NETJOURNALS

*Pharmacy and Pharmacology Research*
**Vol. 2(1), pp. 9-13, June 2014**
***Full Length Research Paper***

# Comparison of the effects of a single bout of resistance exercises with different intensities on oxidative stress in untrained male students

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Accepted 20 June, 2014

**ABSTRACT**

The aim of this study is to compare the effects of a single bout of resistance exercise with different intensities of oxidative stress on male students who did not do any kind of sports whatsoever. In this study, 16 untrained subjects with a mean age of 24.40 ± 1.7 years, height 176 ± 6.83 cm, weight 69.89 ± 6.6 and BMI 22.89 ± 0.89 kg/$m^2$, were divided into two groups of high-resistance (HR) and low-resistance (LR). The exercise protocol involved Scott and leg stretching for the lower limbs and stretch underarm and chest press for the upper limbs. The subjects performed each exercise 3 times (one minute rest between sets). The high-resistance group performed the test in 85 to 90% of one repetition maximum (4 to 6 reps) and the low-resistance group performed the test in 25 to 30% of one repetition maximum (25 to 30 reps). Malondialdehyde (MDA) as an index of lipid peroxidation was measured before exercise, immediately, 6 and 24 h after exercise. Our data were analyzed using two factor repeated measures. Our results revealed a significant increase in MDA in response to two different resistance exercise intensities at pre and post exercise time points in two groups ($P < 0.05$). The results showed, a significant difference was observed in MDA level after challenge between two groups and greater amounts were observed in the high intensity group ($p < 0.01$ $F = 208.99$). Overall, although both intensities appeared to increase resistance oxidative stress, the values of the HR group was significantly higher.

**Keywords:** Resistance exercise, oxidative stress, free radicals, Malondialdehyde.

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## INTRODUCTION

Production of reactive oxygen and nitrogen species (RONS), including singlet oxygen (O), superoxide ($O_2^-$), hydrogen peroxide ($H_2O_2$), hydroxyl (OH), peroxynitrite ($ONO_2$), and nitric oxide (NO), is a result of natural cellular metabolism, which seems to rise in mental and physical stress (Sen et al., 1994). Adequate intensity of both aerobic and anaerobic exercises is followed by a rise in the oxidation of macromolecules (Bloomer et al., 2006). In anaerobic exercises (e.g. resistance, isometric), there are other pathways of RONS production, including ischemia-reperfusion, xanthine and NADPH oxidase production, prostanoid metabolism, phagocytosis respiratory burst activity, disruption of iron-containing proteins, and changes in calcium homeostasis (Bloomer et al., 2006; Bloomer and Goldfarb, 2004). The RONS production through these pathways may, to some extent, result from eccentric muscle activities, which will damage muscle tissue (McHugh et al., 1999). Resistance exercises have many advantages, including weight control, prevention of osteoporosis, improvement of cardiovascular risk factors, and injury prevention (Dinubile, 1991; Verrill and Ribisl, 1996). They, furthermore, stimulate hormonal responses, which influence muscle growth and regeneration (Kraemer and Ratamess, 2005). However, too much resistance exercise may cause oxidative stress and cell damage (Liu et al., 2005). Only two hypotheses propose that resistance exercises can contribute to an increased

