REGULATING RESISTANCE EXERCISE INTENSITY USING PERCEPTUAL RESPONSE AND THE “ANTICIPATORY FEEDBACK” MODEL

By

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PURPOSE: To assess how accurately trained subjects can predict exercise endpoint in resistance training. METHODS: 12 female (age 20.33 ± 1.61 years; height 166.12 ± 3.95 cm; weight 69.99 ± 9.76 kg) and 12 male (age 22.17 ± 1.40 years; height 176.83 ± 8.78 cm; weight 82.12 ± 12.91 kg) resistance trained subjects were tested for their one repetition maximum (1-RM) in bench press, and then performed four sets to failure with 65% of 1-RM. Prior to each set subjects predicted how many repetitions they could complete. After each set subjects reported a rating of perceived exertion (RPE) using the 10-point resistance training RPE scale. A repeated measured ANOVA was used to determine differences between predicted and actual repetitions-to-failure. Dependent t-tests were used to analyze differences for each set separately. Spearman’s rank correlation was used to determine the relationship between RPE, predicted and actual repetitions-to-failure. RESULTS: The repeated measures ANOVA indicated no significant difference between predicted and actual repetitions-to-failure for both genders ($p > .05$). Significant differences were found across sets for both genders ($p < .05$). Dependent t-tests showed no significant differences between predicted and actual repetitions-to-failure in the last two sets for both genders and in the first set for males ($p$
> .0125). Significant differences were found in the first two sets for females and the second set for males \((p < .0125)\). No significant correlations were found between predicted repetitions-to-failure and RPE in females \((p > .05)\), but in males a negative correlation was present \((r = -.538; p < .05)\). A negative correlation was found for both females \((r = -.351; p = .014)\) and males \((r = -.458; p = .001)\) between actual repetitions-to-failure and RPE. Significant correlations were found between predicted and actual repetitions-to-failure for females \((r = .851; p = .000)\) and males \((r = .932; p = .000)\).

(DISCUSSION: Subjects were more accurate in predicting repetitions-to-failure in the last two sets. This can be due to a learning effect, or how many less repetitions were possible due to acute fatigue, making it easier to predict. CONCLUSION: It may be possible to regulate resistance training intensity using a predicted exercise endpoint, but further research is needed.)
# TABLE OF CONTENTS

ABSTRACT ........................................................................................................................ ii

TABLE OF CONTENTS ................................................................................................... iv

LIST OF TABLES ............................................................................................................. vi

LIST OF FIGURES .......................................................................................................... vii

INTRODUCTION .............................................................................................................. 1
  Problem Statement .......................................................................................................... 1

REVIEW OF LITERATURE ............................................................................................. 3
  Intensity Prescription ...................................................................................................... 4
    Self-selected intensity concerns ................................................................................. 5
  Anticipatory Mechanism of the CNS on Exercise Intensity ........................................... 6
    Intensity measured by repetitions to failure ............................................................... 8

Conclusion ...................................................................................................................... 9

Problem .......................................................................................................................... 10

Purpose .......................................................................................................................... 11

Hypothesis ...................................................................................................................... 11

METHOD ......................................................................................................................... 12

Research Design ........................................................................................................... 12

Subjects ......................................................................................................................... 12

Procedures ..................................................................................................................... 13
  1-RM testing and familiarization session .................................................................. 13
  Experimental session ................................................................................................. 14
LIST OF TABLES

Table 1. Descriptive statistics of subjects ................................................................. 19
Table 2. Descriptive statistics of predicted and actual repetitions-to-failure ........... 21
Table 3. Frequency distribution table of reported RPE for females ....................... 23
Table 4. Frequency distribution table of reported RPE for males ......................... 23
LIST OF FIGURES

Figure 1. Female predicted and actual repetitions-to-failure values in bench press expressed as means. Error bars represent standard deviation. * $p \leq .0125$................................. 21

Figure 2. Male predicted and actual repetitions-to-failure values in bench press expressed as means. Error bars represent standard deviation. * $p \leq .0125$.............................................. 22

Figure 3. Scatterplot showing relationship between predicted and actual repetitions-to-failure for females ............................................................................................................. 24

Figure 4. Scatterplot showing relationship between predicted and actual repetitions-to-failure for males ............................................................................................................. 25
INTRODUCTION

Problem Statement

Intensity is a critical factor in the design and implementation of a resistance exercise program. It is well understood that minimum threshold intensities must be met to stimulate adaptive responses in the body to induce the desired training effect (ACSM, 2009; Kraemer & Ratamess, 2004; Tsuzuku, Shimokata, Ikegami, Yabe, & Warsnich, 2001). Strength and conditioning coaches, as well as personal trainers, can prescribe intensities, most commonly as a percentage of a tested or predicted 1-repetition maximum (1-RM), to their athletes or clients to induce the desired outcomes. Since not everyone has access to a personal trainer to prescribe appropriate intensities, many trainees are left to train independently. Recent studies reveal that women training independently do not typically self-select intensities that are sufficient to induce significant muscular or skeletal adaptations (Focht, 2007; Glass & Stanton, 2004; Ratamess, Faigenbaum, Hoffman, & Kang, 2008). Therefore, women who train for the associated muscular and skeletal health benefits may not experience significant improvement in these areas.

Women training recreationally may perceive resistance exercise intensity to be higher than it really is if they are consistently under selecting intensity. Tucker (2009) suggests, in the “anticipatory feedback” model, that effort is regulated in exercise by perceptual sensations of effort that are generated by physiological signaling mechanisms.
Tuckers (2009) model is based on research in aerobic exercise, but not in resistance training. Therefore, a deeper understanding of the role perceived effort plays in the regulation of resistance exercise effort is needed.
REVIEW OF LITERATURE

Resistance exercise has been shown to have numerous health and performance benefits. Besides improving the components of muscular health and performance (endurance, hypertrophy, strength, and power), resistance exercise can improve bone mineral density, insulin sensitivity and body composition as well as lower blood glucose, blood lipids and resting blood pressure (Kraemer, Ratamess, & French, 2002). Resistance training is often the cornerstone of preparation programs for athletes to improve sport performance and reduce the risk of injury (Stone, 1990).

Designing resistance-training programs requires the manipulation of variables such as exercise selection, volume (sets and repetitions), rest periods, and intensity (load) (Baechle & Earle, 2008). Although various set and repetition protocols and exercises have been shown to be effective, intensity may be one of the most important factors to ensure progression in muscular and skeletal health. In order to stimulate an adaptive response there is a certain threshold intensity (load) that the trainee must train at or above (ACSM, 2009; Kraemer & Ratamess, 2004; Tsuzuku, Shimokata, Ikegami, Yabe, & Warsnich, 2001). Therefore manipulations in training volume and rest periods will not produce a significant training effect unless the intensity is above the threshold intensity. In an untrained individual, threshold intensity is typically very low (~45% to 50% of 1-RM), meaning a training adaptation can still be achieved with relatively low loads (Kraemer & Ratamess, 2004). As training status increases, greater intensities are required
to maximize fiber recruitment, optimize bone loading, and ensure continued training progress (Kraemer & Ratamess, 2004; Tsuzuku et al., 2001).

Intensity Prescription

Intensity can be expressed in several ways, but each expression refers to the load used. A percentage of 1-RM is one of the most common methods for prescribing intensity. Other accepted methods include using a repetition max, a load that limits the lifter to a specified number of repetitions before reaching concentric failure (e.g., 10-RM as a load that only allows 10 reps to be performed), and the use of a Rating of Perceived Exertion scale (RPE) (ACSM, 2009; Lins-Filho et al., 2012; Naclerio et al., 2011; Robertson et al., 2003).

