Characterization of the Effects of One Maximal Repetition Test on Muscle Injury and Inflammation Markers

Corresponding Author:
Dr. Sandro M Hirabara,
Professor, ICAFE, Cruzeiro do Sul University, Rua Galvão Bueno, 868, 01506-000 - Brazil

Submitting Author:
Dr. Sandro M Hirabara,
Professor, ICAFE, Cruzeiro do Sul University, Rua Galvão Bueno, 868, 01506-000 - Brazil


Source(s) of Funding:
This work was supported by CNPq, FAPESP and CAPES.

Competing Interests:
This study has no competing interests.
Characterization of the Effects of One Maximal Repetition Test on Muscle Injury and Inflammation Markers


Abstract

We assessed the influence of the one repetition maximum (1RM) bench press exercise on the temporal profile of markers of muscular injury (creatine kinase - CK - activity) and inflammation (interleukin-2 - IL-2, IL-1β, tumoral necrose factor-α - TNF-α, IL-6, and C-reactive protein - CRP). Participants were 11 healthy subjects both genders (eight men and three women), active, involved in strength training, for recreational purposes for more than six months. Characteristics of the volunteers were: age (21.5 ± 6.5 years), weight (70.1 ± 21.1 kg), height (172.8 ± 52.1 cm), and fat mass (14.5 ± 5.7 %). Sample blood was collected before the 1 RM test and at 1 h, 24 h, 48 h, and 6 days after the test. Statistical analysis was performed using ANOVA with repeated measurements and Bonferroni post-test. There was a significant increase in the CK activity after 6 days of the test when compared to pre-test time, whereas CRP activity increased 24 and 48 hours when compared to pre-test period. There was not significant difference in the plasma cytokine levels. Although 1 RM test did not alter the levels of inflammatory cytokines, it can be observed through this work that this test can induce muscle damage, which would be a negative factor for athletes, since the muscle injury and inflammation are associated with increased performance, especially strength and muscle power.

Introduction

Before the prescription of resistance exercise, it is common to use some tests in order to evaluate muscle strength and track, as for example the one repetition maximum test (1 RM test). This test, by raising the maximum weight possible in a single complete movement, aims to stimulate the dynamic maximum strength by the practitioner (Ware et al. 1995). The 1 RM test has several advantages, such as low cost, easy implementation, specificity, and ability to adapt to reality of various sports (Barnard et al. 1999). However, physiological changes induced by the 1 RM test have been poorly studied. Here, we evaluated the effects of 1 RM on muscle injury and inflammatory markers in healthy subjects.

Resistance exercise has been shown to be an important intervention for promoting and maintaining health and quality of life. However, the physiological changes promoted by resistance exercise are under investigation yet. It is noteworthy to date that no studies are found about the muscle damage and inflammation caused by the 1RM test in healthy subjects.

Analysis of markers of muscular injury and inflammation is frequently used to investigate whether there is muscle damage induced by exercise (Glesson 2002; Margonis et al. 2007; Uchida et al. 2009). The activity of the creatine kinase (CK) in blood has been used as a main surrogate marker of muscle damage, resulting from eccentric exercise (Stupka et al. 2000; Totsuka et al. 2002; Evans et al. 2002; Nosaka et al. 2002a; Nosaka et al. 2002b; Tartibian et al. 2009). The increase CK activity in plasma indicates that there was a release of the enzyme due to a rupture of the muscle cell membrane (muscle damage), considering that CK does not have the ability to cross the membrane when the sarcoplasm is intact (Brown et al. 1997; Brancaccio et al. 2007). Increased plasma activity of this enzyme is influenced by both the volume and intensity of exercise (Tidus and Ianuzzo 1983; Uchida et al. 2009).

Tissue damage leads to activation of the immune defense cells, the leukocytes, in order to remove unwanted elements arising from such injury (Pyne 1994). When activated, the leukocytes can stimulate the release of proinflammatory cytokines such as tumor necrosis factor-α (TNF-α) and interleukins (IL), IL-8 and IL-6. These factors stimulate the release of anti-inflammatory cytokines as IL-1ra and may also stimulate the acute phase proteins, such as C-reactive protein (CRP) (Nieman et al. 2005; Smith 2000b; Robson 2003; Steensberg et al. 2003).

Abrupt increases in markers of muscle damage and inflammation resulting from intense muscle effort can affect the immune system and metabolism, impairing the performance of athletes (Nieman 2007;
Steensberg et al. 2003). The 1 RM test is greatly and frequently used for measuring muscle strength, but its effects on muscle damage and inflammatory process is not known yet. Thus, the purpose of this study was to assess the influence of the 1RM bench press exercise on the temporal profile of markers of muscular injury and inflammation in healthy subjects.

