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Effects of Resistance Exercise to Failure with Different Intensities on Urinary 8-Iso $PGF_{2\alpha}$ in Athletes

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Abstract: The purpose of the present study was to examine the effects of resistance exercise (RE) to failure with different intensities on lipid peroxidation response. A week after one repetition maximum (1RM) test, 10 resistance-trained men performed high-intensity RE (4 sets of 5 exercises to failure at 90% of the 1RM, with 3 min rest) and moderate-intensity RE (4 sets of 5 exercises to failure at 75% of the 1RM, with 90 second rest) in a randomized and cross-over design. Urine samples were collected before (Pre), after (Post), 3h after (3h Post) and 24 h after RE (24h Post) for analyzing lipid peroxidation as measured by 8-isoprostane (8-Iso $PGF_{2\alpha}$). The findings indicated that urinary 8-Iso $PGF_{2\alpha}$ significantly increased at Post and 3h Post RE with 75% of 1RM compared to Pre RE ($p<0.05$). Also, urinary 8-Iso $PGF_{2\alpha}$ significantly increased at Post RE with 90% of 1RM compared to Pre RE ($p<0.05$). In addition, urinary 8-Iso $PGF_{2\alpha}$ concentrations significantly increased at Post and 3h Post RE with 75% of 1RM compared to RE with 90% of 1RM ($p<0.05$). Total exercise volume (kg) and volume in each exercise (kg) were significantly higher in RE with 75% 1RM protocol compared to RE with 90% 1RM protocol ($p<0.05$). These data suggest that lipid peroxidation is higher in moderate-intensity RE performed to failure compared with high-intensity RE performed to failure.

Key words: Resistance exercise to failure · Oxidative stress · 8-iso $PGF_{2\alpha}$

INTRODUCTION

Oxidative stress is a condition which can occur as a result of increased production of reactive oxygen species (ROS) despite normal antioxidant capacity, as a result of normal ROS production but in the presence of decreased antioxidant capacity, a combination of both or due to an imbalance in different antioxidant components [1]. Oxidative stress following strenuous aerobic and anaerobic exercise is owing to production of excess ROS such as superoxide (O_2^{2x}), hydrogen peroxide (H_2O_2), hydroxyl radical ($^{\bullet}OH$) and organic hydro peroxide [2] which can result in oxidative damage to DNA, lipids and proteins [1, 3, 4]. From these ROS, superoxide, H_2O_2 and $^{\bullet}OH$ are able to acquire the protons adjacent to double bounds in unsaturated fatty acids, such as those in cell membranes [5]. This leads to a chain reaction which deforms this fatty acid and produced lipid peroxides [6].

This process is known as lipid peroxidation which is measured by expired pentane, malondialdehydes (MDA), lipid hydroperoxides, isoprostanes and conjugated dienes [7]. MDA have been frequently used as markers of oxidative stress in response to RE [3, 8, 9].

However, measurements of 8-isoprostane (iPF-III or 8-Iso $PGF_{2\alpha}$) in body fluids such as plasma and urine provide a reliable approach to assess oxidative stress *in vivo* than other markers of lipid peroxidation [10]. The 8-Iso $PGF_{2\alpha}$ was generated due to ROS attack to arachidonic acid carboxyl chain and separation a bis-allyic hydrogen [11,12]. Studies investigated the effect of acute exercise on 8-Iso $PGF_{2\alpha}$ level reported inconsistent results, including increased levels of 8-Iso $PGF_{2\alpha}$ after exercise compared to resting levels [13, 14], decreased after short-term (14 min) intense exercise [15] or reported no significant changes [16, 17]. However, only one study have evaluated acute effect of RE on urinary 8-Iso $PGF_{2\alpha}$

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level [18] and reported that the levels of 8-Iso $PGF_{2\alpha}$ in urine collected 24 h after a single session of resistance exercise increased by 40% compared to the pre exercise baseline values.

