Comparison of the effect of rest interval between sets and set – repetition configuration during bouts of eccentric exercise on muscle damage and inflammatory markers

Hossein Mohammadi¹, Mohammad Esmaiel Afzalpour², Seyed Hossein Abtahi Ivary³*

¹Sport Physiology Dept., University of Birjand, Birjand, I.R. Iran, ²Sport Physiology Dept., University of Birjand, Birjand, I.R. Iran, ³Medical Dept., Gonabad University of Medical Sciences, Gonabad, I.R. Iran

ABSTRACT:
Background and Objective: Various studies have demonstrated that different rest Intervals has a significant effect on hormonal, metabolic and cardiovascular responses. This factors can lead to different muscle damage responses. Materials and Methods: 40 untrained subjects (25.4 ± 0.068 years, height 1.74 ± 0.97 cm and weight 30.8 ± 8.48 kg) in three sessions of eccentric resistance exercise with 24 hours rest between each session Participated in this study. Subjects were divided into 4 groups, A group: 5 sets of 10 repetition with the interset rest interval 1 minutes, B group: 10 sets of 5 repetition with the interset rest interval 3 minutes, C group: 10 sets of 5 repetition with the interset rest interval 3 minutes and D group: 5 sets of 10 repetition with the interset rest interval 3 minutes that performed 50 eccentric contractions with 85% of one repetition maximum. Each set includes 10 or 5 contractions that lower a person’ s weight in 3 s and at least 2 s to reach the next contraction without weights placed in full flexion Around 1- or 3-min rest was given between each set. The experimental protocol was repeated for three consecutive days. The range of motion, the arm circumference, soreness and Alpha necrosis tumor factor were measured immediately before, immediately after and 24 hours after training. Results: Variance analysis with repeated measure demonstrated, non-dominant arm circumference (P= 0.44), soreness (P= 0.76) and alpha necrosis tumor factor (P= 0.37) in different time points in 4 groups significantly increased and the range of motion (P= 0.44) decreased, but no significant difference in all dependent variables were found in 4 groups at different time points (P <0.05). Conclusion: Mechanisms of muscular damage caused by consecutive eccentric activities is independent of manipulating resistance exercise components (rest and the number of set-repetition) and possibly related to the muscular pressure entering to the muscles. Keywords: Eccentric physical activity, muscle damage, inflammatory markers, rest interval, set – repetition configuration

DOI: 10.22631/ijaep.v7i1.238
INTRODUCTION
Resistance exercises are one of the types of sport exercises to increase muscle volume and increase strength. For this purpose, different strength training methods such as variable resistance, by manipulating the number of repetitions and sets, contraction rates and resting intervals between sets and repetitions[1]. A common type of resistance training is eccentric exercise that is associated with cellular damage, which usually appears as a delayed onset muscle soreness [12, 11]. Delayed onset muscle soreness is a common experience after physical activity, which is associated with reduced movement, pain, swelling and loss of functional strength [4].

Warming up before workout, cooling down afterwards and stretching; have always been considered as strategies to prevent delayed muscle pain. In addition to these methods, many drug therapies have been used to reduce the symptoms and complications of delayed onset muscle soreness [4].

Adaption with eccentric exercise occurs when the same exercise is repeated in the following days (The bout repeated effect) [4]. In this type of exercise, by varying the number of repetitions, the number of sets, the rest time between the training sessions and inter set rest interval, different results are obtained [5]. Among these variables, the inter set rest interval and the number of sets and repetitions are important variables that manipulating it to change the goals of the exercise [6].

Rodrigo [8 ] investigated the changes in cellular injury indices after two eccentric exercises with a 4 week rest interval with 100% intensity of one maximum repetition, with a difference in the number of contractions. The results of this study showed that the number of contractions versus set-repetition manipulation is more effective than muscle damage. On the other hand. The initiation of primary muscle damage induced by high-force eccentric exercise may be fatiguing but is not painful; however, the ensuing inflammatory response leads to delayed-onset muscle soreness beginning 8–24 h after the damage is initiated [8]. Primary muscle tissue damage promotes infiltration by inflammatory cells that, in conjunction with local muscle, endothelial, and satellite cells, produce an array of cytokines to regulate the inflammatory process, including TNF-, IL-1, and IL-6 [8]. The relationship between markers of muscle injury induced by eccentric exercise and indications of inflammation is complicated and inconsistent across investigations. Events of both the muscle damage and inflammatory responses occur in a specific order with peaks and durations that vary among individuals [8].

