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

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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.

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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

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

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CHAPTER 1

INTRODUCTION

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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).

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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

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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

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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.

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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

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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).

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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).

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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.

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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

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CHAPTER 2

LITERATURE REVIEW

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2.1 Introduction

This chapter has reviewed literature and published studies conducted by previous studies. Researcher has conducted a study to compare effect of different rest intervals between sets on number of repetition completed during bicep curl and bent over row exercise. The second objective of this study is to compare the effect of different rest interval between sets on muscle activation during bend over row and biceps curl exercises. Third, objective is to compare the effect of different rest interval between sets on rating of perceived exertion (RPE) during bent over row and biceps curl exercises. The fourth objective is to compare the effect of different rest interval on heart rate (HR) during bent over row and biceps curl exercises.

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Then, this chapter has reviewed the previous published studies and literature studies which presented based on the subtopics below:

- Hypertrophy Training
- Hypertrophy and Rest Interval
- Rest Interval
- Rest Interval and Fatigue
- The Effect of Rest Interval on Metabolic Response
- The effect of Rest Interval on Neural Effect
- The Effect of Rest Interval on Mechanical Effect

2.2 Hypertrophy Training

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Resistance training is a type of physical exercise performed to enhance muscular strength through movement resulted from the force development. Nowadays, resistance training is famous and has become an integral component in strength and conditioning programme. Previous research also reported that resistance training has been showed to improve performance in sports such as football (de Hoyo et al., 2015), rugby (Mayo, Miles, Sims & Driller, 2018), basketball (Freitas, Calleja-González, Alarcón, & Alcaraz, 2016), badminton (Middleton, Bishop, Smith, & Gee, 2016) and sprinting (Delvecchio, Korhonen, & Reaburn, 2016). Besides, resistance training also can be used as a treatment for injured athletes especially for rehabilitation. Resistance training showed positive effect when help to decrease pain, increase muscle strength and enhance functional ability on patient that had chronic low back pain (Kristensen & Franklyn-Miller, 2012).

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Before start the training, training programme must be planned because there are many variables that must be considered. Thus, resistance training programme that was designed should emphasized the variables of training. Furthermore, there are many types of strength program and each program have different strength training goal such as muscle endurance, power and hypertrophy. Based on the ACSM (2009), the main variables of strength training are the intensity, number of sets and repetitions (i.e. volume), rest interval between sets, order of exercises, movement velocity and training frequency.

In a resistance training program, periodization is an important thing to plan systematic training to achieve the goals with the expected time. Fleck (1999) stated that periodization of strength training refers to various training program at regular time intervals in an attempt to bring about optimal gains in strength, power, motor performance, and/or muscle hypertrophy. The aim of periodization of strength training is to optimize training during short (e.g., weeks, months) as well as long periods of time (e.g., years, a life time, or an athletic career). Periodization of strength training can help athlete that advance in training or become more trained to increase variation of their training program because their old program cannot or difficult to stimulate performance gains (Haff & Triplett, 2015). To increase difficult level of strength training, variables of training must be considered based on ability of athletes. Training program that has been structured must be logically designed to avoid mismanaged of training that may risk of injury and potential for overtraining.

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Resistance exercise may functionally can be defined as exercise that has progressively overload the skeletal muscle that can cause muscle growth (Vierck et al., 2000). Resistance training is a method to increase muscular strength, power, and hypertrophy. Muscular strength can be defined as the ability neuromuscular system to generate force (Earnest, Snell, Rodriguez, Almada, & Mitchell, 1995). Hypertrophy is the result of protein collection, through whether synthesis rate increase, degradation decline, or both (Glass, 2005). Increase muscle mass is one of goals for athlete that involved in powerlifting, rugby and footballer. Muscle hypertrophy occurred when athletes have long time involved in resistance training.

Hypertrophy training become popular among recreational lifters who aimed to develop strength, gaining mass and muscle. For new people who are involve in hypertrophy training, hypertrophic muscles are near does not exist during the early stages of resistance training, with the majority of strength increasing as a result of the neural adaptation. In a few months of practice, hypertrophy factor will appear, which upper-body started to become hypertrophy than followed lower-body (Abe, DeHoyos, Pollock, & Garzarella, 2000). Designing hypertrophy training is a complex process and need a true concern to avoid injury and vain training.

Parallel with the principle of specificity, appropriate manipulation of training variables is crucial for utilising exercise-induced muscle hypertrophy at its finest. It has been proven that intensity or load has a prominent effect on muscle hypertrophy and is potentially the most significant exercise variable to initiate muscle growth (Fry, 2004). Intensity is normally manifested as a percentage of 1RM and is associated to the repetitions number that can be done with a prescribed weight. Repetitions are

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categorized into 3 basic ranges. The first range is low (1-5), followed by the second range, moderate (6-12), and completed with the last range, high (15 and above) (Schoenfeld, 2010). The use of various energy systems and tax the neuromuscular system differently are covered by each of these repetition ranges, and thus affecting the extent of the hypertrophic response. In starting increments of muscle hypertrophy, the application of high repetitions is confirmed to be inferior to moderate and lower ranges (Campos et al., 2002). Intensity not more than 65% of 1RM is inadequate to produce substantial hypertrophy in the deprivation of artificially induced ischemia like occlusion training. The definition of set is the number of repetitions conducted continuously without rest, meanwhile the outcome of total repetitions, sets, and load performed in a training session is the definition of exercise volume. In regards of increased muscle hypertrophy, it has been consistently shown that higher-volume, multiple-set protocols are better than single set protocols. The sharp release of GH has also been reduced by higher-volume sets, specifically in routines that are crafted to increase metabolic stress.

Various studies discover that multiple-set protocols evoke higher GH responses than single set protocols (Krieger, 2010). Next is exercise selection, it is a widely approved fitness principle that various initiation patterns within muscle compartments can be caused varying exercise ranges such as angle of pull, position of extremities and many more, and making synergists more or less active (Bloomer & Ives, 2000). This is specifically significant in a hypertrophy-oriented model, where encouraging steady growth of muscle tissue is important in maximizing overall muscle width. Muscles may have varying attachment parts that supply higher leverage for different actions. The time taken between sets is known as the rest interval. Rest intervals are grouped into 3

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wide categories: the first is short (30 seconds or less), the second is moderate (60-90 seconds), and the last category is long (3 minutes or more). Depending on the use, each of these categories has different impacts on strength capacity and metabolite accumulation, therefore influencing the hypertrophic response (Willardson & Burkett, 2005). Additionally, the hypertrophic response can be affected by the speed in which a lifter performs repetitions. A few conclusions can be deduced from the topic regardless of the restrictions both in the quantity of research and aspects of study design. In correlation to concentric repetitions, there are evidences that quicker repetitions are advantageous for hypertrophy. Nogueira et al. (2009) discovered that instead of 3 seconds, conducting concentric actions at 1-second tempo is more benefiting on upper and lower limb muscle girth in elderly men. An improved recruitment and corresponding fatigue of high-threshold MUs may be the cause of this.

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Protein synthesis increased about 24 hours after exercise and remained high from 2-3 hours after exercising through 36- 48 hours after exercising (Ratamess et al., 2009). Hypertrophy training may increase synthesis of protein with concentration of several hormone such as testosterone, human growth hormone, and cortisol (Buresh, Berg, & French, 2009). Testosterone and human growth are anabolic hormone and it functions enhance rates of protein synthesis and prevent degradation of protein (Buresh et al., 2009; Crewther, Cronin, & Keogh, 2005). Cortisol is a catabolic hormone and it works by decreasing protein synthesis, increase rates of protein and also vital role on remodelling new tissue (Buresh et al., 2009; Kraemer & Ratamess, 2005).

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2.3 Hypertrophy Training and Rest Interval

To evoke various types of muscular adaptations like strength, power, hypertrophy, or endurance, strength training programs may be devised (Baechle & Earle, 2008). In order to obtain the suitable responses, a number of variables must be manipulated and taken into consideration when designing a strength training program. Intensity, volume, frequency, repetition, velocity, and rest within sets are the response variables that are included, but not limited to (Kraemer, Noble, Clark, & Culver, 1987). The objective of the individual involvement in the strength training program must be pinpointed to precisely manipulate training variables. Plateaus in development may be reached or and overtraining syndrome could happen if manipulation of training variables is not done properly (Rahimi, 2005).

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The cross-sectional area (CSA) of the existing muscle fibers is heightened by strength training program with the objective of muscle hypertrophy (Baechle & Earle, 2008). Muscle hypertrophy includes a raise in the net accumulation of the contractile proteins actin and myosin between the myofibrils and a hike in the amount of myofibrils within a muscle fiber (Beachle & Earle, 2008). The duration of rest intervals between sets of exercises is a major area of focus for suitable hypertrophy training. The significance of rest intervals is deduced by perceiving strength training as a form of interval training. By utilising pre-decided intervals of exercise and rest periods (i.e. work-torest ratios), interval training amplifies bioenergetics adaptations for a better energy transfer (Baechle & Earle, 2008). For muscles to heal and for energy stores to replenish appropriately, the body needs rest (Richmond & Godard, 2004; Willardson & Burkett, 2006).

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If work-to-rest intervals are ranged better when creating a strength training program, then more work can be achieved at higher exercise intensities with equal or lesser fatigue than during ongoing training at the same respective intensity (Baechel & Earle, 2008). There are numerous disparities in metabolic recovery rates and enzyme pathways used within the muscle itself, which results in variations in performance; some of these variations in performance are able to influence potential muscle adaptations (Richmond & Godard, 2004). In this research, the definition of performance is the capability to perform the allocated amount of repetitions without failing, or reaching muscular fatigue, which hinders an individual from continuing the ongoing exercise. According to the National Strength and Conditioning Association (NSCA), to trigger the most muscle fiber hypertrophy responses, rest intervals between 30 seconds and 1.5 minutes must be taken (Baechle & Earle, 2008). From American College of Sports Medicine's (ACSM) "Progression Model in Resistance Training for Healthy Adults", 1-2 minutes is the suggested rest period range for novice and intermediate training programs (Ratamess et al., 2009). Greater anabolic hormone secretions inside the body are triggered impact fully by training protocols with shorter rest periods (≤ 2 minutes) in comparison to training protocols with longer rest periods (> 2 minutes). Greater muscle adaptations are obtainable due to these increased responses in anabolic hormone levels. Higher increments in lean muscle tissue are bound to happen because of the higher anabolic hormone secretions that are achieved in short periods (Kraemer et al., 1987; Kraemer et al., 1990).

