THE EFFECTS OF INTERSET REST DURATION ON MUSCLE ACTIVATION AND PERFORMANCE DURING RESISTANCE TRAINING

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UNIVERSITI PENDIDIKAN SULTAN IDRIS

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ABSTRACT

The purpose of this study was to determine the effects of interset rest duration on muscle activation and performance during resistance training. Fifteen trained men were randomly recruited based on volunteerism as participants of this study. Participants were instructed to perform three sets of bent-over row and biceps curl exercises with three different rest intervals: i) 60 seconds (60s), ii) 90 seconds (90s) and iii) 120 seconds (120s) between sets in a randomized crossover design. The rest interval between sets were randomly performed in different days with a rest period of 72 hours. Each set was performed with 10 repetitions maximum loadings until fatigue. Muscle activation, number of repetitions, rating of perceived exertion (RPE) and heart rate (HR) were analyzed using One Way Analysis of Variance (ANOVA) with repeated measures. Results showed that performing bent-over row exercise with 120s rest interval produced higher number of repetitions [$F(2,28) = 91.00$, $p < 0.05$], greater activation of latissimus dorsi [$F(2,28) = 23.49$, $p < 0.05$] and biceps brachii [$F(2,28) = 14.59$, $p < 0.05$] and lower RPE [$F(2,28) = 16.63$, $p < 0.05$] and HR [$F(2,28) = 20.53$, $p < 0.05$] compared to 60s and 90s. For biceps curl exercise, results showed that 90s and 120s rest intervals produced higher number of repetitions [$F(2,28) = 60.15$, $p < 0.05$], greater biceps brachii muscle activation [$F(2,28) = 22.35$, $p < 0.05$] and lower RPE [$F(2,28) = 36.58$, $p < 0.05$] and HR [$F(2,28) = 20.77$, $p < 0.05$] compared to 60s. In conclusion, performing bent-over row with 120s rest interval interset and 90s and 120 seconds rest intervals for biceps curl allow participants to produce higher number of repetitions, recruit more motor unit to activate the latissimus dorsi and biceps brachii in every set and control RPE and HR from increasing dramatically over the 3 sets. In implication, the results can be used as a guideline for resistance training design in order to achieve optimum benefit while being time-effective.

KESAN TEMPOH MASA REHAT ANTARA SET TERHADAP PENGAKTIFAN OTOT DAN PRESTASI SEMASA LATIHAN BEBANAN

ABSTRAK

Tujuan kajian ini adalah untuk mengenalpasti kesan tempoh masa rehat terhadap pengaktifan otot dan prestasi semasa latihan bebanan. Lima belas peserta lelaki terlatih telah dipilih secara rawak atas dasar sukarela sebagai peserta kajian ini. Peserta-perseta dikehendaki melakukan tiga set senaman bent-over row dan biceps curl dengan tiga jenis masa rehat antara set yang berbeza: i) 60 saat (60s), ii) 90 saat (90s) dan iii) 120 saat (120s). Ketiga-tiga masa rehat antara set dilakukan secara rawak pada hari yang berbeza dengan tempoh rehat selama 72 jam. Kesemua peserta melakukan kedua-dua senaman dengan menggunakan bebanan sebanyak 10 ulangan maksimum sehingga keletihan. Aktiviti otot, jumlah pengulangan, rate of perceived exertion (RPE), dan kadar degupan jantung (HR) direkodkan dan dianalisis menggunakan kaedah Analisis Varians Satu Hala (ANOVA) dengan pengukuran berulang. Hasil kajian menunjukkan peserta yang melakukan senaman bent-over row dengan masa rehat selama 120s dapat menghasilkan jumlah pengulangan [$F(1.428,19.996) = 91.000$, $p < 0.05$], pengaktifan otot latissimus dorsi [$F(2,28) = 23.493$, $p < 0.05$] dan biceps brachii [$F(2,28) = 14.590$, $p < 0.05$] yang lebih tinggi dan kadar RPE [$F(2,28) = 16.625$, $p < 0.05$] dan HR [$F(2,28) = 20.532$, $p < 0.05$] yang lebih rendah berbanding 60s dan 90s. Untuk senaman biceps curl pula, keputusan menunjukkan masa rehat selama 90s dan 120s dapat menghasilkan jumlah pengulangan [$F(2,28) = 60.153$, $p < 0.05$] dan pengaktifan otot biceps brachii [$F(1.389,143.026) = 22.350$, $p < 0.05$] yang lebih tinggi dan kadar RPE [$F(2,28) = 36.576$, $p < 0.05$] dan HR [$F(2,28) = 20.773$, $p < 0.05$] yang lebih rendah berbanding 60s. Kesimpulannya, masa rehat selama 120s ketika melakukan senaman bent-over row dan masa rehat selama 90s dan 120s semasa melakukan senaman biceps curl dapat menghasilkan prestasi yang lebih baik serta pengrekrutan unit motor yang lebih banyak untuk mengaktifkan otot latissimus dorsi dan biceps brachii dalam setiap set di samping mengawal RPE dan HR daripada meningkat secara dramatik dalam 3 set tersebut. Implikasi kajian, dapatan kajian ini boleh digunakan sebagai garis panduan latihan bebanan untuk mencapai tahap yang optimal dan efektif dari segi masa.