Given that even if the total number of eccentric contractions in a similar exercise is similar, it is likely that the magnitude of muscle damage varies according to the number of sets, the number of repetitions, the rest time between the training sessions and inter set rest interval, and given that most of the research The past has been examining an outsourcing exercise that is less like an athlete training program; it's a question of which rest time (one minute to three minutes) and how many times leads to less muscle damage?

METHODS
40 subjects were selected randomly and divided into four groups of 10: the first group was rested one minute and five set with 10 repetitions; the second group was resting for
one minute and 10 set with 5 replications; the third group was resting for three minutes and five set With 10 replications, the fourth group was divided by rest for three minutes and ten set with 5 replications.

In the present study delayed onset muscle pain free weights (dumbbells) were used. Because, eccentric contractions may cause delayed muscle aches, lifting the second phase, which involves reducing weight with the non-dominant hand was used [4]. In order to become familiar with the test and the 1RM, subjects were recruited through questionnaires 48 hours before the start of the performance were invited to the Physical Education School Hall. During their meeting, they start to warm up for 5 minutes.

After warming up, the estimated 1RM, with 3 to 5 repetition, the maximum concentric contraction was in the non-dominant hand [4].

48 hours after the test, measurements were performed in the period between 8pm to 11pm. Subjects initially completed questionnaire and consent form.

Questions were as follows: Participants should not experience neurological, muscle, heart and brain disease, and the history of the non-dominant upper limb fractures were included. During the 6 months prior to the study, the non-dominant upper body weight-training had drug injection and during the 10 days prior to study, It is better for them to feel at the beginning of the training.

They did not have high- fat meal, especially during the protocol and the night before each workout had to begin. Height, weight, and blood samples for determination of Alpha Necrosis Tumor Factor levels were measured. Too, soreness, range of motion and Arm circumference were measured [4].

The VISUAL ANALOG SCALE (VAS) was used to measure muscle soreness. This scale contains 10 degrees, zero indicates the absence of pain, and grade 5 represents the pain that is caused by motion and creates a limited amount of pain. Grade 10 also indicates pain that may prevent any movement [4].

To measure the Arm circumference, first, the midpoint of the acromion-radial line was determined. The person then placed his hand in the hanging position next to the body, and the arm circumference at the indicated point was measured vertically on the arm length [7,4].

To measure the range of motion, the fixed arm of the goniometer was aligned with the acromion-radial line, and the moving arm of the goniometer was placed on the radial line-lowered ground in anatomical state [7].

For the measurement of Alpha Necrosis Tumor Factor levels (France Diaclone Kit), 5 ml of venous blood radius (antecubital) was performed by an expert. Blood samples of 5 minutes at room temperature were immediately centrifuged. When the serum was separated, it was stored at -20°C for subsequent analysis. All measurements were performed by one person. The subjects sat on a chair and performed 50 eccentric contractions of 85% 1RM In four groups. Each set includes 10 or 5 contract that lowers a person's weight in 3 seconds and at least 2 seconds to reach the next contraction without weights placed in full flexion [7]. One or three minute rest was given between each set. The experimental protocol was repeated at three consecutive days. All measurements
except contusion, immediately before and after each training session.

**STATISTICAL RESULTS**

**soreness:** The mean of soreness in the four groups was significantly different at different times (p = 0.00). There was no significant difference between all groups (p = 0.712) and time and group interaction was not significant (p = 0.767). (Table 1)

**range of motion:** The mean range of motion in the four groups was significantly different at different times (p = 0.001). There was no significant difference between the four groups (p = 0.013) and time and group interaction was not significant (p = 0.326). (Table2)

**Arm circumference:** The mean arm circumference in the four groups was significantly different at different times (p = 0.00). There was no significant difference between groups (p = 0.66), and time and group interaction was not significant (p = 0.446). (Table 3)

**Alpha Necrosis Tumor Factor:** The mean of tnf alpha in the four groups was significantly different at different times (p = 0.00), and no significant difference was observed between the groups (p = 0.284), and the interaction between time and group was not significant P= 0.371). (Table4)

---

**Table 1: Analysis of repeated measurment variance of soreness in four groups**

| Source       | Type III Sum of Squares | df | Mean Square     | F   | P   |
|--------------|-------------------------|----|----------------|-----|-----|
| Time         | 648.00                  |    | 262.363        | 22.961 | 0.00 |
| group        | 56.00                   |    | 7.558          | 0.661 | 0.712 |
| interaction  | 16.50                   |    | 5.50           | 0.382 | 0.767 |