formation of free radicals at active muscles. One hypothesis addresses the damage induced by ischemia-reperfusion (McBride et al., 1998). Severe muscle contractions may induce a temporary decline in blood circulation and available oxygen, as well as, the resulting ischemia-reperfusion. Subsequent to contraction (muscle relaxation) and reperfusion, a huge load of extraordinary oxygen is produced, which results in the formation of $O_2^-$ radicals. Mechanical pressure is another hypothesis for justifying the increased free radical production (Viitala et al., 2004). In particular, eccentric exercises tend to damage muscle tissue, as they maintain high levels of force. The resulting inflammation process triggers the production of free oxygen radicals. The significant increase in free radical production can, indirectly, be determined through measuring the produced lipid peroxidation, including plasma malondialdehyde (MDA) (Halliwell and Chirico, 1993). The majority of studies conducted in this area have focused on the effects of exercise on aerobic activities (Maughan et al., 1989; Child et al., 1999; Kanter et al., 1988; Kanter et al., 1993; Dillard et al., 1978; Pincemail et al., 1990; Sumida et al., 1989), while, a limited number of studies has addressed resistance exercises and free radical formation (McBride et al., 1998; Güzel et al., 2007). Some studies (Sahlin et al., 1992; Saxton et al., 1994; Dixon, 2002) have shown that resistance exercises exert no influence on the rise of free radical formation. However, others (McBride et al., 1998; Güzel et al., 2007), have observed a significant increase in the degrees of oxidative stress indices. Accordingly, the aim of this study was to investigate the effects of two different protocols of resistance exercise, in terms of volume and intensity, on oxidative stress in untrained male students.

## METHODOLOGY

This semi-empirical applied study was conducted using two sample groups and fourtime points of testing. A number of 16 untrained voluntary male students participated in this study. Subjects who did not do any regular resistance exercises in the past year were considered untrained. Cooperation, personal information, and medical background questionnaire was, first and foremost, filled by the participants. Any record of illness, skeletal and muscular injury, and medication and supplement intake were taken into consideration inthe questionnaire. The subjects were randomly assigned to two high intensity (HR) (n = 8) and low intensity resistance exercise groups (n = 8), and were informed of the stages of the study. Then, height and weight of each subject was measured and their body fat was estimatedthrough bioelectrical impedance analysis (Inbody mass, made in South Korea). The participants were introduced to 4 resistance exercises, including Scott and leg stretching for the lower limbs, and *latissimus dorsi* (underarm) stretch and chest press for the upper limbs, and their single repetition maximum, one week before commencing the study.

The subjects underwent the tests with two intensities. The HR group performed the test in 85 to 90% of one repetition maximum (4 to 6 reps) and the LR group performed the test in 25 to 30% of one repetition maximum (25 to 30 reps).

The subjects were asked to abstain from having protein foods, foods enriched in anti-oxidant substances including vitamins C and E, doing intense sports activities, and taking medications which may affect the study results, three days prior to and one day after the tests were conducted.

Subjects commenced the resistance exercises in the morning, while fasting. After 15 min of warm-up and stretching exercise, both groups performed the resistance exercise in 3 rounds. The recovery time was designated at 30 seconds for each round and 1 min between different exercise stations.

Venous blood samples were taken from the forearm before the bout, immediately after the bout (within 1 min), and 6, 24 h after the bout, which were preserved in the ice compartment until transferred to the laboratory. To collect plasma, prior to being centrifuged for 15 min at 1000 rounds per min, the samples were left at room temperature for 30 min to coagulate. The plasma was, later on, divided into two equal parts and preserved at -80°C. Samples were centrifuged for a second round after melt down and before the experiment.

As for MDA measurement, Cusabio kit, manufactured by a Chinese-American Company, was used.

Descriptive statistics was utilized to describe the data, and determine the mean and standard deviation, and repeated measures ANOVA and Bonferroni post hoc test were employed to compare MDA values before and after resistance exercise with high and low intensities in 4 intervals.

## RESULTS

The participants' physical characteristics including age, weight, height, and body mass index are presented in Table 1.

As shown in Figure 1, basic MDA index values were identical for both groups, and MDA levels rise immediately after cessation of the exercise ($P < 0.05$ for both groups). This sudden increase is significantly higher in the HR, rather than for the LR group ($P < 0.05$). MDA levels in both groups sharply decline 6 and 24 h post-exercise, and return to pre-exercise levels (Table 2).

Significance of time-related indices indicate that MDA levels, regardless of the group type, are different in all 4 measurement intervals ($P < 0.01$, $F = 208.99$). Furthermore, significance of the indices pertinent to the interaction of time and exercise intensity also maintains that changes of MDA level are different in the two groups ($P < 0.01$, $F = 16.60$).

Figure 2 shows that the changes of MDA values for all 4 measured intervals were higher in HR, compared to LR group.

