ผลของระยะเวลาพักต่อการตอบสนองของแรงดันหายใจเข้าสูงสุดและอัตราการเต้นของหัวใจขณะออกกำลังกายแบบมวยไทยในผู้หญิงที่มีภาวะอ้วน

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บทคัดย่อ

วัตถุประสงค์การวิจัย เพื่อศึกษาผลของความแตกต่างของระยะเวลาพักระหว่างการออกกำลังกายมวยไทย ที่มีต่อการตอบสนองของค่าแรงดันหายใจเข้าสูงสุดและอัตราการเต้นของหัวใจในผู้หญิงที่มีภาวะอ้วน

วิธีการดำเนินการวิจัย อาสาสมัครเพศหญิงที่มีภาวะอ้วนระดับที่ 1 จำนวน 10 คน (อายุเฉลี่ย 21.5 ± 0.5 ปี) แต่ละคนทดสอบออกกำลังกายมวยไทยทั้งหมด 3 โปรแกรม แต่ละโปรแกรมออกกำลังกายประกอบด้วยจำนวน 5 ยก ๆ 3 นาที โดยมีระยะเวลาพักระหว่างยกแตกต่างกันได้แก่ 2, 4 และ 6 นาที (3:2, 3:4, และ 3:6 ตามลำดับ) วัดค่าแรงดันหายใจเข้าสูงสุดโดยเครื่องวัดแรงดันหายใจก่อนและหลังการออกกำลังกาย และวัดอัตราการเต้นของหัวใจโดยอุปกรณ์วัดอัตราการเต้นของหัวใจแบบไร้สายตลอดช่วงทดสอบการออกกำลังกาย วิเคราะห์ข้อมูลทางสถิติด้วยการทดสอบความแปรปรวน 2 ทางชนิดวัดซ้ำและเปรียบเทียบความแตกต่างระหว่างเงื่อนไขด้วยวิธีของ Bonferroni โดยกำหนดระดับนัยสำคัญทางสถิติที่ $p < 0.05$

ผลการวิจัย พบว่าทั้งสามโปรแกรมมีการตอบสนองของค่าอัตราการเต้นหัวใจขณะออกกำลังกายสูงกว่าขณะพัก ($p < 0.05$) โดยโปรแกรมการออกกำลังกายมวยไทยแบบ 3:2 มีค่าอัตราการเต้นของหัวใจขณะพักระหว่างยกสูงกว่าเมื่อเทียบกับโปรแกรมการออกกำลังกายแบบ 3:4 และ 3:6 ตามลำดับ ($p < 0.05$) นอกจากนี้ การตอบสนองของค่าแรงดันหายใจเข้าสูงสุดหลังออกกำลังกาย ทุกโปรแกรมการมีค่าลดลงเมื่อเทียบกับก่อนการออกกำลังกาย ($p < 0.05$) อย่างไรก็ตาม เปอร์เซ็นต์การเปลี่ยนแปลงของค่าแรงดันหายใจเข้าสูงสุดหลังการการออกกำลังกาย พบว่าไม่มีความแตกต่างกันเมื่อเปรียบเทียบระหว่างทุกโปรแกรม ($p > 0.05$)

สรุปผลการวิจัย ระยะเวลาการพักระหว่างออกกำลังกายแบบมวยไทยที่แตกต่างกัน ส่งผลต่อการเปลี่ยนแปลงการตอบสนองของค่าอัตราการเต้นของหัวใจ แต่ไม่มีผลต่อค่าแรงดันหายใจเข้าสูงสุดหลังออกกำลังกายในผู้ที่มีภาวะอ้วนระดับที่หนึ่ง

คำสำคัญ: ช่วงเวลาการฟื้นฟูระหว่างออกกำลังกาย/ กล้ามเนื้อหายใจ/ การออกกำลังกายแบบหนักสลับเบา

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INFLUENCE OF RECOVERY DURATION ON MAXIMAL INSPIRATORY PRESSURE AND HEART RATE RESPONSES DURING THAI BOXING EXERCISE IN OBESE CLASS I WOMEN

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Abstract

Purpose The purpose of this study was to assess the effects of recovery duration on maximal inspiratory pressure and heart rate (HR) responses during Thai boxing exercise in obese female subjects.