Methods

Subjects
Participants of the study were 11 healthy subjects both genders (eight men and three women), active, involved in strength training, for recreational purposes for more than six months. Characteristics of the volunteers were: age (21.5 ± 6.5 years), weight (70.1 ± 21.1 kg), height (172.8 ± 52.1 cm), and fat mass (14.5 ± 5.7 %). The subjects voluntarily signed a consent form. This study was approved by the ethics committee and research of the Cruzeiro do Sul University (protocol No. 039/2009).

Exercise protocol (1 RM test)
For the determination of 1 RM in a bench press exercise, participants were instructed to grip the bar at a comfortable position, which was typically 10 to 20 cm wider than shoulder width (Kim et al. 2002). Subjects performed a warm-up consisting in 3 sets: 1st set: 8–10 repetitions using a light weight (~ 50% of 1 RM); 2nd set: 3–5 repetitions using a moderate weight (~ 70% of 1 RM); 3rd set: 1–3 repetitions using a heavy weight (~ 80% of 1 RM). After the warm-up, each participant was submitted to the 1 RM test by increasing the resistance on subsequent attempts until he or she was unable to finalize a full correct movement. Approximately 5 sets of one repetition were accomplished and each attempt was separated by 3 min of rest (Shimano et al. 2006). The 1 RM tests were accomplished by two trained spotters.

Determination of the CK, plasma interleukin concentrations and serum CRP
CK activity and CRP were determined by a highly sensitive immunoturbidimetric method (Bioclin Diagnostics, São Paulo, Brazil), according to the manufacturer’s instructions. Plasma concentrations of IL-6, IL-8, TNF-α, and IL-1Ra were determined based on the enzyme-linked immunosorbent assay (ELISA), using a Duoset Kit (Quantikine, R&D Systems, Minneapolis, MM, USA), following the manufacturer’s instructions.

Statistical analysis
Analysis of variance (ANOVA) with repeated measurements, followed by the Tukey post-test, was performed to verify the statistical differences. Criterion for statistical significance was set at p <0.05.

Results

Illustration 1 shows the activity of CK and the concentration of CRP in plasma (Illustration 1A and 1B, respectively). The 1 RM test increased the CK activity after 24 h, remaining elevated up to 6 days after the test (p<0.05) in a time-dependent manner (Illustration 1A). CRP concentration was elevated 24 h after the 1 RM test (p<0.001), remained elevated up to 48 h (p<0.001) and returned to the basal value at 6 days after the test (Illustration 1B). No changes in the pro-inflammatory cytokines IL-6, TNF-α and IL-1Ra induced by 1 RM test were found (Illustration 2).

Discussion

Although a growing number of studies focusing the changes in markers of inflammation and injury during and after resistance exercise, nothing is known about the physiological aspect of the test after completion of a 1 RM test, one exercise of high intensity and low volume. In this study, we found a linear increase in activity of CK at the times 24 h, 48 h, and 6 days after the 1 RM test. Studies have shown that CK may remain increased up to 7 days after the execution of an effort (Brancaccio et al. 2007; Bruunsgaard et al. 1997).

Uchida et al. (2009) conducted a study which aimed to investigate muscle damage in different intensities in bench press exercise. The intensities were 50%, 75%, 90% and 110% of 1 RM. The activity of CK enzyme increased significantly in all groups after bout, with no significant difference among groups, probably because the total volumes were similar among them. Already Paschalis and colleagues (Paschalis et al. 2005) compared two different protocols of resistance exercise, with a moderate and one with high intensity, finding a significant increase of CK in both protocols. But, it is noteworthy that the highest value of CK activity presented in this study was found in the group who performed intense exercise, showing that the intensity of exercise is the major factor in modulating the response of CK activity.

Were also evaluated some markers of muscle inflammation. These markers were cytokines (IL-8, IL1R-a, TNF-α and IL-6), which did not show significant changes with the test of 1RM. Our results
corroborate the findings of Uchida et al. (2009) and Hirose et al. (2004), who also found no significant changes of the cytokines analyzed with a protocol of strength training. The Uchida study (2009) evaluated the cytokines IL-6 and IL-1β, in addition to TNF-α. No significant change was found in none of these cytokines in any of intensities studied (50, 75, 90 and 110% of 1 RM). Hirose et al. (2004) investigated the effect of a protocol of eccentric exercise (6 sets of 5 repetitions in exercise of elbow flexors) in several cytokines, among them the IL-1ra, IL-6, IL-8 and TNF-α. These cytokines, in corroborating with our results, were not significantly modified by the eccentric exercise. Changes in plasma cytokines have been found in exercises cyclic bulk (Toft et al. 2000; Nieman 2001). Thus, one possible reason for the lack of alteration of cytokines in our study is the small volume used by the 1 RM test. In addition, an important factor that should be taken into account is the difficulty in detecting cytokines in plasma, due to the short time that they are stable (Petersen and Pedersen 2005).

