Stability of Experienced Lifters’ Heart Rates During and After Free Weight Exercises

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ABSTRACT


Heart rates (HR) during and after bench and squat pyramid free weight lifting cycles of 10, 8, 6, 4, 6, 8, 10 repetitions at 50, 65, 75, 85, 75, 65 and 50 percent of 1 RM, respectively, were obtained on 40 experienced lifters. Testing sequence was randomly assigned and repeated after two but no more than seven days. HRs were determined using UNIQ CIC Heart Watches which were programmed to record/store HRs at five second intervals beginning with the initial lift and ending when the HR began to decrease during recovery after the final descending cycle of the pyramid. The exact time for each lift was determined and the HR during the last five seconds was used to represent the HR for that lift. HRs obtained immediately after the lift represented the initial recovery HR. A second recovery HR was the highest (peak) obtained during the recovery. There were no significant ($p > 0.01$) differences in HRs between any individual cycles on days one and two. Differences in HRs among the various repetitions, exercises and days one and two revealed that HRs during both recovery periods were significantly ($p < 0.01$) higher in response to the squats than for the bench press. There were no significant ($P > 0.01$) differences in HRs between any individual cycles on days one and two.

KEY WORDS: heart rates, experienced weight lifters, free weights, strength

INTRODUCTION

The physiological response to submaximal aerobic exercise has been extensively investigated and clearly demonstrates that heart rates increase proportionally to the metabolic demands of this type of exercise. The heart rate responses to weight lifting or resistive exercise, however, do not appear to be as directly related to metabolic requirements but are complicated by various factors, such as the type of contraction, muscle mass, amount of weight lifted, number of repetitions, time between repetitions, etc. (2, 7, 13, 15). Generally, the studies investigating heart rate responses to weight lifting have involved resistance exercise using various machines such as the Universal (4, 5, 14, 18), Nautilus (6, 8), or multi-purpose hydraulic apparatus (1, 9), rather than free weights, which are typically used by experienced weight lifters. Furthermore the majority of studies which have included heart rates have been in conjunction with measuring VO2 in response to resistive exercise circuits (1, 2, 3, 4, 8, 9, 18) with novice lifters (1, 2, 3, 8, 9, 18). Few studies have described heart rates during free weight lifting exercises in experienced lifters (10, 11, 16) and many did not include post-exercise heart rates. There are few studies which have determined the variability of heart rates during and after performing free weight exercises on different days in experienced weight lifters.

The purpose of this study was to determine the ability to reproduce heart rate response measured on two separate days during pyramid lifting cycles, and at various times during recovery for the bench press and squats in experienced weight lifters using free weights.
Table 1. Subject characteristics (N=40)

<table>
<thead>
<tr>
<th>Variable</th>
<th>( \bar{X} )</th>
<th>SE</th>
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</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>22.4</td>
<td>.50</td>
</tr>
<tr>
<td>Height (cms)</td>
<td>178.6</td>
<td>1.45</td>
</tr>
<tr>
<td>Weight (kgs)</td>
<td>83.0</td>
<td>1.69</td>
</tr>
<tr>
<td>1 RM (kgs)</td>
<td></td>
<td></td>
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<tr>
<td>Squat</td>
<td>150.0</td>
<td>11.18</td>
</tr>
<tr>
<td>Bench</td>
<td>119.5</td>
<td>7.01</td>
</tr>
<tr>
<td>Resting Heart Rate (bpm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 1</td>
<td>59.5</td>
<td>1.39</td>
</tr>
<tr>
<td>Day 2</td>
<td>59.6</td>
<td>1.61</td>
</tr>
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</table>

**METHODS**

Forty experienced weight lifters volunteered to participate in this study. All subjects read and signed an informed consent document in accordance with the University Human Subjects Review Guidelines prior to engaging in any aspect of this project. Each subject was required to participate in a practice session during which their maximal (1 RM) squat and bench press weights were determined. On a separate day, the subjects completed a pyramid cycle of 10, 8, 6, 4, 6, 8 and 10 repetitions at 50, 65, 75, 85, 75, 65 and 50–percent of their 1 RM on both the squat and bench lifts. All subjects repeated the same testing sequence after at least two days, but no more than one week after the first sequence of tests. The testing sequence, bench and squat or squat and bench, was randomly assigned. If the subject used wraps during the 1 RM tests they were required to wrap for their pyramid tests. Furthermore, on the morning of each test day, the subjects were instructed to obtain their resting heart rates for one minute.