Methods Ten obese (Class I) female subjects (aged 21.5 ± 0.5 years) participated in this study. A Thai boxing exercise protocol was completed on three separate occasions, comprising 5 × 3-minutes rounds, with either 2 (3:2), 4 (3:4) or 6 (3:6) min recovery. Maximum inspiratory pressure (MIP) was assessed using a hand-held mouth pressure meter before (Pre) and after (Post) the Thai boxing exercise. HR was assessed throughout exercise and during the intermittent recovery periods. Data were analyzed using ANOVA with Bonferroni post hoc analysis. A statistical significance was accepted at $p < 0.05$.

Results While HR increased ($p < 0.05$) during exercise in all three exercise protocols, HR was higher ($p < 0.05$) during recovery in the 3:2 condition compared with the 3:4 and 3:6 conditions, respectively. Moreover, MIP was lower post-exercise compared to pre-exercise in all three exercise protocols ($p < 0.05$), however no between-condition differences were observed ($p > 0.05$).

Conclusion This study indicated that recovery duration between rounds during Thai boxing exercise influences the recovery of HR, but not MIP, in obese class I women.

Keywords: Recovery duration / Respiratory muscle / Interval exercise

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Introduction

Obesity is a major public health problem across the world and is major risk factor for a number of chronic diseases, including diabetes, cardiovascular and respiratory disorders, and lower back pain (Bischoff et al., 2017; Zammit, Liddicoat and Moonsie, 2010). An increase in body fat leads to an increased resistance in the respiratory system, which in turn can reduce cardiorespiratory fitness (Chen et al., 2016; Mongkol, 2012; Ramar and Caples, 2010). In particular, obese subjects may present with a decreased forced expiratory volume in 1 second (FEV1), functional residual capacity (FRC) and expiratory reserve volume (ERV) (Zammit, Liddicoat and Moonsie, 2010). This increases the work of breathing muscles and the demand of oxygen consumption during physical activity (Chen et al., 2016; Mongkol, 2012; Rabec, De and Ramos, 2011; Scano, Stendardi and Bruni, 2009; Zammit, Liddicoat and Moonsie, 2010).

A well balanced diet combined with regular physical activity and exercise is well known to promote the loss of body fat, leading to a better quality of life, improvement in cardiorespiratory performance, and decreased risk of chronic disease (McQueen, 2009). In particular, aerobic exercise leads to beneficial cardiovascular adaptations, such as an increase in peak oxygen consumption and a decrease in blood pressure. A popular type of aerobic exercise, high intensity interval training (HIIT), is typically performed at an exercise intensity above 85% of maximum heart rate (HR) with timed recovery periods between bouts of exercise (Ramírez-Vélez et al., 2019). The allotted recovery periods enable the restoration of energy metabolism, allowing the maintenance of a high work intensity during subsequent work bouts. This permits a high energy expenditure over a short duration compared with more traditional steady state aerobic exercise (Wewege, van den Berg, Ward and Keech, 2017). Consequently, HIIT is a time-efficient method to potentially improve body composition. In support, meta-analytical data has shown that 10 weeks of HIIT can reduce body mass, percent body fat, and waist circumference in overweight and obese subjects (Wewege, van den Berg, Ward and Keech, 2017).

Thai boxing, developed from the martial art of Muay Thai, has training components, which are similar to HIIT (i.e., intense work bouts with periods of rest), which can be individualized to fit an individual or groups fitness capacity. The benefits of Thai boxing have been documented to improve health outcomes in obese male and female participants (Class I), partly via increase in maximal minute ventilation (Tarapong, 2019). Nevertheless, in Thailand, obesity rates are currently greater in females compared with males, leading to significant decreases in respiratory muscle strength in this gender (Rabec, De and Ramos, 2011; Ramar and Caples, 2010; Scano, Stendardi and Bruni, 2009; Zammit, Liddicoat and Moonsie, 2010). Basically, the Thai boxing match consists of 5×3 min rounds with a 2 min rest between rounds. Furthermore, our previous research in obese subjects demonstrated that, the health benefits can be gain even at 4 mins rest between rounds (Tarapong, 2019). Therefore, whilst Thai boxing represents an alternative form of exercise, the physiological demands and efficacy of different types of Thai boxing protocols (work/rest ratio) has yet to be evaluated in obese females.