There are some limitations to the use of imposed intensities as a percentage of 1-RM. One problem is the large amount of variation in the number of repetitions performed until failure between individuals at prescribed intensities (Baechle & Earle, 2008; Hoeger, Hopkins, Barette & Hale, 1990; Shimano et al., 2006). Therefore, two individuals who are prescribed the same sets, repetitions and intensity may not actually be experiencing the desired stimulus. For example, if the prescribed intensity in a resistance-training program was a set of 10 repetitions at 75% of 1-RM, then that could be a maximal effort if the lifter could not perform any additional repetitions afterward. However, another lifter may complete the prescribed repetitions, at the prescribed intensity, and still be able to complete more repetitions. That intensity may have been too
high for the first lifter and too low for the second lifter. Both lifters could be prescribed
the same effort by having both lifters train to failure, that way it is a maximal effort for
both lifters. However, training to failure may not always be appropriate or desired
(Izquierdo et al., 2006).

Another limitation of prescribing intensity as a percentage of maximal effort is the
need for a 1-RM measurement. Conducting a 1-RM test may not be appropriate for
certain populations (Baechle & Earle, 2008). People who train by themselves may not
have spotters, and conducting a maximal test may not be safe. The other problem is that
not everyone will have access to a trainer to prescribe appropriate intensities, leaving
recreational lifters to select their own resistance (intensity).

Self-selected intensity concerns

The results of recent studies on self-selected resistance exercise intensity indicate
that men and women, who self-select intensities, do not select adequate intensities to
produce significant adaptations in the muscular and skeletal systems (Focht, 2007; Glass
& Stanton, 2004; Ratamess, Faigenbaum, Hoffman, & Kang, 2008). Women are at an
increased risk, compared to men, of developing osteoporosis due to the rapid loss of bone
mineral density following menopause (Golden, 1998). This makes resistance training at
the appropriate intensity to stimulate bone growth crucial for long-term health and quality
of life for women in particular. The ACSM (2013) recommends moderate loads of 60-
80% of 1-RM to vigorous loads of 80-90% of 1-RM for optimal bone mineral density
improvement. Glass and Stanton (2004) found that untrained men and women self-selected intensities ranging from 42-57% of 1-RM in all the tested exercises. Focht (2007) reported an average of 56% 1-RM as the self-selected load in women in resistance training. Even women who had been training with a personal trainer for at least 3 months, when left to select intensities on their own, selected intensities between 43-57.4% of 1-RM (Ratamess, Faigenbaum, Hoffman, & Kang, 2008). Although that was higher than the self-selected intensities of women who trained without a trainer (38-48% of 1-RM), it was still below the minimum recommendation for bone mineral density improvements (Ratamess et al., 2008). This data indicates that men and women who train independently may be selecting intensities insufficient for inducing muscular strength and hypertrophy adaptations, or increases in bone mineral density. They may perceive their training intensity to be much higher than it really is. If that were the case, the perceptual response to fatigue and effort would be a key factor in manipulating self-selected intensity behavior.

Anticipatory Mechanism of the CNS on Exercise Intensity

The central governor theory, developed by Noakes, Gibson, and Lambert (2005), suggests that fatigue occurs in the central nervous system, rather than in the peripheral exercising tissue, as a means of controlling homeostasis in the internal environment. Even at complete exhaustion, only about 30% of available motor units are recruited and ATP levels are never below 50% of resting values under any exercise conditions, suggesting
exercise is terminated while homeostasis is still maintained in voluntary exercise (Gibson, Schabort, & Noakes, 2001; Noakes & Gibson, 2004; Noakes, Gibson, & Lambert, 2005). Rather than fatigue occurring because of peripheral factors interfering with the actual contractile mechanisms, such as metabolite accumulation or substrate depletion, the researchers conclude that fatigue is an affective response to signaling properties of metabolites and feedback from multiple physiological systems. By using the proposed feedback and feed forward mechanism, the brain can regulate exercise intensity and effort by altering the level of skeletal muscle recruitment and increasing or decreasing the affective sensation of fatigue (RPE) to ensure no loss of cellular homeostasis (Noakes, Gibson, & Lambert, 2005).

Tucker (2009) proposed the “anticipatory feedback” model in which the brain develops pacing strategies in exercise performance using RPE, past experiences, physiological feedback and anticipated exercise duration or distance. There are various models for different exercise situations, however for the purpose of this review, only the models for exercise at a fixed work rate will be discussed, because it has the greatest potential for application to resistance training, as intensity (weight) is constant during a given bout (set).

At the onset of fixed intensity exercise, such as a graded exercise test, the brain processes physiological and environmental input to determine a duration at which the current exercise intensity can be performed safely, resulting in the rise of RPE. This mechanism is especially crucial in bouts for which no information on duration is provided. The rate of increase in RPE regulates the time to exhaustion, with exercise
being terminated at the maximal tolerable RPE, which occurs well before potentially harmful homeostatic changes can occur. The rate of increase in RPE is constantly modified based on the integration of physiological feedback. In this model, a central controller forecasts future physiological changes using current physiological responses, afferent feedback, and expected exercise duration (Tucker, 2009).

Past performance experiences play a critical role in the anticipatory mechanism as well. The accumulation of past performances develops what Tucker terms as a “template RPE”, which is a subconscious template of the various metabolic, physiological, afferent, and affective inputs. The central controller can further regulate exercise intensity by comparing current feedback with the template RPE. As training status improves, the trainee may perform an exercise bout at the same given intensity, but with an RPE that is lower than the template RPE, by the central controller allowing for increases in intensity to match the template (Tucker, 2009).

Intensity measured by repetitions to failure

The central governor theory and the anticipatory feedback model are based on studies done on aerobic modes of exercise, but have the potential to be applied to resistance training as well. Using the fixed work rate anticipatory feedback model, resistance trainees could determine repetitions to the termination of the exercise in the same way duration is used in aerobic exercise modes. Given the variability in repetition performances at given intensities, it has been suggested that the most accurate
measurement of intensity is the perceived effort at a given load, defined by the number of repetitions performed compared to the number of repetitions possible (Fisher, Steele, Bruce, & Smith, 2011; Hoeger et al., 1990; Shimano et al., 2006). Hackett, Johnson, Halaki, and Chin-Moi (2012) validated a repetitions-to-failure scale by showing that bodybuilders were able to predict their repetitions to failure at 70% of 1-RM within one repetition. This kind of perceptual accuracy could prove to be promising in regulating exercise intensities and developing more precise loading guidelines.

Conclusion

Both RPE and the repetitions-to-failure method of capturing resistance training intensity depend on perceptual responses to exercise intensity, which can be extremely subjective. However, research on the anticipatory mechanism of the brain in regulating exercise intensity brings to light the importance of perceived measures of intensity. Tucker (2009) proposed that perception of effort is a result of the brain integrating signals from numerous physiological systems, and thus is the only conscious link to the physiological processes occurring during exercise. Therefore perceived effort is something worth investigating when it comes to regulating intensity.

Although Tucker’s (2009) conclusions were based primarily on research using aerobic exercises modes, the model he proposed for pacing strategies can explain why the bodybuilders in Hackett et al.’s (2012) study could predict their repetitions to failure with such precision. Since the bodybuilders studied had been training for many years, they
have developed what is called a “template” RPE, which would function as a subconscious blueprint of all the different physiological inputs resulting from the various intensities of exercise. The bodybuilders subconsciously compared their current perception of effort (the integration of all the physiological inputs) with the template RPE and the brain determined the end point of exercise. In previous investigations this would be time to endpoint of exercise (e.g., running) but in this case, it was repetitions to end point, based on the template and the mode of exercise.