.

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ABBREVIATIONS

RM	Repetitions maximum
RI	Rest interval
HR	Hear rate
RPE	Rating perceived exertion
BOR	Bent over row exercise
BC	Biceps curl exercise
LD	Latissimus dorsi
BB	Biceps brachii
EMG	Electromyography
IEMG	Integrated electromyography
SEMG	Surface electromyography
ANOVA	Analysis of variance
H^+	Hydrogen ions
ATP	Adenosine triphosphate
ADP	Adenosine diphosphate
Pi	Inorganic phosphate
PCR	Phosphocreatine
Na^+	Sodium ion
K^+	Potassium ion
Ca^{2+}	Calcium ion

Mg^{2+}	Magnesium ion
Cl^{-}	Chloride ion

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Physical exercises are any movement of body that produced by skeletal muscles and can enhance or maintaining physical fitness and health. Among the physical exercises of interest is the resistance training. Resistance training is carried out for many purposes such as to increase muscle strength, power, endurance, bone mineral density and cardiorespiratory fitness (Lloyd et al., 2014). Faigenbaum, Lloyd, MacDonald, and Myer (2016) also stated that resistance training can improved blood lipid profile, insulin sensitivity in overweight youth, body composition, motor performance skills, increased resistance to injury, enhanced mental health and well-being, and simulation of a more positive attitude toward lifetime physical activity. For athletes, the goals of resistance training are to have optimum strength, power, balance and speed to reach optimal level condition for them to perform well in sports (Faigenbaum et al., 2016).

In life, the most important thing is to have a healthy body that can move to survive in daily life. Healthy body requires adequate muscle strength for increase or maintain functional movement ability and quality of life (American College of Sports Medicine [ACSM], 2009). Based on that fact, resistance training can help to enhance muscle strength to achieve optimal level that required by the body. Resistance training programs can be structured to emphasize muscular power, strength, hypertrophy, or endurance based on the variables of training. When designing a resistance training program, many variables must be considered and manipulated in order to achieve the proper responses. The effectiveness of training depends on how coaches or physical trainer design the training program. Among variables that must be consider in training are intensity of exercises, volume, weekly frequency, movement velocity, exercise order, and duration of the rest interval (RI) between sets and exercises (Fleck & Kraemer, 2014). Physical trainer or coach that develop program without proper variables based on theory can cause either inadequate training or on the other side, overtraining syndrome (Arazi & Rahimi, 2011). Hence, anyone who follow improper resistance training program might be cause them to fail to achieve their training goals.