The aim of this study was to investigate the influence of recovery duration on maximal inspiratory pressure and HR responses during Thai boxing exercise in obese female subjects. It was hypothesized that a Thai boxing exercise program, which permits a longer recovery period between work bouts, would result in an increased maximal inspiratory pressure and lower heart rate response, respectively.

Objectives

The purpose of this study was to assess the effects of recovery duration on maximal inspiratory pressure and heart rate (HR) responses during Thai boxing exercise in obese female subjects.

Material and methods

Sample group

Ten obese (Class I) female participants (age: 21.5 ± 0.5 years; body mass: 70.6 ± 8.6 kg; height: 161.1 ± 5.8 cm; % body fat: 32.6 ± 1.8%; Body mass index: 27.2 ± 1.6 kg·m-2) volunteered to participate in this study. The participants current physical activity level was classified using the International Physical Activity Questionnaire (IPAQ) and rated as moderate (n = 2) or low (n = 8). Exclusion criteria included the use of medication that could affect exercise capacity, any cardiopulmonary or metabolic disease, or orthopedic limitation. The participants provided their written informed consent to take part in this study after all experimental procedures and possible risks of participation were explained. The study was approved by the Naresuan University Ethics Committee in accordance with the Declaration of Helsinki (IRB No.0292/62). A sample size of at least 10 participants was calculated (G power 3.1, Heinrich Heine Universistät, Düsseldorf, Germany) based on the results of a previously published study (Effect size = 1.27, alpha = 0.05 and beta = 0.80) (Crisafulli et al., 2019).

Research methodology

In this randomized counterbalanced crossover study, the participants were instructed to avoid strenuous activities 48 h before experimental testing. All participants were familiarized with all test procedures. The participants were asked to consume a light meal 2 to 3 hours before the commencement of experimental testing and to avoid caffeine ingestion over the course of the study. The testing sessions were conducted between 6:00 p.m. to 8:00 p.m. under similar temperature and humidity conditions, at B-one boxing gym Phitsanulok Thailand. The test days were separated by at least 48 hours period.

All subjects wore hand bandage wrappings on their hands and boxing gloves. The participants performed a 20-minute warm up, consisting of standard boxing movements, before commencing a Thai boxing exercise protocol comprising of 5×3 minutes work bouts (rounds) with either 2 (3:2), 4 (3:4) or 6 (3:6) min recovery. During the boxing exercise protocols HR were recorded at the end of each work bout and recovery period. Maximal inspiratory pressure (MIP) was recorded at before and after the completion of each exercise protocol. The Thai boxing exercise involved a series of offensive and defensive skills against handheld pads, which were performed in a standardized order (Jab, Cross, Hook, Horizontal elbow, Uppercut, Straight kick, Straight knee strike and Straight foot thrust: 10 times/position for each side, respectively). The pads were held by a qualified amateur boxing association coach. The same coach was used for all boxing protocols.

Heart rate was continuously measured using a HR monitor and telemetry strap, which was placed across the participant's chest (Polar FT7, Kempele, Finland). MIP was measured in sitting position using a mouth pressure meter (Micro RPM, Micro Medical Limited, United Kingdom) in accordance with the ATS/ERS statement (American Thoracic Society and European Respiratory Society, 2002). Prior to the measurements, each participant performed 5 maximum inspiratory and 5 maximum expiratory warm-up efforts to be familiarized with the procedure. During the MIP measurements, the participants were asked to hold the gauge with both hands and to close their lips firmly around the flanged mouthpiece. A nose clip was used to avoid nasal air leak. The participants were asked to exhale as forcefully as possible to reduce residual volume (RV), and then inhale maximally for more than one second against the resistance of the gauge.