In addition to rest periods, training volume is the other variable that affects muscle hypertrophy (Schoenfeld, 2010). Training volume is defined as the accumulation of the total number of repetitions done during a training session

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multiplied by the resistance used (Rahimi, 2005). Whereas, the definition of a training session is a singular bout of training which is performed numerous times per week (Baechle & Earle, 2008). It has been proven that training volume influences neural adaptations, tissue hypertrophy, metabolic mechanisms, and hormonal responses and following adaptations to resistance training (Rahimi, 2005). In studies that monitor different rest period durations, individuals with short rest periods allotted performed fewer total volume in comparison to individuals allotted with more rest periods. This is because when the rest periods are short, there is insufficient time for lactate accretion to be removed and phosphocreatine to be fully recovered (Baechle & Earle, 2008; McArdle, Katch, Katch, 2010). Hypothetically, longer rest periods should result in more total volume, leading in better gains in muscle hypertrophy (Krieger, 2010; Lawton, Cronin, Drinwater, Lindsell & Pyne, 2006).

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2.4 Rest Interval

Rest interval is one of important variables that used in resistance training. Rest interval can be define as time for rest between sets for recovery and maintained of training intensity (Baechle & Earle, 2000). It has become a concern to athletes, coaches, fitness trainer and/or practitioner. The time taken between sets is known as the rest interval. Rest intervals are grouped into 3 wide categories: the first is short (30 seconds or less), the second is moderate (60-90 seconds), and the last category is long (3 minutes or more). Depending on the use, each of these categories has different impacts on strength capacity and metabolite accumulation, therefore influencing the hypertrophic response (Willardson, 2006). Notable metabolic stress is likely generated by short rest intervals,

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therefore increasing anabolic processes related to metabolite accumulation (Goto et al., 2004). Howbeit, by restricting rest to 30 seconds or less, athletes will have insufficient time to replenish muscular strength, and hence significantly damaging muscular performance in the coming sets (Ratamess et al., 2007). Thus, the hypertrophic advantages linked with better metabolic stress seem to be neutralized by a drop in strength capacity. This makes short rest intervals to be suboptimal in optimizing hypertrophic gains at its best.

Long rest intervals supply full strength recovery between sets, allowing the capability to train with maximum force capacity (Miranda et al., 2007). de Salles et al. (2009) exhibited that rest intervals of 3-5 minutes allow for more repetitions over multiple sets during training with loads around 50-90% of 1RM. Howbeit, despite long rest intervals maximize mechanical tension, metabolic stress is still compromised (Mero, et al., 1997). This could weaken anabolic drive, impairing a maximal hypertrophic feedback.

Moderate rest intervals are revealed to supply a satisfactory balance between long and short rest intervals in maximizing the muscle hypertrophy. Research shows that most of an athlete's strength capacity is replenished within the first minute after break of a set (Stull & Clarke, 1971). Furthermore, adaptions that let a lifter to maintain a notably greater mean percentage of 1RM during training are caused by steadily training with shorter rest intervals (Kraemer et al., 1987). The adaptations are heightened capillary and mitochondrial concentration and an increased capacity to buffer H^+ and transfer it out of muscle, therefore restricting performance depletions. The body's anabolic environment is also enhanced by moderate rest intervals to a higher

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extent than longer rest intervals. 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. However, there are proofs that this hormonal benefit is not long lasting. Buresh et al. (2009) juxtaposed the anabolic hormonal response to routines with rest intervals of 1 against 2.5 minutes. The difference in hormonal response was not very far between routines by the end of the fifth week, and was absent by week 10, although the shorter rest intervals had an influencing effect on increasing GH levels in the early phases of the protocol. This proposes a post adaptive feedback by the muscles to decline rest intervals, providing support to the demand for periodization in a hypertrophy based resistance training program.

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2.5 Rest Interval and Fatigue

The length of rest between sets affects fatigue during exercise (Willardson, 2006). Thus, fatigue is the incapacity to preserve a power output or force during repeated muscle contraction that may possibly be caused by either metabolic or non-metabolic factors (Enoka & Duchateau, 2008). The contributors to fatigue are categorised into either central or peripheral, with central is comprised of the processes inside the spinal cord and above, whereas the processes in the peripheral nerve, neuromuscular junction, and muscle are put under peripheral (Allen, Lamb, & Westerblad, 2008) By focusing on the changes that happen within the muscle fiber during fatiguing exercise, peripheral fatigue may be studied. The type of muscle fiber is key in muscle fatigue because

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oxidative fibers are way more resistant to fatigue than fast twitch fibers (Allen et al., 2008). The beginning of fatigue may also be cause by other factors like temperature, metabolic shifts, and pH level inside the muscle (Allen et al., 2008). Because fatigue is described as reversible plummet of performance during activity, it varies from muscle injury in which most healing happens within the first hour, and there exists a slow part which may need a few days to recover (Edwards, Hill, Jones, & Merton, 1977). On the opposite, muscle injury often occurs in muscles that are unconventionally stretched during contraction and normal function slowly returns (Allen et al., 2008).

Davis & Bailey (1997) stated central nervous system (CNS) is categorised as a subset of fatigue (inability to preserve the needed or expected force or power output). In the study, it is suggested that "psychological" factors need to be significantly considered with fatigue because fatigue is being linked with particular alterations in CNS function that cannot be clarified by dysfunction in the muscle itself. Changes in neurotransmitters, cerebral oxygen delivery, hyperthemia, and perceived exertion/homeostatic regulation are all hypothesized to be the triggering factors of central fatigue. Athletes and trained individuals usually undergo an amalgam of peripheral and central fatigue during practice and game situations. Decreased force production, reduced velocity of shortening, and slowed relaxation are parts of fatigue related alterations in the muscle. Hampered reaction times and impaired motor performance may be the outcomes of the dysfunction of CNS because of fatigue. The major worry is the effect of the negative changes caused by the onset of fatigue because decreased function at the peripheral (muscle) and the CNS level could weaken sensorimotor function and highten the danger of unintentional musculoskeletal injury (Davis& Bailey, 1997; Nybo & Nielsen, 2001)

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2.6 Rest Interval on Metabolic Effect

Rest interval is important because it will influence the amount of recovery that take place during rest between sets. Different rest intervals (short or long) affect muscles fatigue. Short rest interval may affect the time of recovery and metabolite is higher than longer rest intervals (Faigenbaum et al., 2008). In hypertrophy training, metabolic stress is important for increasing muscle mass. Metabolic stress occurred after doing resistance training and it may produce accumulation of metabolites, particularly lactate, Pi and H^+ (Tesch, Colliander, & Kaiser, 1986; Suga et al., 2009). Besides, for stimulate hypertrophy adaptation, muscle hypoxia with resistance training can increase metabolic build up (Pierce, Clark, Ploutz-Snyder, & Kanaley, 2006; Schoenfeld, 2013; Toigo & Boutellier, 2006).

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Hypotrophy training can enhance muscle mass and increase muscle growth. Muscle that was fatigue and depleted energy needed sufficient time to recovery and prepared for a subsequent bout of physical exercises. Several research have conducted study about different rest interval on ratings of perceived exertion (RPE). Woods, Bridge, Nelson, Risse, and Pincivero (2004) studied the effect length of rest interval (1, 2 and 3 minute) on rating of perceived exertion (RPE) during dynamic knee extension exercise. 15 men and 15 female was participated in this study. Participant needed to perform 3 sets with 10 repetitions at 70% of a theoretical 10RM. Result showed that bench press exercises with 1 minute rest interval was significantly in increase rating of perceived exertion (RPE).

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Study by Senna et al (2016) examined the acute effects of different interset rest intervals on performance of single and multi-joint exercises with near-maximal loads. Fifteen trained men performed eight sessions (2 exercises with 4 interset rest intervals); each consisting of 5 sets with a 3RM load. The exercises tested were the machine chest fly (MCF) for the single-joint exercise and the barbell bench press (BP) for the multi-joint exercise with 1, 2, 3, and 5 minutes of rest between sets. Results showed significantly higher RPE with 1 minute of rest interval between sets.

Study by de Freitas et al. (2015) examined effect different rest interval length on rating of perceived exertion (RPE) during bench press and seated row exercise. Fourteen trained men performed two experimental protocols in random order with 2 minutes (P2) or 4 minutes (P4), which consisted of a bench press set followed immediately by a seated row set with 8-repetition maximum loads, respectively over 3 sets. The findings showed, no significant differences were identified rating perceived exertion (RPE) between 2 and 4 minute rest interval.

Ratamess et al. (2007) investigated the effects of different rest interval (RI) lengths on heart rate (HR) during bench press. Eight resistance-trained men performed 10 randomized protocols [five sets of bench press with 75 or 85% of 1RM for ten (10REP) and five repetitions (5REP), respectively, using different RI (30 s, 1, 2, 3, 5 min)]. The findings showed heart rate started to increase in set 2 until the final sets for both training programme for all rest intervals and both training program (5RM and 10RM) of bench press exercise.

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2.7 Rest Interval on Neural Effect

Resistance training can influence changes of central nervous system (CNS) that play an important role in development of muscle strength (Carroll, Riek, & Carson, 2001; Enoka, 1997; Sale, 1988). de Salles et al. (2009) stated that, previous research have done their research about different rest interval, and researchers have identified different effect of acute and chronic on neuromuscular. Involvement in hypertrophy training may enhance in maximal contractile muscle force (Aagaard, Simonsen, Andersen, Magnusson, & Dyhre-Poulsen, 2002). Maximal contractile force is a how many muscle that activated properly (Zatsiorsky & Kraemer, 2006). Someone that involved in hypertrophy training has produced external force that exceed the normal homeostatic contractile force of the muscle with that motor unit may increase from the stimulation of neural system. Hypertrophy was classified in fast twitch motor unit because muscle produced high velocity, large power outputs and force development (Zatsiorsky & Kraemer, 2006).