One of the limitations of the Hackett et al (2012) study is that all of the subjects were male competitive bodybuilders, which limits the other populations the findings can be applied too. No females were included in the study and the male subjects that were included were a very elite resistance trained group. Based on the anticipatory theory (Tucker, 2009), since the subjects were extremely experienced resistance trainers, they could have developed a very concrete template RPE that gives them the ability to regulate and predict exercise end point precisely. It remains to be seen how accurately female and less resistance-trained population can predict exercise end point in resistance exercise.

Problem

Researchers have found that men and women who train independently do not self-select intensities sufficient for increases in bone mineral density and components of muscular health (Focht, 2007; Glass & Stanton, 2004; Ratamess et al., 2008). As women are at an increased risk for developing osteoporosis, and evidence of resistance training
can decrease the likelihood of developing osteoporosis, it is crucial that women training independently are able to self-select appropriate intensities (Golden, 1998). Anchoring RPE when resistance training with something more tangible, such as a predicted endpoint (repetitions-to-failure), has a strong theoretical basis in the “anticipatory feedback” model and could help individuals gauge intensity more accurately (Tucker, 2009). If more populations are able to predict exercise end point successfully, it may be a useful tool in developing guidelines for self-selecting resistance for individuals training independently.

**Purpose**

The purpose of this study is to assess how accurately trained males and females can predict exercise end point in resistance training using Tucker’s (2009) anticipatory feedback model as a theoretical model. Predicted repetition-to-failure at a fixed submaximal intensity will be compared to the actual repetitions-to-failure using the bench press exercise.

**Hypothesis**

Due to the role of template RPE in the “anticipatory feedback” model, the investigator hypothesizes that both trained men and women will be able to predict repetitions-to-failure accurately. Since subjects have resistance trained for at least two years, they will have a developed template RPE to compare their current performance to.
METHOD

Research Design

There were a total of two lab visits for each subject, one familiarization session and one experimental session. During the familiarization session, subjects performed a 1-RM bench press test, rested 5 min, and then performed a muscular endurance experimental protocol. Subjects also received a copy of the RPE as well as verbal instructions on its use. The muscular endurance protocol consisted of 4 sets at 65% of 1-RM with 30 sec rest between sets. The load and rest times were based on the NSCA recommended intensities and rest periods for muscular endurance training (Baechle & Earle, 2008). The subjects predicted how many repetitions they could perform prior to each set, then performed as many repetitions as possible.

The experimental session was scheduled 48 or 72 hours after the familiarization session. If the subject experienced any soreness they received an extra 24 hours rest. The experimental session consisted of the same warm-up as the familiarization session followed by 5 minutes rest and then the muscular endurance protocol without the 1-RM test.

Subjects

Resistance trained males and females between the ages of 18 and 25 were recruited for this study. Subjects were recruited through a recruitment flier and word of
mouth from the student recreation center on campus. All subjects were required to have had at least two years of previous weight training experience. Subjects were screened for cardiovascular and musculoskeletal disorders and their readiness for participation in an exercise study using the Humboldt State Human Performance Lab medical history questionnaire and the Physical Activity Readiness questionnaire (Par-Q). Subjects with any muscular/skeletal injuries in the last year that affects bench press performance were excluded from the study. Subjects were cleared to participate if they had current athletic clearance. Subjects were excluded if they had high blood pressure and/or are on ergogenic supplements that may affect exercise performance or perceptual response. Subjects were instructed to get plenty of rest the night before lab visits and to have a light meal and to avoid alcohol consumption 24 hours, caffeine consumption 3 hours and food consumption 2 hours prior to lab visits (ACSM, 2013).

Procedures

1-RM testing and familiarization session

Subjects were instructed on how to perform the bench press through a full range of motion with the barbell touching the chest at the bottom and the elbows fully extended at the top. The subjects received a copy of the modified 0-10 category-ratio RPE scale used in previous resistance training studies and were given verbal instruction on its use (Day, McGuigan, Brice, & Foster, 2004; Hackett et al., 2012) Subjects then performed a warm-up that included 10 repetitions at 50%, 5 repetitions at 70%, 3 repetitions at 80%
and 1 repetition at 90% of reported 1-RM with 3 minutes rest between each set (Kwon, 2009). After the warm-up, subjects performed single repetitions. If a repetition was successful, the subject received 5 min rest and then attempted another repetition at a heavier weight. This cycle continued until the participant was unable to complete the movement through the full range or with proper technique. The heaviest load successfully lifted through full range of motion was defined as the 1-RM. By definition, a 1-RM is considered a maximal effort and therefore a 10 on the RPE scale. As a memory anchoring procedure, subjects were instructed to equate the sensation of the measured 1-RM with the maximal value on the RPE scale. After the final attempt, the subject received 5 min rest and then performed the experimental protocol; 4 sets of 65% of 1-RM for as many repetitions as possible with a 30-sec rest between each set. The subjects reported RPE after every set performed including warm-up sets, 1-RM testing attempts, and the 4 sets in the experimental protocol.

**Experimental session**

The subjects performed a warm-up consisting of 10 repetitions at 50%, 5 repetitions at 70%, 3 repetitions at 80%, and 1 repetition at 90% of 1-RM based off of the previously measured 1-RM (Kwon, 2009). After a 5 min rest, the subjects performed 4 sets to failure with 65% of 1-RM with 30-sec rest between sets. Before beginning each set, the subject reported how many repetitions they believed they would complete in the set. The subject then performed repetitions as many repetitions as possible until they
reached concentric failure. This protocol was designed to measure the anticipatory feedback model for predicting exercise endpoint proposed by Tucker (2009) in the context of resistance training. Upon completion of the set, subjects were asked to report their sensation of overall exertion according to the RPE scale.

Measurements

**Bench press**

The bench press exercise was used for the current study due to its popularity and ease of use. The bench press was used for 1-RM testing and at submaximal intensities for the experimental protocols.

**RPE**

Immediately following each set, the subject was asked, “what is your overall feeling of exertion?” and was handed a hard copy of the modified 10-point resistance training RPE scale to measure perceived exertion by (Day et al., 2004).

**Predicted repetitions-to-failure**

Prior to each set, subjects were asked “how many repetitions do you think you can complete in this set?” Predicted repetitions to failure were taken before each set and were compared to the total number of repetitions completed in the set.
Actual repetitions-to-failure

The actual number of repetitions of the bench press exercises performed in each set before reaching concentric failure.

Operational Definitions

Predicted repetitions-to-failure

The number of repetitions the subject predicted they will perform prior to each set.

Actual repetitions-to-failure

The actual number of repetitions performed in each set.

Limitations and Delimitations

Limitations to the level of control in the current investigation included factors that are dependent on the subject. The subject’s dietary and sleep habits could have affected their performance and perceptual responses in the 1-RM and the experimental session. Inadequate sleep and dietary intake may have resulted in underestimation of subjects 1-RM. An overestimation of 1-RM during the experimental session could also have been
possible if the subject was well rested for the familiarization session but not for the experimental session. Although the investigator instructed subjects to get adequate sleep and nutritional intake through the course of the study, it was up the discretion of the subject how strictly they followed the instructions and how honest they were about whether or not they followed them. Subjects were also instructed to avoid fatiguing activities before testing days that may have affected bench press performance and were asked about their previous activity at the start of each session. However, that also depended on the honesty of the subjects as they could lie about participating in fatiguing activities before the session.

Delimitations of the current investigation included the use of only the bench press, the intensity of the experimental protocol and the use of only trained subjects. The bench press exercise was the only exercise used due to its popularity, availability and its ease for spotting. The experimental protocols used fixed intensities and rest periods according to recommendations of the NSCA for muscular endurance training. Other intensities and rest times for muscular hypertrophy and strength were not be included. Finally, only subjects with at least 2 years of resistance training exercise were included in the study.