Data analysis

The Statistical Package for the Social Sciences, was used for all statistical analysis (SPSS inc., version 19; SPSS Inc., Chicago, IL, USA). Normality was assessed using the Shapiro–Wilk test. A two-factor ANOVA was used to evaluate treatment differences in MIP [Condition (2 min, 4 min, 6 min) x Time (pre-exercise MIP, post-exercise MIP)]. A three-factor ANOVA was used to evaluate treatment differences in heart rate response [Condition (2 min, 4 min, 6 min) x Time (Pre-exercise, Post-exercise) x Round (Round 1, Round 2, Round 3, Round 4, Round 5)]. Where a significant interaction between factors was observed, differences were followed up with a Bonferroni post hoc correction. The observed effect size (ES) was expressed as partial eta squared (η^2p), with values of 0.1-0.29, 0.3-0.49, and >0.5, representing a small, medium and large ES, respectively (Cohen, 1992). The statistical significance level was established at $p < 0.05$. All data are presented as mean ± SD.

Results

Maximal Inspiratory Pressure

There was a time effect ($F_{[1,9]}$ = 93.56, P<0.01, η^2p = 0.91) but no condition ($F_{[2,8]}$ = 0.52, P = 0.61, η^2p = 0.05) or interaction ($F_{[2,18]}$ = 0.40, P = 0.68, η^2p = 0.04) effect observed for MIP. The MIP values generally decreased after all Thai boxing exercise protocols, with lower values observed post exercise compared with pre-exercise in the 3:2 protocol (Pre; 121 ± 23 cmH_2O; Post, 113 ± 20 cmH_2O, $p < 0.01$), 3:4 protocol (Pre, 120 ± 20 cmH_2O; Post, 110 ± 21 cmH_2O, $p < 0.001$), and 3:6 protocol (Pre, 121 ± 21 cmH_2O; Post, 114 ± 21 cmH_2O, $p < 0.01$; Figure 1), respectively.

Heart Rate

A condition effect ($F_{[2,18]}$ = 5.11, P = 0.02, η^2p = 0.36) was observed for HR, with higher HR values recorded in the 3:2 compared with the 3:6 protocol (p = 0.02). However, there was no difference (p = 0.59) in HR values between the 3:4 and 3:6 protocols. There was also a bout effect ($F_{[1,9]}$ = 998.89, $p < 0.001$, η^2p = 0.99), with HR values generally higher ($p < 0.001$) during the work bouts compared with the recovery periods.

The changes in HR during the training bouts were dependent on the condition and the round ($F_{[8,72]}$ = 5.48, $p < 0.001$, η^2p = 0.38).

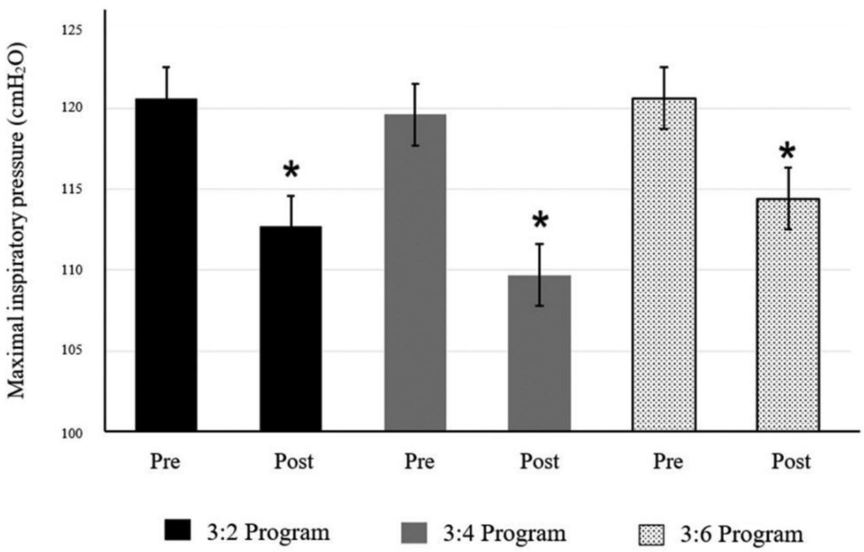

Figure 1 MIP changes pre and post Thai boxing exercise among three protocols (mean ± SD). * Significantly difference ($p < 0.05$) from pre boxing exercise values.

HR was similar between conditions at baseline (3:2, 87 ± 12 bpm; 3:4, 92 ± 15 bpm; 3:6, 90 ± 14 bpm, $p = 1.00$) but increased ($p < 0.001$) after the completion of the first round of exercise. Nevertheless, HR remained similar across conditions (3:2, 182 ± 9 bpm; 3:4, 184 ± 12 bpm; 3:6, 183±8 bpm, $p = 1.00$, Figure 2).