Furthermore, there are limited data regarding the intensity of RE on lipid peroxidation response [19, 20]. For example, Hoffman *et al.* [19] reported an increase in MDA blood concentration after both low- (60% of 1RM) and high-intensity (90% 1RM) RE in trained men. Hudson *et al.* [20] also demonstrated an increase in oxidative stress response to acute moderate (75% of 1RM with 90 second rest in back-squat exercise) and high-intensity exercise (90% of 1RM with 5 min rest in back-squat exercise) in trained men. Recently, Rahimi [3] reported significant increase in plasma MDA following acute bout of RE protocol (7 sets of 4 exercises using 60-90 1 repetition maximum) in the flat pyramid loading pattern. However, the 8-Iso $PGF_{2\alpha}$ responses to different intensities of RE are unknown. Therefore, the purpose of the present study was to investigate the acute effect of moderate- and high-intensity RE on urinary 8-Iso $PGF_{2\alpha}$ levels, a reliable approach to assess exercise-induced lipid peroxidation during the recovery in young athletes.

MATERIALS AND METHODS

Subjects: Ten resistance trained men (age: 21.00±2.30 year; weight: 74.71±8.73 kg; height: 175.14±5.95 cm) who had at least 1 year experience in whole-body resistance training volunteered to participate in this study. The experiment procedure was explained in details to all subjects and they completed a written informed consent approved by the local institutional ethics committee. Subjects were on their ordinary diet and did not consume anabolic steroids or any other anabolic agents known to increase performance. No subjects were smoker or used antioxidant supplementation.

Experimental Design: One week before the experimental resistance exercise workouts, subjects came to the Exercise Physiology Lab for measuring height, weight and one repetition maximum (1RM) for the bench press, leg press, seated bar shoulder press, arm curls and lat pull down exercises [3, 21]. Prior to 1RM testing, all subjects performed warm-up, which consisted of 3 min running, 5-10 repetitions at 50% of perceived maximum strength and stretching period. The warm-up procedure was held constant throughout all the testing sessions. Each subject performed 2 RE protocols of different intensities in cross-over design. At least 72 hours of recovery time was allowed between each training session. Subjects were instructed not to train or be involved in strenuous activity for 48 hours before or after the experimental RE trial. All the subjects completed two RE protocols that consisted of 4 sets of the bench press (BP), leg press (LP), seated bar overhead press (OP), arm curls (BC) and lat pull down (LPD) exercises at 90% of 1RM with 3 min rest between sets and at 75% of 1RM with 90s rest between sets and each set was performed to exhaustion. To ensure that all subjects were moving at approximately the same velocity for each repetition, each set was timed using a handheld stopwatch. The spotter called out a cadence for the eccentric and concentric phases of each repetition. The repetition velocity consisted of a 3-second eccentric phase followed by a 1-second concentric phase. The volume of each exercise was calculated as the number of sets × complete repetitions × load (kg).

Urine Collection and Biochemical Analyses: Urine samples were collected before RE trail (Pre), immediately post (Post), 3 h post (3h Post) and 24 h post-exercise (24h Post) for analysis of urinary 8-Iso $PGF_{2\alpha}$ excretion level. Urine samples were stored at -20°C until analyzed. Urinary 8-Iso $PGF_{2\alpha}$ levels were analyzed using enzyme immunoassay (EIA) according to the procedures recommended by the manufacturer (Cayman Chemical's ACETM EIA kit, Catalog No: CM 516351, USA). The assay was carried out in duplicate utilizing the manufacturer's instructions.

Statistical Analyses: Data are expressed as Mean ± SD. Statistical evaluation was performed with SPSS (SPSS, Chicago, IL) for windows. The data obtained for urinary 8-Iso $PGF_{2\alpha}$ levels were analyzed using a 2 condition × 4 times repeated measures analysis of variance (ANOVA). Multiple comparisons with confidence interval adjustment by the *Bonferroni* method were used as post hoc when repeated measures ANOVA yielded significant results. Independent-samples t-test was performed to determine possible condition differences for exercises volume. The significance level was set at $p < 0.05$.

RESULTS

Urinary 8-Iso $PGF_{2\alpha}$ concentrations before and following (Post, 3h Post and 24h Post) RE protocols with 90% of 1RM and 75% of 1RM are presented in Figure 1. Urinary 8-Iso $PGF_{2\alpha}$ concentrations significantly increased at Post and 3h Post RE with 75% of 1RM compared to Pre RE ($p=0.01$ and 0.004, respectively). However, urinary 8-Iso $PGF_{2\alpha}$ concentrations significantly increased only at Post RE with 90% of 1RM compared to Pre RE ($p=0.046$).