During each trial, heart rates were determined by telemetry using UNIQ CIC Heart Watches (Model 8799, Computer Instruments Corporation, Hempstead, NY) which had previously been reported to be valid and reliable (12). Two heart rate monitors (one used as a back-up) were programmed to record and store heart rates in their computer memories at five second intervals, starting with the initial lift in the pyramid cycle and ending when the heart rate began to decrease during recovery after the final descending cycle of the pyramid. The exact time for each repetition was determined and the heart rate corresponding to the last five seconds of that repetition was used to represent the heart rate for the actual lift. The heart rate obtained immediately after the repetition was used to represent the first recovery heart rate. The second recovery heart rate was the highest or peak heart rate recorded during the recovery period for that lift. The exact time of these peak recovery heart rates were also recorded. In order to simulate a typical workout, each lifter determined the time necessary between sets.

A three-way mixed design ANOVA with repeated measures was calculated to determine differences in heart rates among the various repetitions, between exercises and between days one and two. In order to reduce the probability of incurring a type I error associated with multiple ANOVAs, an alpha level of 0.01 was used for all significant tests.

**RESULTS**

The subjects’ physical characteristics and maximal squat and bench weights are presented in Table 1. There were no significant (p > 0.01) differences in resting heart rates on day one (59.5 ± 1.4 bpm), compared to day two (59.6 ± 1.2 bpm).

The heart rate responses to the squats were significantly (p > 0.01) higher than the response to the bench press during the actual lift, immediately after or at peak recovery (see Figures 1 and 2). There were no significant (p > 0.01) differences in any heart rate comparisons for specific repetitions on day one, compared to day two for either the squats or the bench press during, immediately after or at peak recovery. In addition, there were no significant (p > 0.01) differences in the total time required to complete either the squat (19:36 ± 1:13 and 19:39 ± 1:01) bench press (14:26 ± 32 and 14:39 ± 37) pyramid cycle between days one and two, respectively. However the time for completing squats was significantly (p < 0.01) longer than for the bench press.

**DISCUSSION**

All 40 subjects were experienced weight lifters and at the time of testing were lifting free weights on a regular basis,
although their specific workouts varied. In Table 1 there was a large range in body weight (65.9 to 107.5 kg), thus considerable variability in the 1 RM for both the bench press (range: 84-164 kg) and squat (range: 98-239 kg).

The self-reported resting heart rates were lower than the 63 bpm reported for experienced body builders (4) and the 67.9 bpm for 10 experienced lifters (11), but were similar to the 58.4 bpm reported by Wilmore et al. (18) after a 10-week circuit weight training program. In a recent review, Stone et al. (15) suggested that resistance training may result in bradycardia. However in the authors’ opinion there is insufficient evidence to definitively establish this occurring as a result of heavy resistance training alone. Due to the various methods used to establish resting heart rates, as well as the various types of weight training programs employed (i.e., circuit exercises, free weights, etc.), it is difficult to determine if bradycardia consistently occurs in response to regular free weight training.

The lack of significant differences between days one and two heart rates during the actual lifts, as well as immediately after and at peak recovery, indicate the heart rate responses were consistently stable across days. This concurs with the findings of Katch et al. (9) of heart rates during resistance exercise on different days in subjects who had no prior experience with weight training or weight lifting. Their subjects completed the maximum number of repetitions possible in three tests of 20 seconds, with 20 seconds rest on a three station hydraulic machine. In that study, heart rates progressively increased between each set but there was no significant difference in heart rates between days. Similar results were reported by Wilmore et al. (18) for beginning male weight lifters during a circuit weight training exercise. Their circuit consisted of three sets of trips through a 10 station circuit on a Universal Gym (30-seconds per exercise, 15-seconds rest) with a recovery period of at least 12 minutes. The times during and between sets in the present study were not pre-determined but rather left to the discretion of the subjects to be more representative of their actual training. Despite this lack of standardization between sets, there was no difference in the total time required to complete either the squat (19:36 vs. 19:39) or bench press (14:26 vs. 14:39). Pyramids between days one and two and the heart
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Figure 2. Heart rate responses during and after pyramid squats

He rates remained stable. These results suggest that experienced weightlifters are consistent in the time they allow themselves during and between sets, which is reflected in their heart rate responses.