Statistical Analyses

Statistical analyses were performed using IBM SPSS Statistics Version 22. Statistical significance was set at $p < .05$. All data from the male and female subjects
were analyzed separately. Differences between predicted and actual repetitions-to-failure overall and across sets were assessed by 2x4 repeated measures analysis of variance (ANOVA). Adjustments were made as appropriate in the presence of outliers or violations of the assumptions of normality and sphericity. Paired sample t-test were used to determine differences between predicted and actual repetitions to failure within each set. A Bonferroni adjustment was used with statistical significance set at $p < .0125$ to account for the error variance of running multiple t-tests. The correlation between both predicted and actual repetitions-to-failure with RPE was assessed using a Spearman’s rank correlation since RPE is not a parametric variable. Spearman’s rank correlation was also used to assess the correlation between predicted and actual repetitions-to-failure.
RESULTS

Subjects

The subjects recruited for this study ($N = 24$) included resistance trained males ($n = 12$) and females ($n = 12$). Subject characteristics are listed in Table 1. All subject strength to weight ratios were classified as “good” or better according to ACSM norm charts. Of the 24 total subjects, 18 were Division II NCAA athletes with current athletic clearance. The female subjects included athletes from basketball ($n = 1$), rowing ($n = 1$), soccer ($n = 3$), and track & field ($n = 5$). Male subjects included athletes from football ($n = 3$, soccer ($n = 4$), and track & field ($n = 1$). All subjects reported regular use (at least once per week) of the bench press exercise in their resistance training routines. The Humboldt State University Institutional Review Board approved this study.

Table 1

Descriptive statistics of subjects

<table>
<thead>
<tr>
<th></th>
<th>Female</th>
<th></th>
<th>Male</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Age (years)</td>
<td>20.33 ±1.61</td>
<td></td>
<td>22.17 ±1.40</td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>166.12 ±3.95</td>
<td></td>
<td>176.83 ±8.78</td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>69.99 ±9.76</td>
<td></td>
<td>82.12 ±12.91</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>25.07 ±3.53</td>
<td></td>
<td>26.31 ±2.95</td>
<td></td>
</tr>
<tr>
<td>Training (years)</td>
<td>4.17 ±1.9</td>
<td></td>
<td>5.96 ±2.36</td>
<td></td>
</tr>
<tr>
<td>Bench Press 1-RM (kg)</td>
<td>57.65 ±12.67</td>
<td></td>
<td>120.77 ±21.15</td>
<td></td>
</tr>
<tr>
<td>Strength:Weight Ratio</td>
<td>.84 ±0.15</td>
<td></td>
<td>1.47 ±0.15</td>
<td></td>
</tr>
</tbody>
</table>
Statistical Analysis

Data for predicted and actual repetitions-to-failure was not all normally distributed as assessed by Shapiro-Wilk’s test ($p < .05$). However, the repeated measures ANOVA test was still run because it is considered robust to deviations in normality. The Greenhouse-Geisser adjustment was used as appropriate with violations to the assumption of sphericity as assessed by Mauchly’s test ($p < .05$). For both females ($p = .215$) and males ($p = .113$) no significant differences were found between predicted and actual repetitions-to-failure overall. Significant main effects were found for both females ($p = .000$) and males ($p = .000$) across sets. Significant main effects were also found for the interaction between sets and predicted and actual repetitions-to-failure for females ($p = .000$) and males ($p = .001$).

Paired samples t-test with a Bonferroni adjustment ($p < .0125$) showed significant differences for females between predicted and actual repetitions-to-failure in the first ($p = .000$) and second set ($p = .008$), but not in the third ($p = .026$) and fourth set ($p = .723$) (Figure 1). In males, significant differences between predicted and actual repetitions-to-failure were found in the second set ($p = .010$) but not in the first ($p = .043$), third ($p = 0.20$) and fourth set ($p = .054$) (Figure 2). Descriptive statistics are presented in Table 2.
Table 2

Descriptive statistics of predicted and actual repetitions-to-failure

<table>
<thead>
<tr>
<th>Set</th>
<th>Female Predicted</th>
<th>Female Actual</th>
<th>Male Predicted</th>
<th>Male Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13.17 ± 5.02</td>
<td>17.33 ± 4.87*</td>
<td>16.00 ± 3.62</td>
<td>17.50 ± 2.61</td>
</tr>
<tr>
<td>2</td>
<td>7.00 ± 1.91</td>
<td>5.08 ± .90*</td>
<td>6.42 ± 2.64</td>
<td>4.17 ± 1.27*</td>
</tr>
<tr>
<td>3</td>
<td>3.92 ± 1.00</td>
<td>3.00 ± 1.21</td>
<td>2.27 ± 1.54</td>
<td>2.33 ± .98</td>
</tr>
<tr>
<td>4</td>
<td>2.67 ± .78</td>
<td>2.75 ± .97</td>
<td>2.25 ± .87</td>
<td>1.83 ± .83</td>
</tr>
</tbody>
</table>

Note: * p ≤ .0125. Data presented as mean ± standard deviation.

Figure 1. Female predicted and actual repetitions-to-failure values in bench press expressed as means. Error bars represent standard deviation. * p ≤ .0125.
Spearman’s rank correlation showed no significant correlation between estimated repetitions to failure and RPE for females ($p = .097$). However, for males a negative correlation was found between estimated repetitions to failure and RPE ($r = -.538; p = .000$). A negative correlation was found for both females ($r = -.351; p = .014$) and males ($r = -.458; p = .001$) between actual repetitions-to-failure and RPE. RPE frequencies and distribution data are presented in Table 3 and Table 4.
Table 3

*Frequency distribution table of reported RPE for females*

<table>
<thead>
<tr>
<th>RPE</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1</td>
<td>2.10</td>
<td>2.10</td>
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<td>4</td>
<td>2</td>
<td>4.20</td>
<td>6.30</td>
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<td>5</td>
<td>6</td>
<td>12.50</td>
<td>18.80</td>
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<td>6</td>
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<td>14.60</td>
<td>33.30</td>
</tr>
<tr>
<td>7</td>
<td>9</td>
<td>18.80</td>
<td>52.10</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
<td>18.80</td>
<td>70.80</td>
</tr>
<tr>
<td>9</td>
<td>7</td>
<td>14.60</td>
<td>85.40</td>
</tr>
<tr>
<td>10</td>
<td>7</td>
<td>14.60</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>48</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 4

*Frequency distribution table of reported RPE for males*

<table>
<thead>
<tr>
<th>RPE</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>2</td>
<td>4.20</td>
<td>4.20</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>4.20</td>
<td>8.30</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>6.30</td>
<td>14.60</td>
</tr>
<tr>
<td>8</td>
<td>7</td>
<td>14.60</td>
<td>29.20</td>
</tr>
<tr>
<td>9</td>
<td>11</td>
<td>22.90</td>
<td>52.10</td>
</tr>
<tr>
<td>10</td>
<td>23</td>
<td>47.90</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>48</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

A non-parametric test was used to analyze the correlation between predicted and actual repetitions-to-failure because the data violated the assumption of normality as assessed by Shapiro-Wilk’s test ($p < .05$). Spearman’s rank correlation showed a
significant positive correlation between predicted and actual repetitions to failure for both females \( (r = .851; p = .000) \) and males \( (r = .932; p = .000) \) (Figure 7; Figure 8).