In the present study, we found an increase in acute phase protein CRP, which peaked at 48 hours after the 1 RM test. CRP has proinflammatory characteristics (activation of the complement system and opsonization of bacteria) and anti-inflammatory (to prevent the adhesion of neutrophils to endothelial cells, inhibit the generation of superoxide by neutrophils and stimulating the synthesis of the receptor antagonist IL-1) (du Closs 2000; Epstein 1999, Semple et al. 2004). Taylor et al. (1987) found an increase of 300%, 24 hours after performing a triathlon race. Semple and colleagues (2004) also found a significant increase of this protein after an ultramarathon. It is well known that the cytokines IL-6 and TNF-α stimulate the production of acute-phase proteins, such as CRP (Semple et al. 2004; D Closs 2000). In our study we found a significant increase in CRP, but was not detected increased IL-6 and TNF-α, possibly because the CRP is more stable in plasma than cytokines, which are more difficult to detect (Pedersen 2005).

In conclusion, the 1 RM test (a session of high intensity, but low volume) was enough to increase CK activity and CRP concentration in the plasma. These results suggest that indeed there were muscle damage and inflammatory response (increased CRP) after the 1 RM test. Concentration of pro-inflammatory cytokines, however, was not modified by the test.

Conclusion(s)

The 1RM test is widely used by athletes of various sports. It can be observed through this work that this test of high intensity and low volume can lead to induction of muscle damage, which would be a negative factor for the athletes, since the muscle injury and inflammation are associated with decreased performance, especially strength and muscle power. Therefore, special care must be taken in introducing the 1RM test in sports periodization.

Abbreviation(s)

1 RM, one repetition maximum; IL, interleucin; TNF, tumoral necrosis factor; CK, creatine kinase; CRP, C-reactive protein

Acknowledgement(s)

This study was supported by grants from FAPESP, CNPq, and CAPES.

References

Illustrations

Illustration 1

Means and standard deviations of the activity of CK (A) and concentration of CRP (B) at baseline (pre) and after the 1RM test session at 1 h (post), 24 h, 48 h, and 6 days.

Illustration 2

Mean (and range) of the concentrations of L-6, IL-8, IL-1ra and TNF-α at baseline (pre) and after the 1 RM test session at 1 h, (post), 24 h, and 48 h.

<table>
<thead>
<tr>
<th>Cytokine (pg/mL)</th>
<th>Pre mean (range)</th>
<th>Post mean (range)</th>
<th>24h Mean (range)</th>
<th>48h Mean (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IL-6</td>
<td>4.2(3.2-5.2)</td>
<td>4.2(3.2-5.9)</td>
<td>3.9(2.6-5.4)</td>
<td>4.5(3.2-5.8)</td>
</tr>
<tr>
<td>TNF-α</td>
<td>4.2(3.6-5.3)</td>
<td>4.4(3.1-5.6)</td>
<td>3.9(3.1-4.9)</td>
<td>3.7(3.1-5.5)</td>
</tr>
<tr>
<td>IL-8</td>
<td>2.7(1.7-3.5)</td>
<td>2.5(1.7-3.8)</td>
<td>2.7(1.6-3.9)</td>
<td>2.8(1.4-3.8)</td>
</tr>
<tr>
<td>IL-1 ra</td>
<td>6.9(5.8-7.7)</td>
<td>6.6(5.4-7.8)</td>
<td>5.9(4.8-7.4)</td>
<td>6.1(3.8-9.4)</td>
</tr>
</tbody>
</table>
Disclaimer

This article has been downloaded from WebmedCentral. With our unique author driven post publication peer review, contents posted on this web portal do not undergo any prepublication peer or editorial review. It is completely the responsibility of the authors to ensure not only scientific and ethical standards of the manuscript but also its grammatical accuracy. Authors must ensure that they obtain all the necessary permissions before submitting any information that requires obtaining a consent or approval from a third party. Authors should also ensure not to submit any information which they do not have the copyright of or of which they have transferred the copyrights to a third party.

Contents on WebmedCentral are purely for biomedical researchers and scientists. They are not meant to cater to the needs of an individual patient. The web portal or any content(s) therein is neither designed to support, nor replace, the relationship that exists between a patient/site visitor and his/her physician. Your use of the WebmedCentral site and its contents is entirely at your own risk. We do not take any responsibility for any harm that you may suffer or inflict on a third person by following the contents of this website.