Recently, Weiss (17) addressed the influence of rest on strength gains and concluded that the “appropriate quantity of intertraining-session rest is unclear because of the lack of a definitive physiological marker indicating when recovery is complete.” He further states that the amount of intratraining-session rest also appears to be a factor. Although it is not currently known whether heart rate changes could be used as the physiological marker, the results of the present study demonstrate heart rate is a stable measure in experienced lifters.

Some investigators (1, 4) reported no differences in heart rate responses between lower extremity and upper extremity exercises while performing specific circuit resistance routines. However, the higher heart rates obtained of the squats compared to the bench press in the present study are in agreement with the findings of Harris and Holly (5), Katch et al. and Keul et al. (9, 10). This discrepancy in findings is probably a function of the differences in experiment designs, such as circuit training versus free weights, number of repetitions and subject’s experiences. The higher heart rates during the arm compared to leg exercise generally have been attributed to the larger muscle mass involved (7, 13, 15), as well as the higher amount of weight lifted during the squats compared to the arm press.

The heart rates during the squats were higher than heart rates during the bench press and these differences remained throughout the recovery periods, while exhibiting different patterns. The heart rates during, immediately after and at peak recovery for the bench press, progressively increased during the ascending phase (Figure 1) of the pyramid cycle then leveled or decreased.
In contrast, the heart rates during the actual squats were stable for the ascending phase (approximately 134 bpm) but then increased during the descending phase of the cycle (Figure 2). Subjectively, the majority of subjects stated that the descending repetitions in sets six and eight were the hardest to perform during both the squats and bench press. Because the same amount of weight was lifted in the descending and ascending phases of the cycle, the increase in heart rates during the descending phase might be a reflection of muscle fatigue. The investigators speculate that muscle fatigue may be a factor at this point in the pyramid cycle and would, therefore, cause recruitment of auxiliary muscles to perform the same amount of work resulting in higher heart rates. The differences in these responses between the squat and bench press may also have been a function of time. Although the number of repetitions were identical for both the squats and bench press, the time required to complete the squat pyramids was approximately five minutes longer than that of the bench press. The higher heart rates experienced during the squats may have indirectly influenced the time required to complete the cycle. Generally, lifters frequently take longer to prepare both mentally and psychologically to complete the higher weight for squat lifts compared to the bench press.

Unlike typical aerobic exercise, the heart rate continues to increase during the recovery period. Although most experienced lifters are conscious of having higher heart rates after completing a lift, there has been little documentation verifying this increase. In the present study the average heart rates immediately after completing all sets were higher than those during the actual lift, with the peak rate occurring approximately 21.2 and 17.2 seconds after the squats and bench press, respectively. Keul et al. (10) reported that heart rates were higher 15 seconds after completing the bench press, back lift and knee bends (squat) than those obtained during the actual lift. Stone et al. (15) suggested that this increase in the immediate post-exercise heart rate is related to the amount of weight lifted, the number of repetitions and the amount of muscle mass involved. In the present study the number of repetitions were identical but the amount of weight lifted and the muscle mass employed were higher for the squats. The magnitude of increase in post-exercise heart rates over those obtained during the actual lifts were less for the squats than for the bench press. Possibly these elevated recovery heart rates are simply in response to the continued elevation of the plasma catecholamines, which were released during the actual lift (8, 13). Although it is not clear what physiological mechanism is responsible, heart rates definitely continued to increase after the lifts were completed.

The majority of studies reporting heart rate response to resistance exercise have expressed the heart rates as percentages of maximal. Using the standard 220 minus age to estimate maximal heart rate in the present study, the average heart rates during, immediately and at peak recovery for the bench press were 59.2, 65.1 and 68.9 percent, and 69.2, 75.2 and 79.9 percent for the squats, respectively. The percentage of age-predicted maximal heart rates during the actual lift are slightly lower than those previously reported during various types of circuit resistance exercises (1, 2, 3, 8, 9, 18).

**Practical Application**

Heart rate responses during free weight exercise can be accurately and simply determined using UNIQ CIC Heart Rate Monitors in experienced lifters. It might be advantageous for weight lifters to periodically monitor their heart rates during the workouts, thus establishing a baseline. If this type of information was available over an extended period of time for a particular training cycle it might allow them to discern when their bodies are ready to continue on to the next set or exercise. Although further research is required, establishing weight lifter baseline heart rates also might aid in determining when overtraining occurs and when to make appropriate adjustments.

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**References**