Figure 3. Scatterplot showing relationship between predicted and actual repetitions-to-failure for females
Figure 4. Scatterplot showing relationship between predicted and actual repetitions-to-failure for males.
DISCUSSION

The purpose of this study was to determine if trained men and women can accurately predict how many repetitions they can complete before concentric failure at a submaximal intensity. Subjects reported their predicted repetitions-to-failure prior to failure in the bench press which was compared to the actual repetitions-to-failure. Overall there were no differences between predicted and actual repetitions-to-failure for both males and females. There was also a positive correlation between predicted and actual repetitions to failure, indicating that generally speaking the more repetitions the subject predicted they could complete, the more repetitions they were able to perform. However, differences were observed when each set was analyzed separately. There were differences between predicted and actual repetitions-to-failure in set one for females and in set two for both males and females, but no significant differences in sets three and four for both males and females. Correlation between RPE and actual repetitions-to-failure generally showed that RPE increased as actual repetitions-to-failure decreased.

The subjects were less accurate in predicting their performance earlier when they were less fatigued, and were more accurate later when they acutely experienced fatigued. This is consistent with Hackett et al. (2012) study on the validity of a repetitions-to-failure scale. Hackett et al. (2012) also used four sets to failure in the bench press and found that their subjects were much more accurate in predicting repetitions to failure in the last two sets than they were in the first two. Based on Tuckers (2009) “anticipatory feedback” model and Noakes, Gibson and Lamberts (2005) “central governor” theory,
the subjects may have been able to more accurately predict exercise endpoint in the last two sets due to central processing of the physiological disturbances from the previous sets and the subsequent rise in conscious RPE. Another possibility based on Tucker’s (2009) model is that there may have been a learning effect based on the first two sets. Since most of the subjects were athletes from power sports, training to failure with a low relative intensity for high repetitions and short rest periods may be a novel experience for them. A template RPE for the sensation of going to failure could have been acutely generated from the first two sets if they did not have a chronic template RPE, allowing the subjects to compare their current sensation to their past experience and more accurately predict exercise endpoint. If this is the case, then training to failure may be beneficial early in a training career for trainees to learn that sensation and develop a chronic template RPE so they can more accurately regulate intensity in the future without always having to train to failure. Since males and females training independently typically self-select weight that is too low to provide a training response, this could help them select appropriate resistance to experience the health and performance benefits of resistance training independently (Focht, 2007; Glass & Stanton, 2004; Ratamess et al., 2008).

In contrast, despite RPE having a correlation with actual repetitions-to-failure, most of the RPE were reported to be less than 10 despite all sets being performed to failure. Subjects reported a 10 RPE only 30 out of 96 total maximal effort sets. RPE has been shown in previous research to increase with increased loads and as individuals near fatigue (Duncan, Al-Nakeed, & Scurr, 2006; Gearhart et al., 2002; Lagally et al., 2002).
However, the findings of this study are consistent with previous studies that found even with the occurrence of muscular failure, which is by definition a “maximal” effort, RPE ratings are reported as less than “maximal” (Hackett et al., 2012; Pritchett, Green, Wickwire, & Kovacs, 2009; Shimano et al., 2006). RPE appears to be more sensitive to load and cannot be used to predict and identify muscular failure, which is required for prescribing and regulating resistance training intensity (Kraemer & Ratamess, 2004).

Limitations to the study included multiple variables related to the subjects selected. All participants were between the ages of 18 and 25 and had multiple years of resistance training experience. A majority of the subjects were also current Division II collegiate athletes, which does not represent most exercisers training independently.

Only the bench press exercise was used and the intensity used in the study was fixed at 65% of 1-RM with 30 seconds rest between each set. This follows NSCA (2008) guidelines for muscular endurance training. The effects of training protocols at higher intensities on perceptual response and predicted exercise endpoint need to be studied as well. The increase in the subject’s accuracy in predicting exercise end point in the later sets could have been due to learning outcomes. However, people may be more accurate at predicting exercise end point at higher percentages of 1-RM since they are beginning exercise closer to exercise end point and there is a much smaller range of choices. Since the subjects experienced fatigue by the time they had to perform their final two sets, their 1-RM could have acutely decreased and the fixed weight on the bar was actually a much higher percentage of their 1-RM at the time.

Another limitation of using a fixed intensity is that the study removed the need for
the subject to self-select resistance. This method was used to determine if the subjects could accurately predict exercise end point while limiting other variables. However, many trainees train independently and do not have trainers that can prescribe intensities for them based on percentages of 1-RM.

Future research should study less trained subjects to determine how accurately they could predict exercise endpoint in resistance training and to see if their accuracy changes with more experience. This could help distinguish the roles of chronic or acutely generated template RPE in predicting exercise endpoint. Examining perceptual response and accuracy for predicting exercise endpoint at higher intensities and different states of fatigue can help develop guidelines for individuals training independently to self select appropriate intensities without always having to train to failure. Finally, future studies should see if people could use predicted exercise endpoint to accurately select appropriate weight, rather than predicting exercise endpoint at a fixed weight.
CONCLUSION

Overall, there were not any significant differences between predicted and estimated repetitions-to-failure. There was also a positive correlation between predicted and actual repetitions-to-failure. Both male and female participants over and under estimated repetitions-to-failure in earlier sets and then predicted accurately in the last two sets. Despite all sets being performed to failure, maximal RPE (10) was rarely reported. RPE may not be sensitive to exercise endpoint and effort in resistance training. Male and female trainees can potentially use a predicted exercise end point to regulate resistance training intensity at a fixed percentage of 1-RM based on repetitions performed against repetitions possible rather than using RPE. Further research is required to assess predicted exercise end point as a means of regulating intensity in novice trainees and in influencing self-selected resistance behavior.
REFERENCES


Robertson, R.J., Goss, F.L., Rutkowski, J., Lenz, B., Dixon, C., Timmer, J., ... &


APPENDICES

A. Modified Category Ratio Rating of Perceived Exertion Scale
B. Humboldt State University Human Performance Lab Health History Questionnaire
C. Informed Consent Form
D. Physical Activity Readiness Questionnaire
E. Athletic Background and Training Status Questionnaire
APPENDIX A: MODIFIED CATEGORY RATIO RATING OF PERCEIVED EXERTION SCALE (DAY ET AL., 2004)

<table>
<thead>
<tr>
<th>Rating</th>
<th>Descriptor</th>
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<tr>
<td>0</td>
<td>Rest</td>
</tr>
<tr>
<td>1</td>
<td>Very, Very Easy</td>
</tr>
<tr>
<td>2</td>
<td>Easy</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>4</td>
<td>Somewhat Hard</td>
</tr>
<tr>
<td>5</td>
<td>Hard</td>
</tr>
<tr>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>Very Hard</td>
</tr>
<tr>
<td>8</td>
<td>-</td>
</tr>
<tr>
<td>9</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>Maximal</td>
</tr>
</tbody>
</table>
APPENDIX B: HUMBOLDT STATE UNIVERSITY HUMAN PERFORMANCE LAB HEALTH HISTORY QUESTIONNAIRE

Health History and Training Status Questionnaire

Name _____________________________________________________________________________

Address ______________________________________________________________________________

Home Phone _____________________              Work Phone __________________

Age _______     Date of Birth _____________     Gender _______     Height________    Weight_________

The following questions are designed to help us tailor the health and fitness assessment and follow-up counseling to your personal situation. It is extremely important for us to know if you have any medical conditions which may affect your testing process or your progress in our program. Please take the time to answer these questions accurately.