## DISCUSSION AND CONCLUSION

The present study investigated the effects of different resistance exercise protocols on plasma lipid peroxidation index of untrained male students. The results revealed a significant increase in MDA, in response to two different resistance exercise intensities, before and immediately after the exercise in both groups ($P < 0.05$); moreover, the two groups showed a significant

**Table 1.** Descriptive findings pertaining to individual particulars of the participants.

| Variable | | Mean | Standard deviation | Min | Max |
|---|---|---|---|---|---|
| Age (yrs) | Low intensity | 25.43 | 2.14 | 22 | 28 |
| | High intensity | 25.37 | 2.72 | 22 | 29 |
| Weight (kg) | Low intensity | 70.11 | 6.17 | 63 | 78 |
| | High intensity | 69.70 | 7.47 | 58.60 | 84 |
| Height (cm) | Low intensity | 174 | 6.50 | 169 | 185 |
| | High intensity | 173.87 | 7.47 | 167 | 190 |
| BMI ($kg/m^2$) | Low intensity | 22.74 | 0.85 | 21.60 | 24.10 |
| | High intensity | 23.02 | 1.12 | 21 | 24.20 |

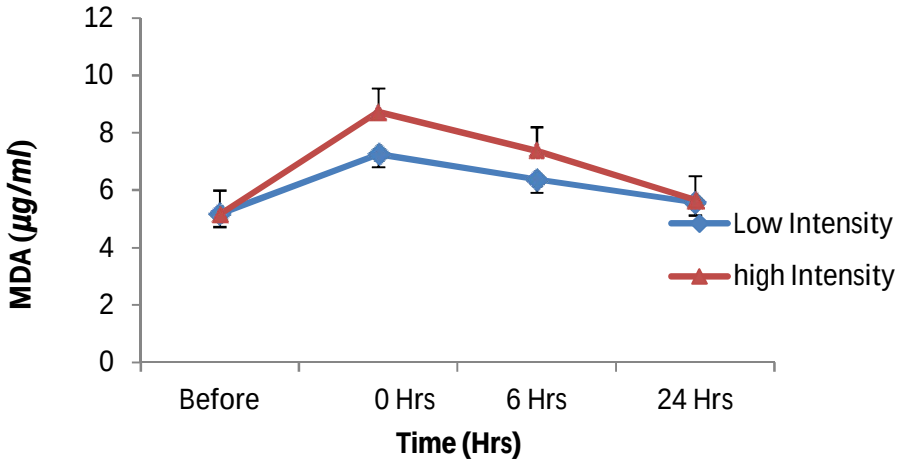


**Figure 1.** Malondialdehyde (MDA) value changes before and after one high and low intensity resistance exercise session.

**Table 2.** Repeated measures ANOVA test indices to compare malondialdehyde (MDA) values before and after single session resistance exercise, separated by low and high intensity exercises.

| Variable | Source of changes | Sum of squares | Degree of freedom (df) | Mean square | F | Significance level |
|---|---|---|---|---|---|---|
| MDA | Time | 72.54 | 3 | 24.18 | 208.99 | 0.001 |
| | Time (intensity) | 5.76 | 3 | 1.92 | 16.60 | 0.001 |
| | Error | 4.51 | 39 | 0.116 | | |

difference in terms of MDA values, immediately after cessation of exercise ($P < 0.05$).

Significance of time-related indices indicate that the MDA levels, regardless of the group type, are different in all 4 measurement intervals ($P < 0.01$, $F = 208.99$). Furthermore, significance of the indices pertinent to the interaction of time and exercise intensity also maintains that changes of MDA level are different in the two groups ($P < 0.01$, $F = 16.60$).