**Table 2: Analysis of repeated measurment variance of range of motion in four groups**

| Source       | Type III Sum of Squares | df | Mean Square     | F   | P   |
|--------------|-------------------------|----|----------------|-----|-----|
| Time         | 599.730                 |    | 201.282        | 6.003 | 0.001 |
| group        | 3122.33                 |    | 1040.77        | 4.154 | 0.013 |
| interaction  | 348.59                  |    | 38.988         | 1.163 | 0.326 |

**Table 3: Analysis of repeated measurment variance of arm circumference in four groups**

| Source       | Type III Sum of Squares | df | Mean Square     | F   | P   |
|--------------|-------------------------|----|----------------|-----|-----|
| Time         | 5.482                   |    | 3.815          | 1.947 | 0.00 |
| group        | 82.215                  |    | 27.405         | 0.542 | 0.656 |
| interaction  | 8.053                   |    | 1.868          | 0.953 | 0.446 |

**Table 4: Analysis of repeated measurment variance of tnf alpha in four groups**

| Source       | Type III Sum of Squares | df | Mean Square     | F   | P   |
|--------------|-------------------------|----|----------------|-----|-----|
| Time         | 9786.87                 |    | 9685.94        | 48.59 | 0.00 |
| Group        | 743.662                 |    | 247.88         | 1.315 | 0.284 |
| Interaction  | 661.66                  |    | 150.67         | 1.095 | 0.371 |
Table 5: Mean and deviation of mean Variables in four groups

| Variable                    | Group       | Pre test | Post test 1 | Post test 2 | Post test 3 | 24 hour after post test 3 |
|-----------------------------|-------------|----------|-------------|-------------|-------------|--------------------------|
| Soreness (degree)           | 5×10×1      | 0.00±0.00| 0.00±0.00   | 4.97±4.50   | 3.49±2.00   | 1.58±5.00                |
|                             | 10×5×1      | 0.00±0.00| 0.00±0.00   | 4.97±4.50   | 3.49±2.00   | 1.58±5.00                |
|                             | 10×5×3      | 0.00±0.00| 0.00±0.00   | 4.59±4.00   | 4.97±4.50   | 0.00±0.00                |
|                             | 5×10×3      | 0.00±0.00| 0.00±0.00   | 4.71±5.00   | 3.49±2.00   | 1.58±5.00                |
| range of motion (degree)    | 5×10×1      | 5.97±144 | 6.04±144    | 5.41±138    | 7.42±138    | 6.97±137                 |
|                             | 10×5×1      | 10.97±136| 11.20±137   | 9.66±136    | 10.44±132   | 8.65±134                 |
|                             | 10×5×3      | 8.43±134 | 8.43±134    | 6.93±134    | 9.78±130    | 8.99±132                 |
|                             | 5×10×3      | 7.94±129 | 7.94±129    | 8.70±132    | 4.40±126    | 9.59±130                 |
| Arm circumference (cm)      | 5×10×1      | 2.93±31  | 2.93±31     | 3.08±31     | 3.52±30     | 2.87±31                  |
|                             | 10×5×1      | 2.19±32  | 2.19±32     | 2.30±32     | 2.47±33     | 2.35±32                  |
|                             | 10×5×3      | 4.30±31  | 4.30±31     | 4.19±31     | 4.24±31     | 4.36±31                  |
|                             | 5×10×3      | 2.80±31  | 2.80±31     | 3.15±32     | 3.34±32     | 3.23±32                  |
| Alpha Necrosis Tumor Factor (nM/mL) | 5×10×1      | 1.98±8.07| 2.40±7.67   | 2.38±7.96   | 11.73±23.72| 3.74±10.10               |
|                             | 10×5×1      | 5.85±10.89| 3.09±9.74  | 5.41±8.15   | 17.14±21.71| 4.63±9.01                |
|                             | 10×5×3      | 1.99±8.34| 2.51±10.06  | 2.11±7.80   | 15.42±31.37| 2.71±7.08                |
|                             | 5×10×3      | 11.30±14.07| 10.65±12.46| 11.76±12.58| 17.31±31.78| 6.02±11.10               |
DISCUSSION

The results of the mean of the arm circumference during the measurement period showed a significant difference, especially after the third time, which showed an increasing trend in all groups, but no significant difference was observed among the groups. The results of this study are in agreement with the results of the research [7, 4]. Possible mechanism for increasing the arm's environment can be due to swelling, which is also due to increased capillary permeability, which results in the transfer of protein-rich fluid and the migration of neutrophils from the bloodstream to the damaged tissue.