Medical History

YES        NO  In the past five years have you had:

( ) ( ) 1. Pain or discomfort in chest, neck, jaw, or arms
( ) ( ) 2. Shortness of breath or difficulty breathing at rest or with mild exertion (e.g., walking)
( ) ( ) 3. Dizziness or fainting
( ) ( ) 4. Ankle edema (swelling)
( ) ( ) 5. Heart palpitations (forceful or rapid beating of heart)
( ) ( ) 6. Pain, burning, or cramping in leg with walking
( ) ( ) 7. Heart murmur
( ) ( ) 8. Unusual fatigue with mild exertion

Have you ever had:

( ) ( ) 9. Heart disease, heart attack, and/or heart surgery
( ) ( ) 10. Abnormal EKG
( ) ( ) 11. Stroke
( ) ( ) 12. Uncontrolled metabolic disease (e.g., diabetes, thyrotoxicosis, or myxedema)
( ) ( ) 13. Asthma or any other pulmonary (lung) condition
( ) ( ) 14. Heart or blood vessel abnormality (e.g., suspected or known aneurysm)
( ) ( ) 15. Liver or kidney disease
( ) ( ) 16. Thyroid disorder
( ) ( ) 17. Are you currently under the care of a physician?
( ) ( ) 18. Do you currently have an acute systemic infection, accompanied by a fever, body aches, or swollen lymph glands?
( ) ( ) 19. Do you have a chronic infectious disease (e.g. mononucleosis, hepatitis, AIDS)?
( ) ( ) 20. Do you have a neuromuscular, musculoskeletal, rheumatoid disorder, or other condition that is made worse by exercise?
21. Do you know of any reason why you should not do physical activity?

If you answered yes to any of these questions, please explain.

______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________

CAD Risk Factors

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
<th>DON'T KNOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>(   ) (   ) (   )</td>
<td>1. Are you a male 45 years of age or older?</td>
<td></td>
</tr>
<tr>
<td>(   ) (   ) (   )</td>
<td>2. Are you a female 55 years of age or older</td>
<td></td>
</tr>
<tr>
<td>(   ) (   ) (   )</td>
<td>3. Do you have a father or brother who had a heart attack or heart surgery before age 55?</td>
<td></td>
</tr>
<tr>
<td>(   ) (   ) (   )</td>
<td>4. Do you have a mother or sister who had a heart attack or heart surgery before age 65?</td>
<td></td>
</tr>
<tr>
<td>(   ) (   ) (   )</td>
<td>5. Have you smoked within the past 6 months?</td>
<td></td>
</tr>
<tr>
<td>(   ) (   ) (   )</td>
<td>6. Do you exercise regularly? If so, explain.</td>
<td></td>
</tr>
<tr>
<td>(   ) (   ) (   )</td>
<td>7. Do you have a waist circumference of greater than 35 inches (female) or 40 inches (male)?</td>
<td></td>
</tr>
<tr>
<td>(   ) (   ) (   )</td>
<td>8. Do you know your blood pressure? <strong><strong><strong>/</strong></strong></strong>_ mmHg-Date: ____________</td>
<td></td>
</tr>
<tr>
<td>(   ) (   ) (   )</td>
<td>9. Are you taking blood pressure lowering medication?</td>
<td></td>
</tr>
<tr>
<td>(   ) (   ) (   )</td>
<td>10. Do you know your total cholesterol? _____________ mg/dL –Date: ____________</td>
<td></td>
</tr>
<tr>
<td>(   ) (   ) (   )</td>
<td>11. Do you know your LDL cholesterol? _____________ mg/dL –Date: ____________</td>
<td></td>
</tr>
<tr>
<td>(   ) (   ) (   )</td>
<td>12. Do you know your HDL cholesterol? _____________ mg/dL –Date: ____________</td>
<td></td>
</tr>
<tr>
<td>(   ) (   ) (   )</td>
<td>13. Do you know your Triglyceride levels? _________ mg/dL –Date: ____________</td>
<td></td>
</tr>
<tr>
<td>(   ) (   ) (   )</td>
<td>14. Are you taking cholesterol lowering medication?</td>
<td></td>
</tr>
<tr>
<td>(   ) (   ) (   )</td>
<td>15. What is your fasting blood glucose? _________ mg/dL –Date: ____________</td>
<td></td>
</tr>
<tr>
<td>(   ) (   ) (   )</td>
<td>16. Do you have a father or brother who had/has diabetes?</td>
<td></td>
</tr>
<tr>
<td>(   ) (   ) (   )</td>
<td>17. Do you have a mother or sister who had/has diabetes?</td>
<td></td>
</tr>
</tbody>
</table>

If you answered yes to any of these questions, please explain.
Health-Related Questions

YES  NO
(    ) (    ) 1. Do you have any other medical condition(s)/surgeries? Discuss below.
(    ) (    ) 2. Are you pregnant?
(    ) (    ) 3. Are allergic to isopropyl alcohol (rubbing alcohol) or latex?
(    ) (    ) 4. Do you have any allergies to medications, bees, foods, etc.?
(    ) (    ) 5. Do you have any skin problems?
(    ) (    ) 6. Have you had any caffeine, food, or alcohol in the past 3 hours?
(    ) (    ) 7. Have you exercised today?
(    ) (    ) 8. Are you feeling well and healthy today?

If you answered yes to any of these questions, please explain.

______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________

Medications

Please Identify Any Medications You Are Currently Using:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Diuretics</td>
<td>□ Other Cardiovascular</td>
</tr>
<tr>
<td>□ Beta Blockers</td>
<td>□ NSAIDS/Anti-inflammatory (Motrin, Advil)</td>
</tr>
<tr>
<td>□ Vasodilators</td>
<td>□ Cholesterol-lowering</td>
</tr>
<tr>
<td>□ Alpha Blockers</td>
<td>□ Diabetes/Insulin</td>
</tr>
</tbody>
</table>
Please list the specific medications that you currently take:
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________

What are your health and fitness goals?
____________________________________________________________________________ __________
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________
____________________________________________________________________________ __________
______________________________________________________________________________________
______________________________________________________________________________________
______________________________________________________________________________________

I certify that the information I have provided is complete and accurate to the best of my knowledge.

Date _______________ Signature of Subject
______________________________________________________________________________________

Date _______________ Signature of Witness
______________________________________________________________________________________

Office Use Only

_____ Low Risk       _____ Moderate Risk       _____ High Risk

Special Considerations:
______________________________________________________________________________________
Body Composition: Bod Pod, skinfold calipers, underwater (hydrostatic) weighing, BIA

1. **Bod Pod.** The Bod Pod procedure involves the measuring of your height, weight and density of your body. You will be wearing a tight fitting swimsuit or unisuit (provided for you). You will sit in an egg-like chamber for several minutes and be assessed for two 40 second cycles. This is a non-invasive test, the only thing that you will need to do is sit quietly and breathe normally in the chamber.

2. **Skinfold Thickness Measurements with Skinfold Calipers.** We will measure skinfold thickness in several different areas using skinfold calipers. Typically we measure 4 different sites on the arm, leg, back, and torso.

3. **Hydrostatic Weighing.** The underwater weighing procedure involves being completely submerged in a tank of warm water. An accurate measurement of weight requires a complete exhalation of air while submerged. You dictate the amount of time spent underwater. This test provides an accurate assessment of your body composition when properly performed.

4. **Bioelectrical Impedance Analysis (BIA).** This test is a simple, quick way of analyzing your body composition using a small amount of electricity through your body. You will have two electrodes placed on your right foot, and two on your right hand, and a small machine will measure how quickly electricity runs between those two points. This test is painless, and quick, and has more measurements than a Bod Pod test. It will determine your % body fat, and % lean mass, as well as breaking down your muscle mass and bone mass.