Numerous different exercise models have been implemented in order to recognize the effects of intense physical activity on the different indices of oxidative stress (McBride et al., 1998; Viitala et al., 2004; Alessio et al., 2000; Atalay et al., 1996; Khanna et al., 1999; Lovlin et al., 1987; Simpson et al., 2005). Resistance bouts are composed of repeated static muscle exercises, including concentric and eccentric muscular activities, considered as low and high intensity resistance exercises, respectively (Liu et al., 2005). A number of studies have investigated the oxidative stress induced by resistance exercises (McBride et al., 1998; Surmen-Gur et al., 1999). An increase in blood MDA was observed

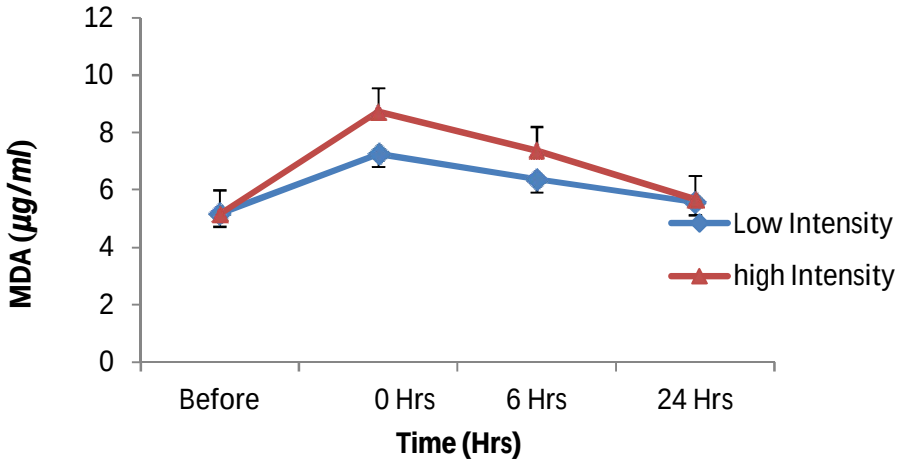


**Figure 1.** Malondialdehyde (MDA) value changes before and after one high and low intensity resistance exercise session.

within 2 days after the resistance training protocol (McBride et al., 1998), while, 6 min after performing 20 eccentric-concentric repetitions involving knee extensors, no change was reported in blood MDA (Surmen-Gur et al., 1999). The difference in exercise protocols seems to account for the diverse results. In this study, both high and low intensity resistance exercises led to a significant increase in lipid peroxidation, immediately after the bout ($P < 0.05$); however, the HR group recorded higher values (Figure 2). Maughan et al. (1989) maintain that peak MDA changes occur within 6 h post-exercise, whereas, some studies have only investigated MDA levels immediately post-exercise. Other studies, addressing the type of resistance exercise and free radical formation, did not report any increase in free radical formation (Sahlin et al., 1992; Saxton et al., 1994; Dixon, 2002). This may be due to lighter weights and lower muscle tissue activation.

Intense muscle contractions accompanied by resistance exercises may cause ischemia-reperfusion at active muscles. For skeletal muscles, free radicals act as mediators of the injury induced by ischemia-reperfusion. Similarly, Kanter et al. (Kanter et al., 1988; Kanter et al., 1993) showed that plasma MDA levels maximized in both groups immediately post-exercise, with higher values observed in the HR group.

Results from this study are consistent with those reported by Guzel et al. (2007) and Goto et al. (2003), and inconsistent with results observed by Dixon (2002) and Goldfarb et al. (2008).

Dixon's work (2002) lacked the required physiological threshold to stimulate free radical formation. Low lactate volume, low exercise volume, and lower muscle activation, which characterize the exercise protocol, may justify the mentioned contradiction. Accordingly, it seems that in order to be able to measure plasma MDA changes, higher threshold intensity is required for resistance exercises. As indicated by the results, full body resistance exercises stimulate oxidative stress to a certain level enough to trigger free radical formation (Güzel et al., 2007). In athletes, on the other hand, acquired adaptations decrease cell damages caused by exercise-induced free radical formation (Dixon, 2002).

According to the results, increased MDA production in response to two different resistance exercises leads to a significant increase in the obtained values before and immediately after the exercise in both groups ($P < 0.05$). Furthermore, there is a significant difference between the two groups in terms of MDA levels.

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