Hypertrophy training is high intensity training that need high energy and involving high activity of muscle. High intensity training would increase neural drive and may increase activation of major muscle when doing specific exercise. Furthermore, skeletal muscle is an adaptable tissue that can absorb tensional stimuli from external force such as exercise with hypertrophy training (Toigo & Boutellier, 2006). The main ability to increase muscle strength is dependent on neural adaptation. Neural adaptation occurred from nervous system that was adjusted to increase efficient recruitment of muscle, increased neural activation, synchronic of the motor unit, the

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excitement of the cymotor neuron and / or plate end motor and reduction inhibitory mechanism from Golgi tendon organs (Ratamess, 2008; Staron et al., 1994).

Designing hypertrophy training programs need attention on many aspects such as variables of training, selection of exercises and acute and chronic adaptation. Rest interval between sets is one of variables training that is importance because rest intervals is need to restore energy that has been used to active the muscle (Baechle & Earle, 2000). Usually, activation of muscle was measured by electromyography (EMG). Electrode of EMG was placed at target muscle and it achieve all impulse to muscle and show level neural activity (Konrad, 2005). Stated that high intensity of training (hypertrophy) produce more neural activity of muscles. Short rest interval may affect muscle quickly fatigue than long rest interval because not enough time for muscle recover after activated.

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Some studies investigated correlation rest interval between sets and acute effect of neuromuscular and fatigued of muscle that activated with parameter of the electromyography (EMG). Sajad et al. (2014) studied about three different rest interval between sets (60 second, 90 second and 120 second) on neuromuscular response. Twelve male student that was experienced at least one year resistance training was participated to perform 4 sets of knee extension with 80% of 1 repetition maximum until failure. This finding showed that there was significant reduction for all three rest interval on right femoral muscle using integrated electromyography IEMG especially for 60 second rest period. It was conclude that muscle decrease on activation because muscle has entered fatigued conditions.

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2.8 Rest Interval on Mechanical Effect

In resistance training, to completed repetition in every sets was important to achieve the goal of training. Several studies was investigated the length of rest period between sets. Most of studies have founded that longer rest period was significantly effective than short rest period (Willardson, & Burkett, 2005; Miranda et al., 2009).

Willardson, & Burkett (2005) compared three different rest intervals on the squat and bench press exercises on total volume completed. 15 collage-aged men that have experienced in recreational lifters volunteered to involve in this study. Participants were performed squat and bench press with 4 sets with 8 repetitions maximum (RM) and different rest intervals (1, 2 and 5 minute). Result indicated that squat and bench press were significantly different between 1 and 5 minute and 2 and 5 minute, while there was no significant different between 1 and 2 minute rest intervals. It was conclude that participants that involved squat and bench press exercises with 5 minute rest interval was highest total volume completed, followed by 2 and 1 minute rest interval.

The study of Rahimi, (2005) compared and identified the effect different length rest period between sets on total volume of squat exercise. 20 volunteered that have experienced in resistance training was completed 3 session with 4 sets and 85% of 1RM as load over 1 minute, 2 minute and 5 minute rest between sets. The finding of this study indicated that number of repetition of squat exercise with 5 minute rest interval was significant higher than 2 minute and 1 minute; 2 minute and 1 minute showed no significant difference.

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Specially, Richmond and Godard (2004) studied the effect of different length rest intervals (1, 3 and 5 minutes) on number repetition that was achieve during bench press exercise. 28 healthy men that had have experienced around 8 week was participated in this studied. Participant were lifted load intensity about (75% of 1RM) and 2 sets with 8-12 repetitions per set. The finding indicated that bench press with 3 and 5 minutes rest intervals was enough to complete 8-12 repetitions for both the first and second sets, but not with the 1 minute that has reduce repetition in second set. It was conclude in this study that 3 minute rest interval was enough to maintain and perform 8-12 repetition in two set of bench press exercise.

Miranda et al. (2009) studied the effects different length of rest period on total volume exercises completed during upper body exercises workout in resistance training. 12 men that have experience in resistance training was performed 3 sets with 8 repetitions maximum (RM) load for barbell bench press, incline barbell bench press, pec deck flye, barbell lying triceps extension, triceps pushdown. The result indicated that all upper body exercises with 3 minute rest interval was significantly higher in total repetition completed than 1 minute rest interval. Beside that, for result repetitions per set showed that all exercises with 3 minute rest interval between set was no significant difference in set 1 and set 2 while 1 minute rest interval between showed significant reduction between first and second sets for barbell bench press, barbell lying triceps extension and triceps pushdown. It was conclude that, 3 minute rest interval was enough for allows greater total exercises volume completed for the upper body exercises.

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Miranda et al. (2007) was investigated about the effect of two different rest interval between sets on number of repetition completed during six upper body exercises. 14 experienced man involved in SEQ 1 (1 minute) and SEQ 3 (3 minute) with same exercise, exercise order but different rest interval between set. Participant performed 3 set and 8RM for every 6 upper body exercises such as wide grip lat pull-down, close grip pull-down, machine seated row, barbell row lying on a bench, dumbbell seated arm curl, and machine seated arm curl with different rest interval (1 and 3 minute). The result indicated that all upper body exercises with 3 minute rest interval was significantly higher on total number of repetitions completed in all sets of all exercises than 1 minute rest interval. Beside that, number repetition of each set in SEQ 1 showed significant decrease in first and second sets for the lat pull down with a wide grip and dumbbell seated arm curl. Result in SEQ 1 and SEQ 3 showed that significant decrease from first to third sets in lat pull-down with a wide grip, lat pull-down with a close grip, dumbell seated arm curl and machine seated arm curl, however, lat pull-down with a wide grip demonstrated significant decrease from the second to the third set.

Next, Azizbeigi, Atashak, and Stannard (2015) to investigated the effect of 90 second and 180 second rest on total work of exercises that was performed during chest press, lat pull down, leg extension, leg curl and back squat exercises. 20 healthy untrained males was participated and need to perform 4 repetitions with 6 repetitions maximum (RM) load for each exercises. The result indicated that there was not significant differences between 90 second and 180 second rest intervals on total work exercises that performed.

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Scudese et al (2015) compared 1, 2, 3,4 and 5 minute rest interval on number repetition that completed during bench press exercise over 5 set and 3 repetition maximum (RM) loads. 16 experienced men in resistance training were participated in this study. The result indicated that 2, 3, 4 and 5 minute rest interval were significant higher than 1 minute rest interval on number repetition completed during bench press exercise. Besides, there was no significant different between 2, 3, 4 and 5 minute on total number repetition. Bench press with 1 minute was significant reduction in repetition started from set 2 until set 5.

Rahimi, Boroujerd, Mozafari, and Faraji (2009) investigated how length of rest period between sets can be affect bench press performance among female physical education students. Fifteen volunteered participants that have experienced in strength training was performed 4 session (4 sets with 12 repetitions of maximum repetitions (RM) over three different rest length between sets (60 second, 90 second and 120 second). Finding of this study showed that the significant difference between 120 second and 60 second and 90 second and 60 second rest length while no significant difference between 120 second and 90 second rest length between sets.

Senna, Salles, Prestes, Mello, and Roberto (2009) studied about the effect of 2 minute and 5 minute length of rest period between sets on total number of repetition in resistance training sessions. Fourteen experienced men in resistance training was involved two session for lower body workout (leg press, leg extension and leg curl) and two session for upper body workout (bench press, pec-deck and triceps pulley) with 3 sets per exercise and 10RM load. Two session of lower body workout were only distinguished by the length of resting time between sets such as two minute rest (SEQA)

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and five minute rest (SEQB) while, for upper boy was classified two minute rest (SEQC) and five minute rest (SEQD). Based on this study, the result showed the total number of repetitions in SEQB was significantly higher than SEQA. Similarly, the total number repetitions in SEQD was significantly higher than SEQC.

Next study of rest interval only focus on single-joint exercises by Senna et al (2016). The researchers studied about the effect of different length of rest period affected the retention of the repetitions performance. Ten trained men completed three session machine chest fly and three session bicep curl exercises with three different rest intervals (1 minute, 2 minute and 4 minute) over 3 sets and 10 repetition maximum (RM) as load. Result for total number repetitions showed both exercises with 4 minute rest interval was significantly higher than rest 2 minute and 1 minute and 2 minute rest interval presented significantly difference when compared with 1 minute. This finding of this study was contrary to ACSM (2009) rest interval guidelines for single-joint exercise

Senna et al (2011) compared three different length period rest between sets (1 minute, 3 minute and 5 minute) of multi-joint and single-joint exercises on total number of repetition that completed during resistance training exercises. Fifteen men that was experienced in resistance training at least 1 year with a minimum frequency of 3 sessions training per week was participated and performed bench press, machine leg press, machine chest fly and machine leg extension over 5 sets with 10 repetition maximum (RM) loads until fatigue. The result indicated that 1 minute rest interval was significant lower than 3 and 5 minute on total number of repetition during bench press exercises while there was no significant difference between 3 and 5 minute. Beside that,

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the result for the machine leg press, machine chest fly and machine leg extension showed that there was significant difference between 1 minute and 3 minute, 1 minute and 5 minute and lastly 3 minute and 5 minute (1<3<5 minute). Besides, for repetition performance between sets indicated that repetition started decrease at the second set for 1 minute rest interval and third set for 3 and 5 minute rest interval., The researcher conclude that there was similar repetition performance for single-joint and multi-joint resistance exercises.