Aerobic Fitness Test (treadmill or cycle ergometer)

1. **Explanation of the Test.** You will perform an exercise test on a cycle ergometer or a motor-driven treadmill. The exercise intensity will begin at a low level and will be advanced in stages depending on your fitness level. We may stop the test at any time because of signs of fatigue or changes in your heart rate, electrocardiogram (EKG), or blood pressure. It is important for you to realize that you may stop when you wish because of feelings of fatigue or any other discomfort.

2. **Attendant Risk and Discomforts.** There exists the possibility of certain changes occurring during the test(s). They include abnormal blood pressure; fainting; irregular, fast or slow heart rhythm; and in very rare instances, heart attack, stroke or death. Every effort will be made to minimize these risks by evaluation of preliminary information relating to your health and fitness and by results and observations during the testing. Emergency trained personnel are available to deal with unusual situations that may arise.
3. **Responsibilities of the Participant.** Information you possess about your health status or previous experiences of unusual feelings with physical effort may affect the safety and value of your exercise test. Your prompt reporting of feelings during the exercise test itself is also of great importance. You are responsible for fully disclosing such information when requested by the testing staff.

4. **Benefits to be Expected.** The results obtained from the exercise test may assist in evaluating your functional (aerobic) capacity and determining what type of physical activities would be appropriate to meet your goals.

5. **Inquiries.** Any questions about the procedures used in the exercise test or the results of your test are encouraged. If you have any concerns or questions, please ask us for further explanations.

6. **Freedom of consent.** Your permission to perform these fitness assessments / tests is voluntary. You are free to stop the test at any point, if you so desire.

7. **Confidentiality.** All tests and accompanying records will remain private unless specifically released through client’s written consent.

HUMBOLDT STATE UNIVERSITY RELEASE OF LIABILITY, PROMISE NOT TO SUE, ASSUMPTION OF RISK AND AGREEMENT TO PAY CLAIMS

I have read this form, and I understand the test procedures that I will perform and the attendant risks and discomforts. Knowing these risks and discomforts, and having had an opportunity to ask questions that have been answered to my satisfaction, I consent to participate in this test.

In consideration for being allowed to participate in this Activity, on behalf of myself and my next of kin, heirs and representatives, I release from all liability and promise not to sue the State of California, the Trustees of The California State University, California State University, Humboldt State University and their employees, officers, directors, volunteers and agents (collectively “University”) from any and all claims, including claims of the University’s negligence, resulting in any physical or psychological injury (including paralysis and death), illness, damages, or economic or emotional loss I may suffer because of my participation in this Activity, including travel to, from and during the Activity.
I am voluntarily participating in this Activity. I am aware of the risks associated with traveling to/from and participating in this Activity, which include but are not limited to physical or psychological injury, pain, suffering, illness, disfigurement, temporary or permanent disability (including paralysis), economic or emotional loss, and/or death. I understand that these injuries or outcomes may arise from my own or other’s actions, inaction, or negligence; conditions related to travel; or the condition of the Activity location(s). Nonetheless, I assume all related risks, both known or unknown to me, of my participation in this Activity, including travel to, from and during the Activity.

I agree to hold the University harmless from any and all claims, including attorney’s fees or damage to my personal property that may occur as a result of my participation in this activity, including travel to, from and during the Activity. If the University incurs any of these types of expenses, I agree to reimburse the University. If I need medical treatment, I agree to be financially responsible for any costs incurred as a result of such treatment. I am aware and understand that I should carry my own health insurance.

Date:_______ Signature of Subject:___________________________________________

Date:_______ Signature of Witness:___________________________________________

Date:_______ Signature of Lab Director:________________________________________
APPENDIX C: INFORMED CONSENT FORM

Regulating Resistance Exercise Intensity Using Perceptual Response and the “Anticipatory Feedback” Model

INFORMED CONSENT FOR PARTICIPATION

This form will explain the study to you, including the possible risks as well as the possible benefits of participating. This is so you can make an informed choice about whether or not to participate in this study. Please read this Consent Form carefully. Ask the investigators or study staff to explain any words or information that you do not clearly understand.

Principal Investigator:

Ben Servais, B.Sc., CSCS
Department of Kinesiology and Recreation Administration
Humboldt State University
(916) 715-1851
brs22@humboldt.edu

Faculty Advisor:

Dr. Young Sub Kwon, PhD, RCEP, CSCS*D
Department of Kinesiology and Recreation Administration
1 Harpst Street
Humboldt State University
707-826-5944
ysk15@humboldt.edu

PURPOSE AND GENERAL INFORMATION:

The purpose of this study to look at how you are able to predict and anticipate exercise endpoint in the bench press exercise. You are being asked to participate because you are healthy, between the ages of 18-25 years and do not have high blood pressure or a previous history of muscle or bone injuries in your upper body. Additionally, you are being asked to participate because you either weight train regularly for at least the past
two years, or you have not been participating in weight training for at least the past 6 months. Approximately 24 - 48 subjects locally will take part in this study at Humboldt State University.

**WHAT WILL HAPPEN IF I PARTICIPATE?**

Participation in this study will take a total of 1.5-2 hours over a 2 day period each separated by 2-4 days.

If you agree to be in this study, you will be asked to read and sign this Consent Form. After you sign the Consent Form, the following things will happen:

All testing will take place in the Human Performance lab in the Kinesiology and Athletics building, Room 254, HSU.

When Scheduling takes place, you will be asked not to drink alcohol for 24 hours prior to each session, not to drink caffeine 3 hours prior to each session, and to not eat 2 hours prior to each session.

Day 1: Screening process, paperwork, familiarization, 1 repetition max (1RM) test, and 65% of 1RM (1 hour)

- You will complete this informed consent form, health history and physical activity questionnaires, and the Physical Activity Readiness Questionnaire (PAR-Q) form.
- Your blood pressure, height and weight will be measured
- You will be screened for eligibility for this study based on your answers to the questionnaires and your resting blood pressure. If the criteria are not met, you will be excluded from the study.
- You will be asked if you have any soreness or injury to your shoulder, triceps, and chest.
- You will be asked if you have refrained from caffeine in the previous 3 hours and alcoholic beverages in the previous 24 hours.
- Females will be tested day 3-10 of their menstrual cycle (day 1 is the first day of bleeding). If you take oral contraceptives, the test will be done during the days you are taking a pill.
- You will be verbally instructed on the use of the modified RPE and Repetitions to Failure Scale, and on the general procedure of the study.
1 Repetition Maximum (1RM) test and 65% of 1-RM

- You will be required to perform a warm-up of 10 repetitions at 50% of 1RM, 5 repetitions at 70% of 1RM, 3 repetitions at 80% of 1RM, and 1 repetition at 90% of 1RM, followed by 4 attempts to determine your 1RM in the bench press exercise. You will be given 3 minutes of rest between sets.
- After the 1RM test, you will have 5 minutes of rest and then will perform 4 sets at 65% of 1-RM to failure with 30 seconds of rest in between each set. Before each set you will predict how many repetitions you will complete. Within each set you will let the investigator know when you can only complete one more repetition. You will then continue performing the set until failure. Immediately after the set you will report how hard the set was.

Day 2: 65% of 1RM (30 min)

- Day 2 will be scheduled 48-72 hours after day 1.
- You will be asked if you have any soreness or injury to your shoulder, triceps, and chest.
- If you are experiencing any soreness, then the session will be postponed one additional day.
- You will be asked if you have refrained from caffeine in the previous 3 hours and alcoholic beverages in the previous 24 hours.
- You will then perform the same bench press protocol as day 1 except for the 1-RM testing.

WHAT ARE THE POSSIBLE RISKS OR DISCOMFORTS OF BEING IN THIS STUDY?