On the other hand, alpha tnf level in all groups at different stages of time was significantly different, especially after the last training, which showed an increasing trend, but no difference was observed between the groups. The results of this study are consistent with the results of research [3] and do not conform to results [4]. The mechanism of release of cytokines that produce an inflammatory reaction during exercise is triggered by skeletal muscle damage. Split protein particles collide with white blood cells and release cytokines. This indicates that only intense exercise or eccentric exercises can increase cytokines. One of the limitations of this research is the lack of measurement of other cytokines. Therefore, high levels of alpha tnf indicate chronic inflammation due to the repetition of eccentric exercise [10,9,3,2]. For other reasons, body temperature increase, low physical fitness, and exercise protocols are different [10,9,3].

The range of motion in all groups was decreased and this trend continued for up to 24 hours after the last training, and a significant difference was observed only between the two groups of 10 × 5 ×1 and 5 × 10 × 1 groups, so that the range of motion in the 10 × 5 ×1 group There was a further reduction. The results of this study are consistent with the results of research [7] and do not conform to results [4]. The mechanism of reducing the range of motion is the defect of the sarcomairs drawn in the actin and myosin and the increase in intracellular calcium ion due to damage to the sarcoplasmic network. Also, the mechanism of reducing the range of motion according to the time intervals between the one-minute set of three-minute intervals due to increased accumulation of hydrogen ion and lactic acid and in the rest period of three minutes is probably due to the tear of the components of myofilamans [4].

On the other hand, there was no significant difference in the response to muscle pain at the time of observation, but there was no significant difference between the groups. The pain was increased in 24 hours after the first time and then decreased to the end in all groups. The results of this study are consistent with the research [4]. Following initial mechanical damage, elevated intracellular calcium activates intracellular destruction pathways, which stimulate inflammatory responses and stimulate neural terminals of type three and four. Also, the accumulation of histamine, potassium and quinine increases the temperature and stimulates pain receptors.

Conclusions

In general, the results of this study showed that repetition of eccentric exercise during three consecutive days increased muscle damage and did not result in adaptation, which is independent of the difference in rest intervals between sets and number of sets-repetitions. Therefore, it should be noted that due to the lack of adaptation in the present study, the rest interval of 24
hours is not enough recovery time to return the person to the proper time, and at least 48 hours between the levels Exercise resistance Exercise.

REFERENCES

1. Arazi H, Rahimi R. The effect of different rest intervals between multiple bench press bouts. South African Journal for Research in Sport, Physical Education and Recreation, 2011. 33(1): 1-8.
2. Howatson K, Van Someren, Hortobágyi T. Repeated Bout Effect after Maximal Eccentric Exercise. International Journal of Sports Medicine, 2007. (28), 557–563.
3. Mayhew D, Thyfault J, and Koch A. Rest-interval length affects leukocyte levels during heavy resistance exercise. Journal of Strenght and Conditioning Research, 2005. (19) 16-22.
4. Mohammadi H, and Sahebazamani M, Ghahraman tabrizi K. The effect of repeated bouts of eccentric exercise on some of Biochemical markers of Delayed onset muscle soreness. International Journal of Applied Exercise Physiology, 2015. Vol 1(2).
5. Pereira R, and Machado M. Resistance exercise- induced microinjuries do not depend on 1 or 3 minutes rest time interval between series. International Journal of Science Issn, 2007. 1885-3137.
6. Rodrigues BM, Dantas E, Salles BF, Miranda H, Koch AI, Willardson JM. Creatine kinase and lactate dehydrogenase responses after upper body resistance exercise with different rest intervals. Journal of Strenght and Conditioning Research, 2010. 24:1657-1662.
7. Chan R, and et al. Effects of set-repetition configuration in eccentric exercise on muscle damage and the repeated bout effect. European Journal of Applied Physiology, 2011. (7), 2653–2661.
8. Rodrigo F, and et al. Effects of a 4-week eccentric training program on the repeated bout effect in young active women. Journal of Sports Science and Medicine, 2011. (10), 692-699.
9. Stephen M, Cornish A, Steven T. Systemic cytokine response to three bouts of eccentric exercise, 2014. 4, 23–29.
10. Trevor C, and et al. Effects of a 7-days eccentric training period on muscle damage and inflammation. Medicine Science in Sports Exercise, 2001. 33(10),1732-8.
11. Willardson J. M. A brief review: factors affecting the length of the rest interval between resistance exercise sets. Journal of Strength and Conditioning Research, 2006. 20(4), 978–84