The study by Senna et al (2012) compared two different rest intervals between sets (1 minute and 3 minute) on total number of repetitions during multi-joint exercise and single-joint exercise. Twelve experienced men was participated in this study and they performed 5 sets per exercises with 10 repetitions maximum (RM) load when completed bench press exercise (multiple-joint) and machine chest fly exercise (single-joint). The finding showed that 3 minute length of rest period between sets was significant higher total number of repetitions than 1 minute rest interval for both exercises. For number repetitions between each sets of bench press and machine chest fly exercises showed decrease repetition started at the second set for both rest intervals.

Next study by Senna et al (2015) indicated that total number repetition for bench press with 1 minute rest interval was significantly decrease when compared with 2 minute, 3 minute and 5 minute. Besides, bench press with 2 minute rest interval also showed significant reduction when compared with longer rest interval (3 minute and 5 minute). However, there was no significant difference after compared between 3 minute and 5 minute rest interval on total number of repetition during bench press exercise. In number repetitions between sets for bench press, repetition start reduction in second

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set when used 1 and 2 minute rest interval while third set when used 3 minute and 5 minute. For machine chest fly exercise showed 5 minute rest interval was significantly higher total number repetitions when compared with 1 minute, 2 minute and 3 minute. Thus, there was no significant different between 1 minute, 2 minute and 3 minute rest interval. In number repetitions between sets for machine chest fly exercise, repetition start reduction in second set for 1 and 2 minute and 3 minute rest interval and only 5 minute reduction on third set. The conclusion of this study also same the previous study.

Sajad et al. (2014) studied about three different rest interval on total training volume (sets x repetitions x load) in resistance training. Twelve volunteered men randomly assigned 60 second, 90 second and 120 second between sets on knee extension over 4 sets with 80% of 1 repetition maximum (RM). Finding of this study showed that total volume knee extension with 60 second rest interval (1133kg) was significant lower than 90 second (1303kg) and 120 second (1326kg) rest interval between sets. But there was no significant difference between 90 second and 120 second rest interval.

2.9 Effects of Exercise on the Physiology

In sudden muscle activation, internal energy stores are used because an immediate external supply of the needed energy substrates cannot handle the rapid transition from rest to intense activity. The energy for muscle contraction needs to be provided in the form of ATP. ATP can be produced from internal stores of creatine phosphate in a quick process. Moreover, through anaerobic glycolysis that utilise intracellular stores of

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glycogen as fuel and generate lactic acid as one of the metabolites, ATP is produced more rapidly. Increasing the level of working of the cardiovascular and respiratory systems can either partly or completely balance the increased metabolic requirements of an activated muscle after some moments. More oxygen and fuel such as glucose and fatty acid have to be provided and more CO_2 along with other waste products like lactic acid have to be eliminated. The effect of the active muscles on the internal environment is influenced by the workload's intensity, the amount of muscle tissue involved, and the type and period of exercise. Usually after the unexpected start of a steady level of exercise, it takes a few minutes before heart rate and oxygen uptake reach a new, higher, and stable state. Under anaerobic conditions, lactic acid is one of the final outcomes generated from the breakdown of glucose into glycogen. Lactic acid can be processed further, thus producing more ATP, CO_2 under aerobic conditions. The difficultness of the performance of a matching rate of aerobic glycolysis increases as the higher general workloads increase. A marked acceleration above a specific workload like the 'lactate threshold' or OBLA is shown through the increase of lactate concentration in blood and extracellular fluids. The lactate threshold is described as the workload at which tissue lactate production and the tissue lactate consumption are in a symmetry. The blood lactate concentration begins to increase beyond this workload (Brooks, 1985). Another definition of lactate threshold is the workload at which the concentration of blood lactate surpasses 1 mmol/L above baseline (Balado, 1996; Coyle, Coggan, Hopper, & Walters, 1988). Whereas, if the concentration of blood lactate goes beyond 4 mmol/L, it is labeled as OBLA (Heck et al., 1985). A heightened acid concentration means a heightened hydrogen ions concentration, which is achievable by, for instance, lowering the pH value. This rising proton load is partially reduced based on the reaction:

$$H^+ + HCO_3^- \leftrightarrow H_2CO_3 \leftrightarrow H_2O + CO_2$$

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The production of excess CO_2 which is exhaled is linked with this reaction. This will result in increment in the respiratory quotient during the last stages of heavy exercises. For untrained subjects, this increment happens at around 50 – 60% VO2max, whilst for trained subjects, it happens at around 70 – 80% VO_2max (Balado, 1996; Ament & Verkerke, 2009). In muscle tissue, the degeneration of purine nucleotide is connected with the metabolism of the anaerobic glycolysis. Ammonia appears as adenosine 5'-monophosphate and is reduced into inosine monophosphate. The final outcome of the anaerobic glycolysis is lactate. This results in increment in the blood concentrations of ammonia and lactate during graded exercise. It is commonly known that before subjects are consumed with fatigueless and forced to stop their exercise because of exhaustion, workloads beyond the OBLA can be preserved for a short timespan (Ament & Verkerke, 2009; Coyle et al., 1988). Thus, exercise-associated fatigue sensations have the inclination to increase align with the build-up of exercise-associated metabolites like lactate. As graded exercise takes place, the amount of metabolic energy transformed into mechanical work is just around 20 – 25%, while the remaining becomes heat (Di Prampero, 1981; Lehninger, 1971). Therefore, exercise leads to 'heat load' in the internal environment.

In other words, the huge number of impacts of muscle exercise towards the internal environment include an increased consumption and possible lack of oxygen and nutrients such as glycogen, glucose, and fatty acids, increased in generation and possible build-up of CO_2, hydrogen ions ('proton loading'), lactate as well as ammonia and increased production and assembly of heat ('heat loading'). These variables have greater impacts on the internal environment if the workload is greater. It is plausible that the function of the CNS could be affected by the changes in the internal

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environment. It is directly affected by interceptive afferents and indirectly affected to a decrease in performance of the exercise-associated muscles. Visceral afferents from some cranial nerves extend to the solitary nucleus of the brain stem (Role & Kelly, 1991). The brainstem and hypothalamus are important in maintaining the stable-state of the internal environment (Ament & Verkerke, 2009). Bothersome feelings of fatigue and exhaustion can be triggered by the degeneration of the stable-state of the internal environment. These bothersome feelings have a damaging impact on exercise performance.

2.10 Effects of Exercise on the CNS

CNS functions in a complex way. The CNS holds a significant part in maintaining the steady state of the internal environment. The generation of the motor drive during exercise is caused by the motor cortex of the brain. We are aware of this motor drive, however we are not well informed of the accompanying motor control of muscles controlling our posture during exercise. Moreover, the centre of our cognition is the brain. In spite of the complexity of all these functions, the amount of issue our mind can focus on is limited at one issue at a time; the issue being the object of our consciousness. In fact, our consciousness state is very restricted. The feelings of fatigue and exhaustion during exercise slowly come to our sense. From a physiological perspective, the awareness of these feelings carries a warning role. Other than these feelings of fatigue, neurophysiological changes also happen in the CNS during exercise.

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2.10.1 Afferents and Motor Control

Motor behaviour is controlled by the CNS using sensory signals of various modalities. In humans, vision is crucial for motor control and the sensitivity of the skin is vital in guiding movements in direct contact with the external world, for instance, to manipulate objects. In every movement, the many afferents deriving from the muscles themselves also carry a prominent part. Muscle afferents have varieties of diameters and their purposes are connected to axonal size and thus, to conduction speed. The signals from muscle afferents can be utilised in multiple ways because all muscle afferents are attached to multiple parts of the CNS. Howbeit, in all muscle contractions, monosynaptic excitation is produced as the muscle spindle afferents play a part since the afferents have a direct relation to motor neurons. Activity in gamma motor neurons causes activity of muscle spindle afferents. Hence, a small part of the whole excitatory input to the motor neurons arrives during voluntary muscle activation by the reflex circuit of the 'gamma loop': gamma motor neurons/muscle spindles/a motor neurons. A number of current researches have been investigating the influence of muscle afferent feedback mechanisms in exercise and fatigue (Ament & Verkerke, 2009; Garland & Kaufman, 1995; Windhorst & Boorman, 1995).

The EMG and the contraction force lessen in sync during sustained isometric contractions at maximum voluntary contraction (MVC). Bigland-Ritchie, Dawson, Johansson, and Lippold (1986) listed the firing rate of single motor units of the biceps brachii muscle during MVC by micro-electrodes under normal and ischaemic circumstances. During MVC, firing rates plummeted and recuperated within 3 minutes after contraction. If ischaemia was administered, the recuperation of the firing rate

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would not be present. The motor neurons located in the spinal cord show a drop in the firing state. An afferent feedback loop between the muscle and its motor neuron in the spinal cord is proposed by these experiments. It is theorized that this feedback loop is triggered by the small chemo- and nociceptive muscle afferents (thin myelinated [III] or unmyelinated [IV or C] fibres) (Garland & Kaufman, 1995; Martin, Smith, Butler, Gandevia, & Taylor, 2006). Martin et al. (2006) used electrical stimuli to invoke the biceps and triceps brachii muscles, the elbow flexor and its extensor, at two contradicting levels in the neuromuscular tract. The mastoid processes at the cervicomedullary induced the corticospinal and reticulospinal tracts. An invoked twitch contraction of both muscles, which are one another's antagonists was the reaction to this. These experiments were conducted with and without muscle ischaemia created with an inflated cuff. The end products of this research propose that in the extensor muscles, a feedback loop of III and IV nerve fibres exists.