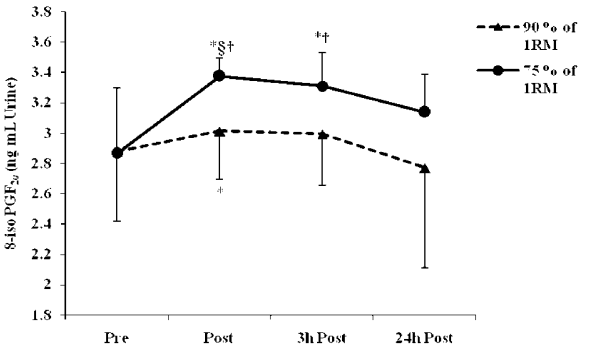

Fig. 1: Urinary 8-iso PGF2α concentration at pre-, post- and 3h post- and 24h post- resistance exercise with 90% and 75% of 1RM load

*Significant difference with Pre at p<0.05.

§Significant difference with 24h Post exercise at p<0.05.

†Significant difference between protocols at p<0.05.

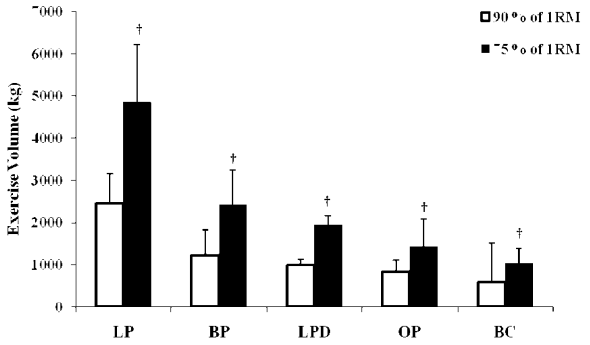

Fig. 2: Exercise volume in leg press (LP), bench press (BP), lat pull down (LPD), overhaed press (OP) and seated bar arm curls (BC) exercises at 90% of 1RM with 3 min rest between sets and at 75% of 1RM with 90s rest between sets.

†Significant difference between protocols at p<0.05.

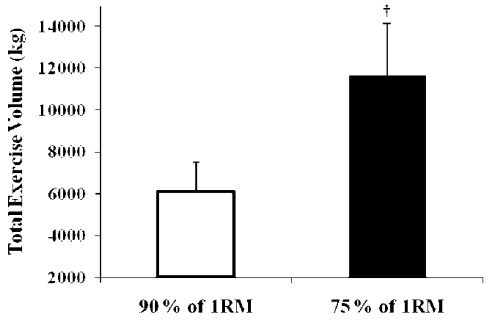

Fig. 3: Total exercise volume (kg) completed by athletes during RE protocols with different intensity.

†Significant difference between protocols at p<0.05.

Urinary 8-Iso $PGF_{2\alpha}$ concentrations significantly increased at Post and 3h Post RE with 75% of 1RM compared to RE with 90% of 1RM (p=0.004 and 0.027, respectively).

Total exercise volume (kg) and exercise volume (kg) in BP, LP, OP, BC and LPD exercises was presented in Figure 2 and 3. Total exercise volume (kg, p=0.001) and exercise volume (kg) in BP (p=0.01), LP (p=0.002), OP (p=0.05), BC (p=0.008) and LPD (p=0.001) were significantly higher in RE with 75% 1RM protocol compared to RE with 90% 1RM protocol.

DISCUSSION

It has been shown that a single session of RE can increase ROS formation and induce oxidative damage to DNA [3], protein [4, 22] and lipids [18, 19, 20]. Our finding demonstrated that urinary 8-Iso $PGF_{2\alpha}$ concentrations significantly increased Post and 3h Post RE with 75% of 1RM and Post RE with 90% of 1RM compared to Pre RE. Our finding agrees with only one study that have evaluated acute effect of RE on urinary 8-Iso $PGF_{2\alpha}$ level [18] that reported the levels of 8-Iso $PGF_{2\alpha}$ in urine collected 24 h after a single session of RE increased by 40% compared to the pre exercise baseline values. However, our results are also consistent with previous studies that have demonstrated significant increase in lipid peroxidation as measured by MDA concentration after a bout of RE [3, 19, 20]. In contrast with our findings, Dixon *et al*. [9] reported that moderate-intensity whole circuit RE (3 set ×10 repetition in 8 exercise) had no effect on MDA concentration in trained and untrained men.