Hypertrophy is one of the resistance training objectives. Systematic hypertrophy training can promote increase in size and strength of skeletal muscle. Beside that, combination of various factors, metabolic stress, neuromuscular control, mechanical stress and endocrine activities also influences in hypertrophy. Furthermore, skeletal muscle is highly plasticity and can change through external stimulus (Ozaki, Abe, Machida, & Naito, 2017). Muscles that were stressed and damaged through hypertrophy training will receive protein to build new muscles (anabolic) and increase

myosin and actin and muscle protein synthesis will be occurred (Tang, Perco, Moore, Wilkinson, & Phillips, 2008). In hypertrophy training, rest interval (RI) between sets is one of the variables that need to be taken into consideration. Furthermore, hypertrophy training is an interval training that should has rest period in training. This is because muscles that were recruited during resistance training will fatigue and it need time to recover before continue the training. The length of rest period must be enough to recover energy sources (e.g., adenosine triphosphate [ATP] and phosphocreatine [PCr]), clear fatigue producing substances, and restore force production (MacDougall, MacDougall, & Sale, 2014). Hence, it can be conclude that rest interval in training is important to recover the muscle that fatigue.

Not enough rest between sets will cause the muscle not able to recover thus cannot sustain the force production as the earlier sets. In contrast, too long rest period might cause the muscle too relaxed and not having enough stimuli for hypertrophy adaptation. Stimuli for hypertrophy adaptation can be obtained through the muscle activation analysis during the movement. Besides, based on Progression Models in Resistance Training, ACSM (2009) recommends 2 to 3 minute rest intervals between sets for multi-joint (core) exercises and around 1 to 2 minute rest for the single-joint (assistance) exercises (Senna et al., 2017). Furthermore, the rest period between set must be consider on complexity of the movement and the load that being lifted (Ratamess et al., 2009).

In any resistance training program, there are going to be variables that can be manipulated. These training program variables consist of exercise order, rest intervals between sets, exercise and sessions, weekly frequency, velocity of movement, training

duration and volume, number of repetitions and sets, load or intensity (de Salles et al., 2009; Willardson & Burkett, 2006). Through manipulation of these factors, individualized training programs can be created for different sets of needs or goals. Systematic resistance training has a well-known potent effect in promoting increases in size and strength of skeletal muscle. This is due to combinations of multiple factors, mechanical stress, neuromuscular control, metabolic demands and endocrine activities (Hill-Hass, Bishop, Dawson, Goodman, & Edge, 2007). When the body is faced with a heavy-resistance exercise protocol performed with a progressive overload principle, it will lead to acute responses in anabolic hormone concentrations and temporary decreases in neuromuscular performance. The magnitude of acute hormonal and neuromuscular responses can therefore be considered an important indicator of training effects during strength training protocol.

Beside that, research has indicated that the rest interval between sets is an important variable that affects both acute responses (increases in hormonal concentrations and decreases in neuromuscular performance) and chronic adaptations (magnitude) to resistance exercise programs (Miranda et al., 2007). When the strength training goal was maximal strength development, multiple sets per muscle group were found to be superior to a single set. For this to occur, the ability to sustain consistent repetitions over consecutive sets must be present. This ability to sustain repetitions over multiple sets is largely dependent on the length of the rest interval. The length of the rest interval must be sufficient enough to recover energy sources (adenosine triphosphate [ATP] and phospocreatine [PCr]), clear fatigue producing substances (H^+ ions) and restore force production (Ahtiainen, Pakarinen, Alen, Kraemer, & Hakkinen, 2005). If the rest interval is not sufficient enough to replenish the PCr system, energy

production shifts to emphasize the glycolytic system. This results in the accumulation of H^+ ions and disturbances in the concentration gradient of other ions (ex. ,'Na^+, K^+, Ca^{2+}, Mg^{2+} and Cl^-) (de Salles et al., 2009). This will in turn lower the pH; at low pH values both the peak isometric and maximal velocity and shortening are substantially decreased. However, the importance of rest intervals is frequently ignored when designing a resistance exercise program, despite its significant effect on the metabolic, hormonal, and cardiovascular response to resistance training.