Interestingly, the contraction traits of the flexor antagonist are also facilitated by the feedback loop of the extensor muscle. There was a reaction exhibited by the feedback loop of the III and IV nerve fibres of the flexor muscles in the extensor antagonist, but the reaction was absent in the flexor itself. Martin et al. (2006) and Bigland-Ritchie et al. (1986) in their experiments theorized that the afferents that were activated are type III and IV nerve fibres. Bigland-Ritchie et al. (1986) calculated the rate frequency of the single motor units, meanwhile Martin et al. (2006) experimented on the excitability of the corticospinal tract. Two different feedback systems are proposed from these observations. Current study of Martin et al. (2006) proved that the motor-evoked potential (MEP) reaction to electromagnetic motor cortex stimulation was reduced by stimulating type III and IV nerve fibre via saline infusions that trigger

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pain sensations by these nerves. Presynaptic inhibition is absent in the corticospinal tract (Nielsen & Petersen, 1994). This shows that at the cortical level by the type III and IV nerve fibres, the corticospinal tract is hindered. In conclusion, the three impacts of muscle afferents of type III and IV nerves are: a reduction in the firing frequency of the motor neuron; (Bigland-Ritchie et al., 1986) a hindrance or facilitation of the motor neuron; (Martin et al., 2006) a suppression of the motor cortex neuron (Martin, Weerakkody, Gandevia, & Taylor, 2008).

2.10.2 Central and Peripheral Fatigue

There are two types of fatigue can be identified: central and peripheral fatigue. In peripheral fatigue, fatigue originated from the outside of the CNS. This contradicts all other cases in which fatigue originates somewhere within the CNS. Howbeit, these terms can be described more accurately. The definition of peripheral fatigue is the loss of contraction force which is triggered by processes distal to the neuromuscular junction. Meanwhile, central fatigue is defined as the alike loss proximal to the neuromuscular junction (Allen, Lannergren, & Westerblad, 1995; Gandevia, Allen, Butler, & Taylor, 1996).

During muscle exercise, exercise or contraction can only proceed at the cost of an increased intensity of cortical commands when a heightened sense of effort is detected. The reasons for the changed command necessities are usually peripheral (drop or force-producing ability in muscles), but may also be located in the CNS (e.g. changes in neuronal and/or synaptic properties). To assess if the maximum force has reduced, the level of fatigue in the muscles can be measured using electrical stimulation.

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Juxtaposing the maximum force gained voluntarily against the force produced by maximum voluntary with electrical stimulation such as the 'twitch interpolation technique' can help to measure the component of 'central fatigue' (Behm & St-Pierre, 1998; Merton, 1954). More force is added at high than at low levels of central fatigue by the superimposed electrical stimulation.

The muscles are initiated by applied electrodes in 'the superimposed electrical stimulation or twitch interpolation technique'. These electrodes stick at the skin surface. The muscles are initiated electrically during sustained isometric contractions. A superimposed contraction is produced by this initiation. The fatigue components in the contracting muscle (peripheral fatigue) and components within the CNS (central fatigue) are distinguishable by using this technique. Other than central changes causing a less functioning central drive of the motor neurons, qualitative changes in the CNS control of movement like loss of coordination and heightened correction-errors may also be caused by extended and intense bouts of motor exercise. There have been little to none experimental investigation that studies the mentioned aspects of 'central control fatigue'.

2.11 Summary

Rest interval is one of important variables in resistance training. Less studies have yet identify effect of number repetitions, muscle activation, RPE and HR during multiple and single joint exercise on the same research participants. Furthermore, less studies examined effect of different moderate rest interval on muscle activation during multiple

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joint exercises. Thus, this current study want to know how different moderate rest interval would give effect on multiple and single joint exercise. Despite been one of the main exercises for back muscles, bent over row is one of the exercises that rarely been used in the strength and conditioning studies. Biceps curl on the other hand, has been used widely in strength and conditioning study. However, still some parameters can be added to measure on the exercises.

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CHAPTER 3

METHODOLOGY

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3.1 Introduction

This chapter has explained on the way upon how the study was conducted, in order to achieve the objectives. This study determined and compared the effects of three different rest intervals on the number of repetitions completed, muscles activation, heart rate and rating of perceived exertion (RPE) during bent over row and biceps curl. The details have been discussed in the following subtopics:

- Research Design
- Participants
- Equipment
- Procedures
- Experiment Protocol

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- Exercise Protocol
- Pilot Study
- Independent Variables and Dependent Variables
- Data Collection
- Statistical Analysis
- Summary

3.2 Research Design

This study mainly used quantitative time series experimental design. It was conducted to determine the acute effect of different rest intervals between sets of repetitions number completed, muscle activations, rating of perceived exertion (RPE) and heart rate (HR). There was no manipulation of variables or experimental treatments during this study. Fifteen men who recreationally-resistance-trained, participated in this study. The participants performed the bent over row and bicep curl exercise over 3 sets 10 Repetition Maximum (RM) load with random order of rest intervals. Data collection has been presented in chapter four and discussion of this finding was described in chapter five

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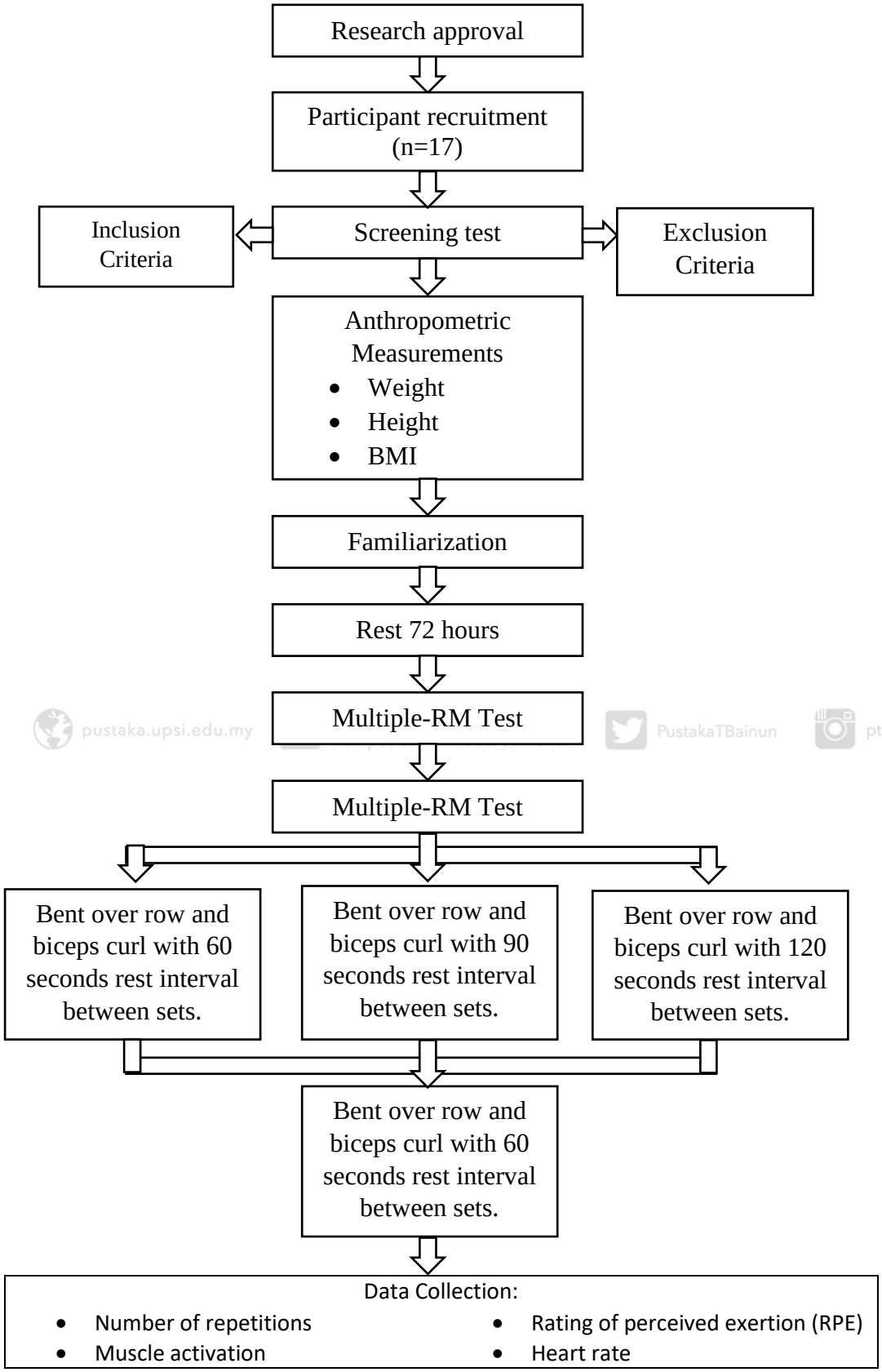


Figure 3.1. Research Design

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Figure 3.1 showed the research design for comparison of three different rest intervals on the number of repetitions completed, muscle activation, rating of perceived exertion (RPE) and heart rate (HR) during bent over row and biceps curl over 3 sets of 10 RM load. The screening process of the fifteen participants was done according to the inclusion criteria of anthropometric measurement. Anthropometric measurement is a process to determine body composition such as height, weight and Body Mass Index (BMI). Initially, participants entered familiarization phase that allows participants to perform bent over row and biceps curl with same protocol exercises. After that, participants have conducted multiple-RM test in order to identify the amount of load that can be lifted during experimental session. After 72 hours, participants returned to biomechanics laboratory three times to randomly performed bent over row and biceps curl with different rest intervals between set. Rest intervals used in this study were 60 seconds, 90 seconds and 120 seconds respectively. Five minute rest between bent over row and biceps curl was enough for recovery between exercise (With each exercises and sets carried out, the total number of repetitions, muscle activation, rating of perceived exertion (RPE) and heart rate was recorded.

3.3 Participants

Fifteen trained men (n=15) that have experienced at least one year in resistance training was recruited as participants in this study. Gall, Borg, and Gall (2003) suggested that there should be minimum amount of 15 participants per group upon a particular research. Before participating in this study, fifteen recreational trained men were required to sign a consent form and were asked to fill out the Physical Activity

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Readiness Questionnaire (PAR-Q). Participants were all males and aged between 20-25 years old based on their birth year. Participants had been selected in accordance to their experience of involvement in resistance training. The minimum involvement should be 1 year of participation with three times of training per week, particularly before this study was carried out. All participants have displayed good technique in bent over row and biceps curl exercises with good health condition and no physical injury or orthopaedic problem that might be aggravated. Lastly, participants are not allowed to take any nutritional supplements that may increase the performance drastically.