Prior to the commencement of round 2, a higher HR ($p < 0.001$) was observed in the 3:2 (139 ± 13 bpm) compared with the 3:6 (119 ± 10 bpm, Figure 2) protocol. However, the subsequent post exercise HR response was similar between conditions (3:2, 185 ± 9 bpm, 3:4, 188 ± 10 bpm, 3:6, 186 ± 7 bpm, $p = 1.00$, Figure 2).

Prior to round 3, HR values were higher ($p < 0.001$) during the 3:2 (144 ± 10 bpm) compared with 3:4 (130 ± 12 bpm, $p = 0.04$) and 3:6 (122 ± 10 bpm, $p < 0.001$, Figure 2) protocols, respectively. The post exercise HR response was similar between protocols (3:2, 188 ± 7 bpm; 3:4, 190±8 bpm; 3:6, 188 ± 9 bpm, $p = 1.00$).

Prior to round 4, a higher HR was subsequently observed during the recovery period in the 3:2 (145 ± 11 bpm, $p = 0.03$, Figure 2) compared with the 3:4 (131 ± 12 bpm, $p < 0.001$) and 3:6 (126 ± 12 bpm, $p < 0.001$) protocols, respectively. After exercise, the HR response was similar between all protocols (3:2, 189 ± 8 bpm; 3:4, 189 ± 8 bpm; 3:6, 188 ± 7 bpm, $p = 1.00$, Figure 2).

Prior to the final round of exercise, HR was higher in the 3:2 (147 ± 13 bpm) compared with the 3:4 (132 ± 11 bpm, $p < 0.01$) and 3:6 (128 ± 9 bpm, $p < 0.001$, Figure 2) protocols, respectively. Immediately after exercise, the HR response was similar between conditions (3:2, 190 ± 8 bpm; 3:4, 191±9 bpm; 3:6, 191 ± 7 bpm, $p = 1.00$, Figure 2).

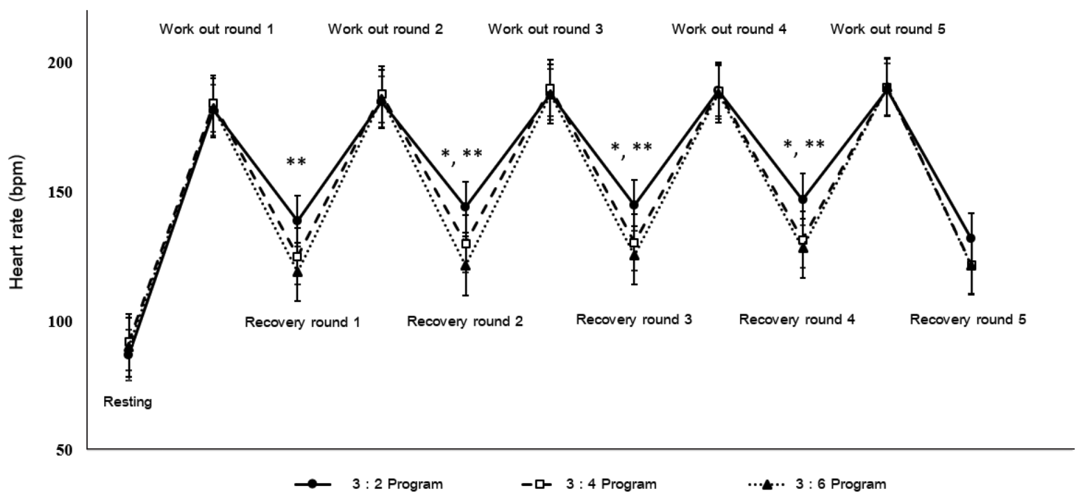

Figure 2 The heart rate during exercise and recovery among three boxing protocols (mean ± SD).
* Significant difference ($p < 0.05$) between the 3:2 and 3:4 protocol.
** Significant different ($p < 0.05$) between the 3:2 and 3:6 protocol.

