muscle power on upper body (such as thoracic region, biceps, triceps and shoulder) and lower limbs (such as hamstrings, quadriceps, gastronemiuos mucles and hip region). There also increased speed strength by moving muscle contraction at rapid speed. According to “The role of plyometric exercises in the physical preparation of junior female football players” which found that plyometric exercise program could improve of strength capacity in the motor, practical and methodological capacity necessary to easily practice the football game.[10] And the study of Vescovi and co - worker[11] found that effect of a plyometric program could help reduced landing force by 17-18%. The same result found in “ Effectiveness and time-course adaptation of resistance training vs. plyometric training in prepubertal soccer players” shown that plyometric training program could improve performance in the 20-m sprint test from subjects and enhance maximal muscle strength and power.[12] The same result was also found in “Isokinetic strength and anaerobic power of elite, sub elite and amateur French soccer players” that plyometric training could improve higher level of muscle strength and muscle power and reduced risk injuries including more powerful jump kick, tackles and sprint.[13]

Conclusion

The present study demonstrated that 12 weeks of applied plyometric training program could improve physical performance, muscle strength and muscle power in male Thai boxing athletes. It had been more beneficial to combine applied plyometric training exercise with normal Thai boxing training exercise for improvement of physical performance, muscle strength and muscle power in Thai boxing athletes or Thai boxers.

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