3.4 Equipment

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In this study has been used calibrated barbell, weight plates, electromyography (EMG), RPE scale, and heart rate monitor. All the equipment had been set up and tested before the study was carried out in the biomechanics laboratory.

The calibrated barbells (Ivanko OB, USA) with 20 kg and weight plates (Ivanko rubber E-Z Lift® plate, USA) were chosen as loads. All participants have used the same barbell and weight plate but with different amount of load that was adjusted according to their 10 repetitions maximum (RM) of bent over row and biceps curl exercises (Figure 3.2). One of objective of the study was to identify the muscle activation of the Latissimus Dorsi and Biceps Brachii. Thus, wireless electromyography (EMG) system (Trigno, Delsys, USA) was used to detect and analyse maximum voluntary isometric contraction (MVIC) and mean of muscles that were activated while doing bent over

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row and biceps curl exercises. Electrodes was placed at right latissimus dorsi and right biceps brachii (Figure3.3).



Figure 3.2. Barbell and Weight Plate

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Figure 3.3. Electromyography

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Next, the objective of this study was to compare the rating of perceived exertion (RPE) between three rest intervals of 60 seconds, 90 seconds and 120 seconds respectively. The rating of perceived exertion (RPE) was used to measure the ability of lifting the load with different rest interval in between each set. Perceived exertion also can be used to identify muscle strain, muscle aches, muscle fatigue, cardiovascular and pulmonary system during resistance training (Groslambert & Mahon, 2006). Therefore, OMNI-Resistance Exercise Scale (OMNI-RES) was chosen and standardized for all participants (Figure 3.4).

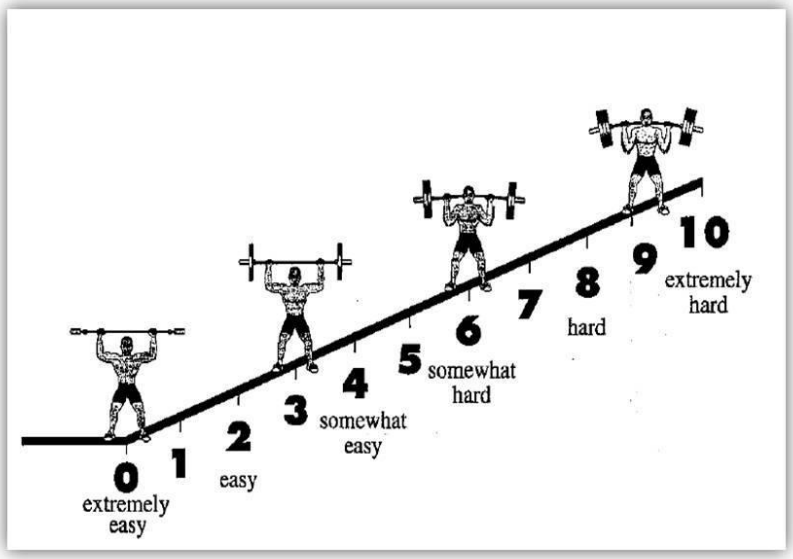


Figure 3.4. OMNI-Resistance Exercise Scale (OMNI-RES) by Robertson et al (2003)

The following objective was to compare heart rate while doing bent over row and biceps curl over different rest intervals between sets. The equipment used to track heart rate in this study was Casio Running Watch PHYS Fizz Heart Rate Monitor Lap Memory CHR-200-2 Foreign Model Watch (Figure 3.5). The heart rate belt was applied

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on the chest of participants (xiphoid level). Then, the heart rate readings have been taken and recorded for every set of each exercises.



Figure 3.5. Polar Hear Rate

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3.5 Procedures

First and foremost, the anthropometric profile of participants had been measured and recorded. The detailing measured were age, height, weight and Body Mass Index (BMI). Height of each participants was measured in meter (cm) and body mass of each participants was measured in kilogram (kg). The data of anthropometric profile was recorded in the result sheet.

After the anthropometric measurement was carried out, participants were required to enter familiarization phase. Familiarization phase was necessary to provide experience and to allow participants to be familiar before undergoing experiment phase.

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During this phase, participants received standardized instruction on the purpose and methods of study and the exercise technique that has been conducted. Participants were also required to perform bent over row and biceps curl with minimal loadings just so that the techniques can be observed.

3.5.1 Determination of Ten Repetitions Maximum (RM)

After familiarization session and resting for 72 hours, the participants were placed in ten repetition maximum (RM) test to identify the maximum load that can be lifted for ten consecutive repetitions on bent over row and biceps curl.

Firstly, participants were asked to warm up with light resistance for active muscles to avoid any further injury. After warming up, 10 repetitions maximum (RM) test were begun with participants required to lift load that they were able to on 10 repetitions maximum (RM) with negotiation and approval by researcher. If participants were to lift load more than 10 repetitions maximum (RM), the load would be added by 4 to 10 kilogram (kg) and 5 minute rest was given before participants were asked to do the next attempt. The amount of repetitions would not be considered if participants did the exercises with wrong technique. Constant velocity that is allowed for each exercise was 3 seconds per repetitions (both concentric and eccentric). A metronome was used to help for reference on velocity movement while doing the exercises.

Failure were defined as the time point when the participant paused more than 1 seconds during lifted load or if the participant was unable to complete each repetition in a full range of motion (Baechle & Earle, 2008).

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To avoid errors and bias during the 10 repetitions maximum test (RM), a brief about the chronology of 10 repetitions maximum test were given by researcher before the test was carried out. All participants should perform standard exercises technique for bent over row and biceps curl exercises with same instruction given to all participant. Researcher closely monitored the position and movement technique before the exercise was started until the exercise ends and precision scale has been used to measure all loads that was used in this study.

3.5.2 Muscle activation procedure

Electromyography (EMG) signals have been recorded from Latissimus Dorsi and Biceps Brachii during the bent over row and biceps curl by using wireless electrodes (Trigno, Delsys, USA). The study by Cram (1998) and Park and Yoo (2013) was used as guideline to determine muscle of Latissimus Dorsi. Besides, for Bicep Brachii muscle, the SENIAM (Surface EMG for Non-Invasive Assessment of Muscles) was used as guideline according to Hermens et al (1999). In order to get a good electrode-skin contact, researcher shaved the skin surface covered with hair, particularly where the electrodes have to be placed in order to avoid reading error. Participants' skins were then cleansed by using alcohol swab and the alcohol was allowed to vaporise first so that the skin would be dry before the electrodes were placed.

After the skin preparation, the participants were required to be in the starting posture (depends on the respective muscle) to determine the proper location of the electrodes on the muscle. Palpation was done to determine the muscle and the

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anatomical landmarks clearly which help to determine a proper electrode positioning. A qualified physiotherapist will be present as well to help in determining the location of muscle.

Maximum voluntary isometric contraction (MVIC) is important for this study to identify maximal contraction of muscle against pressure. Without proper technique and maximum effort to withstand the pressure, the finding of MVIC was not relevant and will be obtained with error. In this study, every participant performed three times of trials with rest of two minutes length in between each trial. Three seconds was given for participant to maintain the maximum isometric contraction (MVIC) for each trial. The order of the MVIC was randomly order and two minute rest was given to avoid the potential of participants being fatigue.

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Latissimus Dorsi is a muscle that is very wide which arise from the lower six thoracic vertebrae, lumbodorsal fascia, sacrum, and iliac ala along with the teres major. It inserts on the medial edge of the bicipital sulcus of the humerus (Cram, 1998). A single-channel surface electrode was placed only at the right side of the muscle. Thus, to determine the Latissimus Dorsi electrode placement, the researcher asked participants to be in seated position and shoulder adduction, extension, and internal rotation should be performed. The electrodes were placed at 25° of oblique angle over the Latissimus Dorsi on the right side, which was approximately 4 cm below the inferior tip of the scapula and midway between the spine and lateral edge of the torso. The MVIC test for Latissimus Dorsi muscle was carried out according to Hislop and Montgomery (2002) and Kendall, McCreary, Provance, Rodgers, and Romani (2005) which participants were asked to prone lying with both arms placed at the side of body

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and the shoulders position with an internally rotation to create a palm-up position. The researcher has laid hands on right forearm and the contralateral side of the pelvis. Participants were also asked to move his right arm toward to the celling (shoulder extension) as maximal as possible and the researcher would exert pressure at right forearm and pelvis of the participants.

Consecutively, researcher would have to determine the Biceps Brachii electrode placement. Hence, participants were required in seated position with the 90° right elbow flexion and the dorsal side of the right forearm pointing downwards. A single-channel surface electrode was placed on the line between the medial acromion and the fossa cubit at one-third (1/3) from the fossa cubit. Before the MVIC test was conducted, right hand of participant was placed on the bench with supination of forearm. The MVIC test for this muscle was initiated by asking the participant to move his elbow towards the body (elbow flexion) while applying pressure to the forearm in the direction of extension.

Raw Electromyography (EMG) signals were recorded at an analogue-to-digital conversion rate of 2000 Hz and 16-bit resolution after being amplified at 1000×. Recorded signals were full-wave rectified and filtered by using a dual-pass of sixth-order, 10 to 500 Hz band-pass Butterworth filter, and then a linear envelope was created by using a low-pass, second-order Butterworth filter with a cut-off frequency of 6 Hz (Earp, 2013).

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For each muscle, the EMG signals were collected from the beginning of the movement upon the completion of the movement over three sets. The data was recorded in the aspect of muscle activity's average. The average of recorded muscle activity was used to show the mean of muscle activation during all single repetition.

3.5.3 Heart Rate Monitor Procedure

Heart rate monitor was used in this study to identify heart rate reading in each set of bent over row and biceps curl exercise with different rest intervals. Before started, the researcher placed a little water at the back surface of electrode and chest strap. Researcher also assisted participants to wear transmitter belt with wireless Polar heart rate monitor and belt was tighten to ensure it has intact contact with skin. Participant was asked to wear heart rate watch at the right hand and the signal was checked to ensure that it was connected with Polar heart rate (Laukkanen, & Virtanen, 1998; Wang et al., 2017). Heart rate reading was taken on every set after participant completely lifts the load.