Positive muscular adaptations that can be affected by rest intervals include; an increase in anaerobic enzyme activity, intramuscular glycogen, and force production. Additionally shifts within major fiber type groups can be affected by the amount of rest taken in between sets while training. The body also can undergo neural adaptations from resistance training which include; improvements in motor unit recruitment and synchronization, force development, and the stretch-shorting cycle (Faraji, Sheikholeslami, & Arazi, 2011; Matuszak, Fry, Weiss, Ireland, & McKnight, 2003). When the goal of the resistance training program is strength gain, the optimal rest interval is 2-5 minutes (Ahtiainen et al., 2005; Hill-Hass et al., 2007; Miranda et al., 2007). This rest interval allows for greater repetitions over multiple sets. Furthermore, in terms of chronic adaptations, resting 2-5 minutes between sets produced greater increases in absolute strength due to higher intensities and volumes of timing. Resting periods between sets and exercises had a significant effect on the total training volume completed during a training session and on the volume of a particular exercise in a session (de Salles et al., 2009). When designing a resistance exercise program, rest interval length should not be overlooked as a variable to be manipulated to help with needs and reach desired goals.

1.2 Problem Statement

Rest interval is one of the variables in designing resistance training. Schoenfeld (2010) classified length of rest interval between sets into three categories that are short (30 seconds or less), moderate (60-90 seconds), and long (3 minute or more). Based on these three categories, moderate rest interval can enhanced the body's anabolic environment to a greater extent than longer rest interval (Haff & Triplett, 2015). Besides that, greater hypoxia that increases the potential for better muscular growth is also evoked by moderate rest intervals (Toigo & Boutellier, 2006). Moderate rest intervals are also being related with a better metabolic accumulation, catalysing a huge hike in anabolic hormonal concentrations post exercise (Ratamess et al., 2007). Moreover, Study by Sajad, Arsalan, and Rahmat (2014) proved that at least 90 seconds rest interval between sets produced higher muscle activation on single joint exercises. Thus, it is the interest of researcher to concentrate on moderate rest interval in this current study.

Thus, this current study aimed to examine the effects of various moderate rest interval on muscle activation during multiple joint exercise. The exercise of interest in current study is bent over row. Through several previous literatures review, bent over row was found to be less used and studied. Bent over row is an exercise that targeted the upper back muscles, mainly latissimus dorsi and rhomboids as agonists and biceps brachii as the assistant muscles. Without machines such as lat pull down and back rowing, bent over row is undoubtedly among the main exercise for the upper back.

Additionally, study by Sajad et al. (2014) only examined training volume and muscle activation on biceps curl exercise. Thus, this current study will used the rating of perceived exertion (RPE) and heart rate (HR) as parameters to measure the effects of different moderate rest intervals on single joint exercise. The addition of this measuring instruments can strengthen the findings from previous study on single- joint exercise especially biceps curl. Biceps curl is among the most popular exercise due to its simple movement and concentration to the biceps brachii muscle. Lastly, there was lack of study to identify the effect of moderate rest intervals on number of repetitions every sets, muscle activation, RPE and HR during both multiple and single joint on the same research participants.

1.3 Objective of Study

The objectives of this research was:

i. To compare the effects of 60 second, 90 second and 120 second rest interval on number of repetitions completed during bent over row and biceps curl exercises.

ii. To compare the effects of 60 second, 90 second and 120 second rest interval on muscle activation during bent over row and biceps curl exercises.

iii. To compare the effects of 60 second, 90 second and 120 second rest interval on rating of perceived exertion (RPE) during bent over row and biceps curl exercises.

iv. To compare the effects of 60 second, 90 second and 120 second rest interval on heart rate during bent over row and biceps curl exercises.