In addition, our finding demonstrated that urinary 8-Iso $PGF_{2\alpha}$ concentrations were significantly higher at Post and 3h Post RE in 75% of 1RM compared to RE with 90% of 1RM. While no study has investigated RE intensity on 8-Iso $PGF_{2\alpha}$ response, in contrast to our findings, two studies have reported an increase in MDA concentration after both low- (5 set × 15 repetition of squat at 60% of 1RM with 3 min rest) and high-intensity (5 set × 4 repetition of squat at 90% 1RM with 3 min rest) RE as well as after moderate- (75% of 1RM with 90s rest in back-squat exercise) and high-intensity RE (90% of 1RM with 5 min rest in back-squat exercise) in trained men [19, 20]. The possible reasons for inconsistency can allude to the type of RE protocols, exercise intensity, rest between sets and training status of the subjects. For example, in two previous mentioned studies [19, 20], a single exercise with fixed repetition in each set was used, but in the present study RE protocols include multiple exercise (5 exercise) and each set performed to failure. In comparison to previous RE protocols [19, 20], our RE protocols had higher metabolic stress and higher training volume. In addition, our findings may be explained by long recovery in high-intensity RE and low volume of

training during this session. Also, a possible mechanism to explain our results as shown by previous studies [2, 23] may be attributed to relative lack of oxygen supply (anoxia) in the exercising muscle was induced by 10 RM curl exercise. In the present study, 75% of 1RM load was used in hypertrophy RE protocol that is same as 10 RM intensity used in aforementioned study. Previous studies reported that both reduced blood flow in the muscle and saturation of blood flow occurs in the contracting muscle at this level of exercise intensity [24], that is similar to ischemia-reperfusion-like state [2].

In the present study, total exercise volume (kg) and volume in each exercise (kg) were significantly higher in moderate-intensity RE (4 set of 5 exercise performed to failure at 75% of 1RM with 90s rest) compared to high-intensity RE (4 set of 5 exercise performed to failure at 90% of 1RM with 3 min rest). Rooney *et al.* [25] demonstrated greater increases in dynamic and isometric strength for group performed 1 set of 6 consecutive repetitions to failure compared to group performed 6 sets of 1 repetition not to failure with 30 seconds of rest between sets. Previous studies showed that RE to failure resulted in grater fatigue and a greater drop in PH and PCr compared with RE not to failure [26, 27]. It should be mentioned that greater acidosis accompanied with moderate-intensity RE (4 set of 5 exercise performed to failure at 75% of 1RM with 90s rest) due to short recovery and higher training volume may be the possible reason for greater lipid peroxidation in moderate-intensity RE compared to high-intensity RE. This assumption was supported by Waterfall *et al.* [28] who reported lactate accumulation that occurs following high intensity exercise and accompanying acidosis lead to lipid peroxidation. In addition, previous studies reported greater activation of motor unites and secretion of growth-promoting hormones by RE to failure compared to RE not to failure [21, 29].

In conclusion, evidence from the present investigation suggests that lipid peroxidation as measured by urinary 8-Iso $PGF_{2\alpha}$ response is higher following RE with 75% of 1RM to failure when compared with RE with 90% of 1RM to failure, likely owing to an increase in training volume resulting higher metabolic stress during the former. Based on our findings it could be concluded that lipid peroxidation induced by acute RE performed to failure may be dependent on the intensity of RE and training volume. Also, it should be noted that urinary 8-Iso $PGF_{2\alpha}$ response was higher in the hypertrophy-intensity protocol compared to strength-intensity protocol, both performed to failure.

CONCLUSION

To our knowledge, the present study was the first to examine the effects of whole-body RE to failure with different intensities on lipid peroxidation as measured by 8-Iso $PGF_{2\alpha}$ response. Taken together, our findings show that regardless of the RE intensity, urinary 8-Iso $PGF_{2\alpha}$ concentration was increased after whole-body RE to failure in young resistance trained men. Also, the findings of the present study demonstrated that moderate-intensity RE (75% of 1RM) was associated with higher lipid peroxidation compared with high-intensity RE (90% of 1RM). The possible explanations for these results are unknown. However, these findings may be attributed to higher training volume and short recovery in moderate-intensity RE compared with high-intensity RE. These findings are useful knowledge for coaches and athletes designing these types of training. Moreover, it could be mentioned that athlete performing regular moderate-intensity RE to failure may consider the use of antioxidant supplementation in an attempt to attenuate any potential increase in oxidative stress.

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