3.6 Experimental Protocol

The experimental session took place after the participants rest about 72 hours after 10 repetition maximum (RM) test. Participants were required to perform six different training sessions. In each training session, participants performed exercise with randomized rest intervals of 60 seconds, 90 seconds and 120 seconds over 3 repetitions and 10 repetitions maximum (RM) loads. This session started with participants

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warming up for 10 to 15 repetitions with 50% of the 10RM loads. Two minutes rest was given before the first experimental sets was started. Participants performed bent over row exercise and followed by biceps curl exercise after 5 minute rest in between exercises. To avoid bias on the experiment, movement velocity was controlled 3 seconds per repetitions (concentric and eccentric) and same verbal encouragement was used to all participants. The total number of repetitions, muscle activation, heart rate, and rating of perceived exertion (RPE) was observed and recorded for every session.

3.7 Exercises Protocol

In this study, there were two exercises performed by participants, which were the bent over row and biceps curl. Bent over row exercises protocol that have been performed was referred to Fenwick, Brown, and McGill (2009) and biceps curl exercises protocol guided by National Strength & Conditioning Association (US) (Baechle & Earle, 2008).

3.7.1 Bent over Row Exercise

Using the mass determined from the 10RM test, participants lifted the loaded barbell from the ground, flexed the trunk over the hips, and were instructed to keep a neutral spine while they pulled the barbell to their upper abdomen, bending their arms at the elbows. Push the barbell towards to the ground same as starting position and maintained the body and knee position (*Figure 3.6*). Participants lifted the load until reached fatigue.

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Figure 3.6. Bent over Row Exercise

3.7.2 Biceps Curl Exercise

Using the mass determined from the 10RM test, participants grasp the barbell as tightly as possible and the wrist in neutral position. Participants lifted barbell through full elbow flexion. Body position of participant should be stationary and not swing the body when lifted the barbell upward (*Figure 3.7*). Participants lifted the barbell until archived fatigued.

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Figure 3.7. Biceps Curl Exercise

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3.8 Pilot Study

The pilot study revolve in terms of informal trying procedure in a few participants, for effectiveness study, or to small-scale clinical trials of interventions (Hertzog, 2008). In this study, pilot study has been done to identify reliability of measurement that were electromyography (EMG), rating of perceived exertion (RPE) and heart rate monitor. Lackey and Wingate (1997) recommend at least 10 percent of the sample size was enough on pilot test. Thus, this study used 5 participants to involve in pilot test.

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The pilot study process were conducted two session that were pre and post with 72 hours rest between both sessions. The data of muscle activation was collected on latissimus dorsi and biceps brachii during bent over row, while biceps brachii during biceps curl. The data of RPE were collected after participants finished exercises. The data of heart rate (HR) was recorded after exercises.

The result of reliability that measured by Cronbach's alpha in SPSS for muscle activation during bent over row exercise were: i) latissimus dorsi, r=0.98 ii) biceps brachi, r=0.95 and biceps curl exercise: i) biceps brachii, r=0.98. Besides, the result of RPE during bent over row exercise was, r=0.75 and biceps curl was, r=0.83 Next, the result of heart rate (HR) during bent over row was, r=0.83 and biceps curl was, r=0.88.

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Table 3.1

Reliability Statistics

Variables	N	Pre (Mean±SD)	Post (Mean±SD)	Cronbach's Alpha
Latissimus Dorsi (Bent over Row)	5	80.484±9.422	78.492±9.444	0.98
Biceps Brachii (Bent over Row)	5	50.908±2.501	44.338±7.324	0.95
Biceps Brachii (Biceps curl)	5	75.158±12.148	75.078±5.662	0.89
RPE (Bent over Row)	5	7.200±0.447	7.400±0.547	0.75
RPE (Biceps Curl)	5	6.800±0.447	7.000±0.707	0.83

(*continue*)

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Table 3.1 (*continued*)

Variables		Pre (Mean±SD)	Post (Mean±SD)	Cronbach's Alpha
Heart Rate (Bent over Row)	5	123.000±3.742	121.000±2.909	0.83
Heart Rate (Biceps Curl)	5	121.000±1.732	122.600±1.817	0.88

3.9 Independent Variables and Dependent Variables

Independent and dependent variables were very crucial and significant to guide data collection in this study. The description of the independent and dependent variables in this study can be seen as shown below:

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Table 3.2

Independent Variables

Independent Variables	Descriptions
Different Rest Intervals	In this study, there were three different rest intervals which were 60 seconds, 90 seconds and 120 seconds during the bent over row and biceps curl exercises. The time was monitored by using stopwatch

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Table 3.3

Dependent Variables

Dependent Variables	Descriptions
Total Number of Repetitions	The total number of repetitions was calculated by the sum of repetitions in Set 1, Set 2 and Set 3.Total number repetitions= Set 1+ Set 2 + Set 3
Muscle Activation	Electromyography (EMG) was used to collect, record and analysis the data. Data recorded was showed in mean muscle activation and maximum voluntary isometric contraction (MVIC).
Heart Rate	The heart rate for each sets (set 1, set 2 and set 3) were also observed and identified after exercises each set.
Rating of Perceived Exertion	Participants determined the scale of rating of perceived exertion (RPE) according to the difficulty level during the training after exercise each set.

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3.10 Data Collection

In this study, all data collection has been done by same trained tester. Data collection was analysed by the same person in order to avoid any possible error. Researcher started to analyse anthropometric profile for every participants that consists of age, height, weight and body mass index (BMI). All the anthropometric profile for every participants was arranged and managed in the Excel 2013 (Microsoft Limited, UK). Number of repetitions for every set during bent over row and biceps curl with different

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rest intervals that has been counted was also recorded and arranged in Excel 2013 (Microsoft Limited, UK). Next, researcher tried to identify and compare the two categories of muscle activation. Firstly, researcher identified maximum voluntary isometric contractions (MVIC). Next, researcher identified the average of muscle activation for every repetition of exercises. To get the average of muscle activation, the formula used is as shown below:

$$\text{Average Muscle Activation (\%)} = \left[\frac{\text{mean muscle activation each set}}{\text{Maximum voluntary isometric contraction (MVIC)}} \right] \text{X } 100$$

After calculated and the average of muscle activation were obtained, the data were presented in percentage of average muscle activation. The data has been compiled and managed in Excel 2013 (Microsoft Limited, UK). On the other hand, the data of heart rate and rating of perceived exertion which has been recorded during every set of exercises was managed in Excel 2013 (Microsoft Limited, UK).

3.11 Statistical Analysis

In this study, Statistical Package for the Social Sciences (SPSS) Version 20 Windows software has been used to analyse the data. Descriptive statistics were presented through the calculation of mean and standard deviation (SD). All the data in this study was normal distribution and repeated measure Analysis of Variance (ANOVA) was used to compare three different rest intervals between sets on number of repetitions, muscle

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activation, rating of perceived exertion (RPE) and heart rate during bent over row and biceps curl exercises. Statistical significance were accepted in this study at an alpha level of $p \leq 0.05$.

3.12 Summary

In this chapter, the researcher tried to explain about study design, criteria of participants, equipment used, procedures carried out to collect data, procedures of exercises, method of collecting data and calculation of statistical analysis. All these things were important because it can determine either the research conducted successfully or unsuccessfully in order to achieve the objectives of the study.

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CHAPTER 4

RESULTS

4.1 Introduction

This was an acute study that compared three different rest interval between sets on number of repetitions, muscle activation, rating of perceived exertion (RPE) and heart rate (HR during bent over row and biceps curl exercise with different rest interval between sets such as 60 seconds, 90 seconds and 120 seconds. Rest interval is one of variables in resistance training that is important when designing training program. It may influence performance especially in hypertrophy training.

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This chapter presented the results that was obtained during these study and the details were discussed in the following subtopics:

- Basic anthropometry profile of participants
- The Result of Different Rest Interval on Repetitions during Bent over Row Exercise
- The Result of Different Rest Interval on Muscle Activation of Latissimus Dorsi during Bent over Row
- The Result of Different Rest Interval on Muscle Activation of Biceps Brachii during Bent over Row
- The Result of Different Rest Interval on Rating of Perceived Exertion (RPE) during Bent over Row
- The Result of Different Rest Interval on heart rate during Bent over Row
- The Result of Different Rest Interval on Repetitions during Biceps Curl Exercise
- The Result of Different Rest Interval on Muscle Activation of Biceps Brachii during Bicep Curl Exercise
- The Result of Different Rest Interval on Rating of Perceived Exertion (RPE) during Biceps Curl Exercise
- The Result of Different Rest Interval on heart rate during Biceps Curl Exercise

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4.2 Basic anthropometry profile of participants

Table 4.1

Basic anthropometry profile of participants (n=15)

Variables	Minimum	Maximum	Mean ± SD
Age (years)	20	25	21.20 ± 1.146
Height (cm)	161	180	170.93 ± 5.049
Body Mass (kg)	60	77	65.13± 5.854
BM1 ($kg.m^{-2}$)	20.00	25.60	22.29 ± 1.520
10 RM Bent Over Row (kg)	22.5	40.00	30.00 ± 4.119
10 RM Biceps Curl (kg)	20	25.50	22.53 ± 1.941

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Table 4.1 showed the anthropometry profile such as age, height, weight, body mass index (BMI) and 10 RM of bent over row and biceps curl on participants (n=15) that was participated in this study. The data of age indicated mean for all participants in this study was 21.20 ± 1.146 years old, the oldest age was 25 years old and the youngest age was 20 years old. The data of mean height showed 170.93 ± 5.049 cm which highest participants in this study was 180 cm while lowest height was 161 cm. The mean weight of participants in this study was 65.13± 5.854 kg, within showed the heaviest weight 77 kg while lightest weight 60 kg.