1.4 Hypothesis of Study

The hypothesis of this research was:

i. There was no significant differences between the effects of 60 second, 90 second and 120 second rest interval on number of repetitions completed during bent over row and biceps curl exercises.

ii. There was no significant differences between the effects of 60 second, 90 second and 120 second rest interval on muscle activation completed during bent over row and biceps curl exercises.

iii. There was no significant differences between the effects of 60 second, 90 second and 120 second rest interval on rating of perceived exertion (RPE) during bent over row and biceps curl exercises.

iv. There was no significant differences between the effects of 60 second, 90 second and 120 second rest interval on heart rate during bent over row and biceps curl exercises.

1.5 Research Questions

The research questions of this research was:

i. Is there any significant differences of the number of repetitions completed during bent over row and biceps curl exercises between 60 second, 90 second and 120 second rest interval.

ii. Is there any significant differences of muscle activation during bent over row and biceps curl exercises between 60 second, 90 second and 120 second rest interval.

iii. Is there any significant differences of the heart rate during bent over row and biceps curl exercises between 60 second, 90 second and 120 second rest interval.

iv. Is there any significant differences of the rating of perceived exertion (RPE) during bent over row and biceps curl exercises between 60 second, 90 second and 120 second rest interval.

1.6 Significant of Study

Athletes or recreational lifters that involved in hypertrophy training must be careful during designing the program. Athletes or recreational lifters can understand mechanisms of muscle hypertrophy will enable good development of muscle mass and enhance performance. Beside that, the findings of this study will help to give information on how changing rest intervals between set in resistance training will affect the muscle activation and performance. These findings can provide guideline for the individuals involved in hypertrophy training to choose the best rest interval to be adopted during training session.

1.7 Limitation of Research

Among the limitations existed in this research was:

i. Honesty

   All the information received from the participants has to be accurate and honestly written when answering the demographic questionnaire. Beside that, participants must be honest during perform the bent over row and biceps curl exercises and give maximum afford.

ii. Commitment

The participants should give full commitment in completing this study. Lack of commitment to attend every session and not give full effort during evaluation could affect the findings of this study.

1.8 Delimitation of Research

This research is delimited to:

i. The participant in this study were delimited to university students that have experienced at least one year in resistance training. All participants were within the age 20-25 years old.

ii. The participants were delimited to those who meet the inclusion criteria, which required the participants to be free of any physical injury, musculoskeletal injury, neuromuscular limitation and chronic disease that would participant not performing very well during this study.

iii. Research variables consisting of total number of repetition completed, mean of muscles activation, heart rate and rating of perceived exertion.

iv. Muscles activation were recorded and analysed using electromyography (EMG) method.

v. Heat rate were recorded using Casio Polar Hear Rate.

vi. 10 repetitions maximum (RM) test was used to identify load that will be raised until reaching failure.

vii. OMNI-RES scale was used to identify rating of perceived exertion (RPE).

viii. Participants in this study performed same protocol bent over row and biceps curl exercise.

ix. All the assessment were conducted at the Faculty of Sports Science and Coaching Biomechanics Lab, Universiti Pendidikan Sultan Idris (UPSI).

1.9 Definition of Term

1.9.1 Conceptual Definition

i. Rest Interval

Rest interval is rest period between sets or exercises of strength training and it will allow the body to recovery before continue the next set or exercises (Grgic, Schoenfeld, Skrepnik, Davies, & Mikulic, 2018).

ii. Hypertrophy Training

Hypertrophy training is high intensity training that need high energy, involving high activity of muscle and increase muscle size (Toigo & Boutellier, 2006).

1.9.2 Operational Definition

i. Total Number of Repetitions Completed

The number of repetitions performed by participants in all three sets of bench press exercise.

ii. Muscles Activation

Muscles activation in this study presented in terms of mean value during concentric and eccentric phase of movement.

iii. Heart Rate (HR)

Heart rate was recorded after completed repetition for every sets.

iv. Rating of Perceived Exertion (RPE)

Rating of perceived exertion (RPE) was recorded after participant completed the repetitions for every sets.

v. Performance

Performance of participant in this study can be measured through the number of repetitions performed by participants in all the three sets.

vi. Resistance Trained

Participants already involved in resistance training at least one year with a minimum of three time per week before this study was started