Every effort will be made to protect the information you give us. However, there is a small risk of loss of confidentiality. There are also small risks of stress, emotional distress, and inconvenience.

Some of the risks of weight lifting include soreness of your muscles or muscle injuries. These injuries can be prevented using proper techniques. Weight training injuries occur less often than other sports like basketball or football. Sports injury during weight training has occurred at a rate of about 0.0035 injuries per 100 hours. Every effort will be made to minimize this risk by allowing a proper warm-up and having a certified strength and conditioning specialist conducting all of the testing. As with any research, there may be unforeseeable risks.
If you become pregnant, the treatments and procedures in this research may involve risks to the embryo or fetus that are currently unforeseeable. If you should become pregnant, you should immediately notify an investigator and terminate participation.

Emergency equipment (defibrillator and first aid kit) are available in the laboratory and emergency procedures are established to call for help.

**HOW WILL MY INFORMATION BE KEPT CONFIDENTIAL?**

Your name and other identifying information will be maintained in locked files, available only to authorized members of the research team, for the duration of the study. For any information entered into a computer, the only identifier will be a unique study identification (ID) number. Any personal identifying information and any record linking that information to study ID numbers will be destroyed when the study is completed. Information resulting from this study will be used for research purposes and may be published; however, you will not be identified by name in any publications.

Information from your participation in this study may be reviewed by federal and state regulatory agencies, and by the HSU Institutional Review Board (IRB) which provides regulatory and ethical oversight of human research.

**WHAT ARE THE BENEFITS TO BEING IN THIS STUDY?**

There are no direct benefits to you from being in this study. However, your participation may help answer the question of how accurately perceptual response to exercise can regulate exercise intensity and predict exercise endpoint. These findings could ultimately increase our knowledge related to prescribing intensities in strength and conditioning or general fitness training settings.

**WHAT OTHER CHOICES DO I HAVE IF I DON’T PARTICIPATE?**

Taking part in this study is voluntary so you can choose not to participate.

**WILL I BE PAID FOR TAKING PART IN THIS STUDY?**

There will be no compensation.

**WHAT WILL HAPPEN IF I AM INJURED OR BECOME SICK BECAUSE I TOOK PART IN THIS STUDY?**
If you are injured or become sick as a result of this study, HSUHPL will follow emergency treatment procedures at your cost. It is important for you to tell the investigator immediately if you have been injured or become sick because of taking part in this study. If you have any questions about these issues, or believe that you have been treated carelessly in the study, please contact Institutional Review Board (IRB) at the Humboldt State University Student Business Services Building, Arcata, California 95521, (707) 826-5165 for more information.

CAN I STOP BEING IN THE STUDY ONCE I BEGIN?

Yes, you can withdraw from this study at any time without consequence.

The investigators have the right to end you participation in this study if they determine that you no longer qualify to take part, if you do not follow study procedures, or if it is in your best interest or the study’s best interest to stop your participation.

AUTHORIZATION FOR USE OF YOUR PROTECTED HEALTH INFORMATION

As part of this study, we will be collecting health information about you. This information is “protected” because it is identifiable or “linked” to you.

PROTECTED HEALTH INFORMATION (PHI)

By signing this Consent Document, you are allowing the investigators and other authorized personnel to use your protected health information for the purposes of this study. This information may include: resting blood pressure, height, weight, age, %body fat, and health and fitness related items on the questionnaires.

In addition to researchers and staff at HSUHPL and other groups listed in this form, there is a chance that your health information may be shared (re-disclosed) outside of the research study and no longer be protected by federal privacy laws. Examples of this include disclosures for law enforcement, judicial proceeding, health oversight activities and public health measures.

RIGHT TO WITHDRAW

Your authorization for the use of your health information for this study shall not expire unless you cancel this authorization. Your health information will be used as long as it is needed for this study. However, you may withdraw your authorization at any time provided you notify the HSU investigators in writing. To do this, please send a letter notifying them of your withdrawal to the principal investigator.
Please be aware that the research team will not be required to destroy or retrieve any of your health information that has already been used or shared before your withdrawal is received.

REFUSAL TO SIGN

If you choose not to sign this consent form and authorization for the use of your PHI, you will not be allowed to take part in the research study.

WHAT IF I HAVE QUESTIONS OR COMPLAINTS ABOUT THIS STUDY?

The Investigator will answer any questions you have about this study. Your participation is voluntary and you may stop at any time.

If you have any concerns with this study, contact the Chair of the Institutional Review Board for the Protection of Human Subjects, Dr. Ethan Gahtan, at eg51@humboldt.edu or (707) 826-4545.

If you have questions regarding your rights as a participant, you may report them to the IRB Institutional Official at Humboldt State University, Dr. Rhea Williamson at Rhea.Williamson@humboldt.edu or (707) 826-5169.

CONSENT AND AUTHORIZATION

You are making a decision whether to participate in this study. Your signature below indicates that you read the information provided (or the information was read to you). By signing this Consent Form, you are not waiving any of your legal rights as a research subject.

I have had an opportunity to ask questions and all questions have been answered to my satisfaction. By signing this Consent form, I agree to participate in this study and give permission for my health information to be used or disclosed as described in this Consent Form. A copy of this Consent Form will be provided to me.

Name of Adult Participant (print): _____________________________________

Sign: _____________________________________ Date _______________

I have explained the research to the subject and answered all of his/her questions. I believe that he/she understands the information in this consent form and freely consents to participate.
APPENDIX D: PHYSICAL ACTIVITY READINESS QUESTIONNAIRE

1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor? Yes/No

2. Do you feel pain in your chest when you do physical activity? Yes/No

3. In the past month, have you had chest pain when you were not doing physical activity? Yes/No

4. Do you lose your balance because of dizziness or do you ever lose consciousness? Yes/No

5. Do you have a bone or joint problem that could be made worse by a change in your physical activity? Yes/No

6. Is your doctor currently prescribing drugs (ex. water pills) for your blood pressure or heart condition? Yes/No

7. Do you know of any other reason why you should not do physical activity? Yes/No
APPENDIX E: ATHLETIC BACKGROUND AND TRAINING STATUS

QUESTIONNAIRE

Athletic Background and Training Status Questionnaire

1. Please circle/mark yes or no for the following:
   ( ) Yes or ( ) No: Are you currently injured?
   ( ) Yes or ( ) No: Do you have chronic back pain?
   ( ) Yes or ( ) No: Do you have any medical condition made worse by exercise?

2. ( ) Yes or ( ) No: Did you participate in collegiate athletics?
   If yes: What sport(s) did you play? _____________________________
   What was your position? _____________________________
   When was your last season of competition? _____________________________

3. ( ) Yes or ( ) No: Are you currently participating in a collegiate athletic sport?
   If yes: What sport are you participating in? _____________________________

4. ( ) Yes or ( ) No: Have you been cleared for athletic participation within the last 2 years?

5. ( ) Yes or ( ) No: Do you exercise vigorously on a regular basis?
   If yes: What activities do you engage in on a regular basis?
   _____________________________
   How often per week do you workout? ________________
   How often do you participate in cardiovascular training? _____

6. ( ) Yes or ( ) No: Do you lift weights?
   If yes: How long have you been lifting weights? ________________
   How often do you lift weights? _____________________________
   Describe a typical session: _____________________________

7. ( ) Yes or ( ) No: Do you know your bench press 1 repetition maximum?
   If yes: What is it? _____

8. ( ) Yes or ( ) No: Do you participate in any other type of physical activity on regular basis?
If yes: Please describe: ____________________________________________

I certify that the information I have provided is complete and accurate to the best of my knowledge.

Date________________ Signature of Subject____________________________________________

Date________________ Signature of Witness__________________________________________