Discussion

The main finding of this study was that Thai boxing exercise decreased MIP in obese females, however no differences in MIP was observed between the different recovery protocols. Moreover, we also observed HR to remain elevated during the recovery periods when a shorter recovery duration was provided. Our findings are in line with previous studies (Coast et al., 1990; Ozkaplan, Rhodes, Sheel and Taunton, 2005; Wüthrich et al., 2015), which have demonstrated MIP to decrease following other types of exercise. Coast et al (1990) demonstrated MIP to decrease (10% at 10 s post-exercise) in untrained subjects after maximal cycle ergometer exercise (Coast et al., 1990). Wüthrich, Marty, Kerherve, Millet and Verges, (2015) reported that MIP and MEP values significantly decreased after ultra-trail running, indicating a decreased respiratory muscle strength. Similarly, Ozkaplan, Rhodes, Sheel and Taunton, (2005) reported MIP to be significantly reduced in moderately trained males and females following an aerobic capacity test. An increase in body fat leads to an increased resistance in the respiratory system and can reduce cardiorespiratory fitness (Chen et al., 2016; Mongkol, 2012; Ramar and Caples, 2010). In the present study, the provision of longer recovery durations (e.g., 4 or 6 minutes) after each work bout did not influence the MIP response, or offset respiratory muscle fatigue in the obese participants. Although difficult to ascertain, it is possible that blood flow may have been diverted to the arms and legs and compromised oxygen delivery to the diaphragm, and/or the removal of metabolic by-products (Johnson, Aaron, Babcock and Dempsey, 1996; Sheel, Boushel and Dempsey, 2018). during the high-intensity Thai boxing exercise.

In this study, HR averaged 94-95% of HRmax during the exercise work bouts (in each round) and was not different between protocols. This HR response is typical of HIIT sessions, which alternate high-intensity efforts (>85% HRmax) with low intensity periods of recovery (Riebe, Ehrman and Liguori, 2017). These findings are consistent with previous observations (Crisafulli et al., 2009; Nassib et al., 2017), which have examined the acute physiological responses to boxing exercise. In agreement with our work, Nassib et al (2017) reported a similar HR ($93 \pm 3\%$ of HR) during boxing matches, which consisted of 3×3-minute rounds with only 1 minute of recovery (Nassib et al., 2017). Similalry, Crisafulli, Vitelli, Cappai, Milia, Tocco and Melis, (2009) investigated the physiological responses during a simulated Muay Thai match and reported the attainment of heart rates above the anaerobic threshold.

In the present study, HR was reduced ($p < 0.001$) during the recovery periods after completion of each work bout (in all conditions), however HR remained above baseline values. This finding is in line with a previous study, which demonstrated that HR did not recover to resting values during a simulated 3×3-min amateur boxing contest (El-Ashker, Chaabene, Negra, Prieske and Granacher, 2018). Our data showed that average recovery HR was 71%, 64% and 62% of HRmax across the different protocols (3:2, 3:4 and 3:6, respectively), with a higher HR observed during the recovery periods in the 3:2 protocol compared with the 3:4 and 3:6 protocols, respectively (Figure 2). This finding is in agreement with previous research that has shown a short recovery period to increase HR and oxygen consumption during a simulated Olympic boxing match of 3×2 minutes rounds with a 1-min recovery (de Lira et al., 2013). Our current findings potentially support the mechanistic basis of extending HIIT recovery duration by delaying the attainment of critical intramuscular metabolites to extend the tolerable duration of exercise (Chidnok et al., 2013). This may help permit a high energy expenditure over a short duration compared with more traditional steady state aerobic exercise (Jones and Vanhatalo, 2017), and potentially help towards improving body composition in obese subjects.

There were several limitations in this study, which did not enable full interpretation of our findings. For example, we did not include blood lactate analysis or pulmonary oxygen uptake measurements, which may have helped explain the post exercise reduction in MIP and the higher HR response with a decreased recovery duration. Therefore, further research is required to identify the underlying mechanisms of different recovery protocols on the key physiological indices related to Thai boxing exercise.

Conclusions

This study indicated that recovery duration during Thai boxing exercise influences the recovery of HR, but not MIP, in obese subjects. These findings might have implications for improving our understanding of the physiological strain associated with different Thai boxing exercise protocols.

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