The data of mean body mass index (BMI) indicated that 22.29 ± 1.520 $kg.m^{-2}$ which highest BMI 25.60 $kg.m^{-2}$ and lowest 20.00$kg.m^{-2}$. Participants in this study was performed 10RM on bent over row and biceps curl exercises, the mean of 10RM bent

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over row exercise was 30.00 ± 4.119 kg which highest 10RM was 40.00 kg and lowest 10RM was 22.5 kg. The data of mean of 10RM biceps curl was 22.53 ± 1.941 kg with that highest lifted was 25.50 kg and lowest 20 kg.

4.3 The Result of Different Rest Intervals on Number of Repetitions during Bent over Row Exercise

Table 4.2

Number of Repetitions during Bent over Row Exercise with different rest intervals

Time(s)/Set	Set 1	Set 2	Set 3
60	9.467±0.640	7.400±0.737	5.600±0.910
90	9.333±0.724	8.067±0.799	6.867±0.743
120	9.667±0.617	9.533±0.640	8.933±0.594

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The results of the one way repeated-measures ANOVA showed that there was significant difference between sets (Set1, Set2 and Set 3) on the number of repetitions during bent over row with 60, 90 and 120 seconds rest interval [$F(2,28) = 134.517$, $p < 0.05$], [$F(2,28) = 146.714$, $p < 0.05$] and [$F(1.363,19.075) = 11.820$, $p < 0.05$].

Bonferroni post hoc tests showed that number of repetitions for bent over row with 60 seconds rest interval was significantly decrease from set 1 (mean = 9.467; SD = 0.640) to set 2 (mean = 7.400; SD = 0.737), $p < 0.05$ and continues decrease in set 3 (mean = 5.600; SD = 0.910), $p < 0.05$. Bent over row with 90 seconds also got same result that number of repetitions significantly decrease from set 1 (mean = 9.333; SD = 0.640) to set 2 (mean= 8.067; SD= 0.799), $p < 0.05$ and continues decrease in set 3 (mean= 6.867; SD= 0.743), $p < 0.05$. However, it was contrast with 120 rest interval

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that there was no significantly difference on number of repetitions between set 1 (mean= 9.667; SD= 0.617) and set 2 (mean = 9.533; SD = 0.640), $p > 0.05$ and started decrease in set 3 (mean= 8.933; SD= 0.594), $p < 0.05$.

Beside that, profile plots clearly showed number of repetitions during bent over row with 60 seconds and 90 seconds rest interval were decrease from set 1 to set 2 and continues decrease in set 3. However, it was in contrast to 120 seconds rest interval. Thus, this evidence has rejected the null hypothesis that there was no significant difference between numbers of repetitions during bent over row with 60, 90 and 120 seconds rest interval.

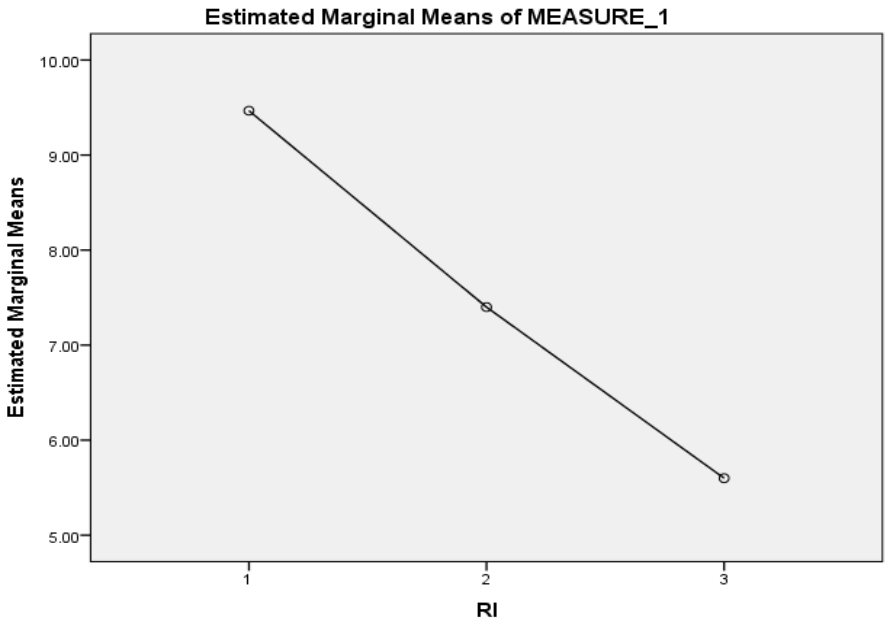


Figure 4.1. Profile Plots Number of Repetitions during Bent over Row with 60 seconds

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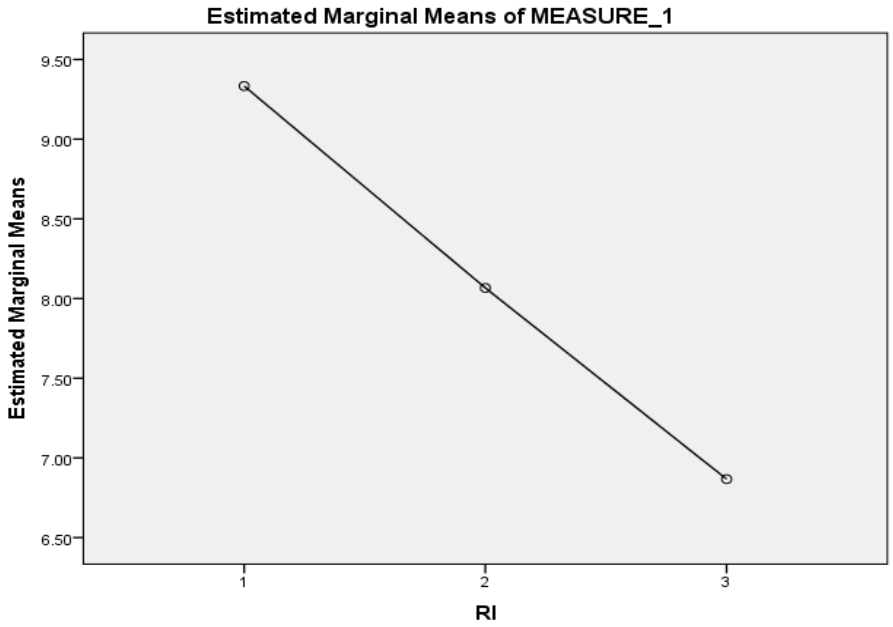


Figure 4.2. Profile Plots Number of Repetitions during Bent over Row with 90 seconds

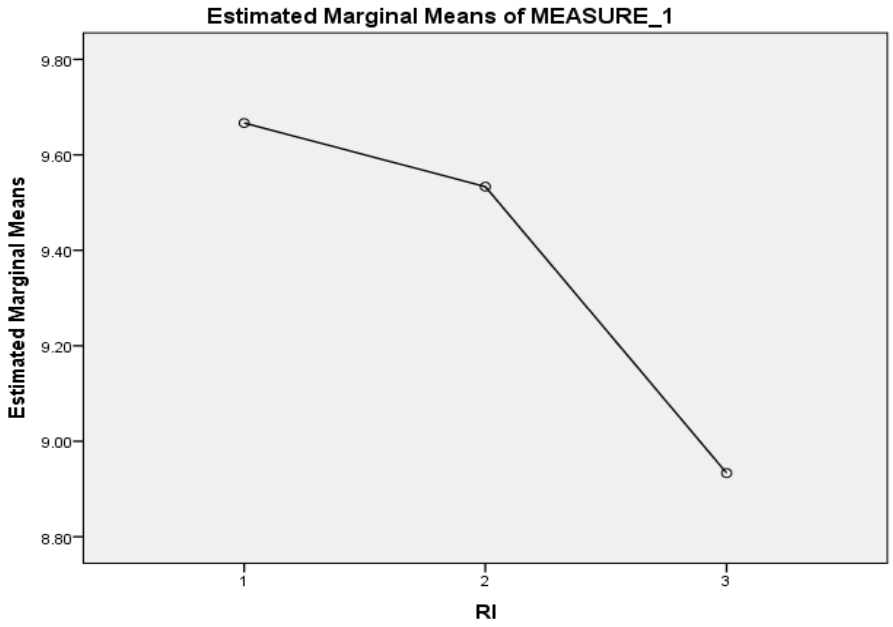


Figure 4.3. Profile Plots Number of Repetitions during Bent over Row with 90 seconds

One way repeated-measures ANOVA was used to compare number of repetitions during bent over with different rest intervals in set 1, 2 and 3. The result showed that there was no significant difference on number of repetitions between rest intervals (60 seconds, 90 seconds and 120 seconds) in set 1 [$F(2,28) = 1.291$, $p > 0.05$].

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However, in set 2, there was significant difference [$F(2,28) = 43.126$, $p < 0.05$] and followed by set 3 [$F(1.428,19.996) = 91.000$, $p < 0.05$].

Bonferroni post hoc tests showed that there was no significantly difference on number of repetitions between 60 seconds (mean = 9.467; SD = 0.640), 90 seconds (mean = 9.333; SD = 0.724) and 120 seconds (mean = 9.667; SD = 0.617), $p > .05$ in set 1. In set 2, there was no significant difference on number of repetitions between 60s (mean = 7.400; SD = 0.737) and 90s (mean = 8.067; SD = 0.799), $p > 0.05$, while significant difference with 120s (mean = 9.533; SD = 0.640), $p < 0.05$. The result also showed there was significantly difference between 90s and 120s, $p < 0.05$. In set 3, showed that there was significant difference on number of repetitions between 60 seconds (mean= 5.600; SD= 0.910), 90 seconds (mean = 6.867; SD = 0.743), $p < .05$, and 120 seconds (mean = 8.933; SD = 0.594), $p < 0.05$. The result also showed there was significantly difference between 90 seconds and 120 seconds, $p < 0.05$.

Profile plots also showed that the number of repetitions was no significant difference between 60s, 90s and 120s in set 1. In set 2 and 3, 120 seconds rest interval produced the highest number of repetitions during bent over row exercise.

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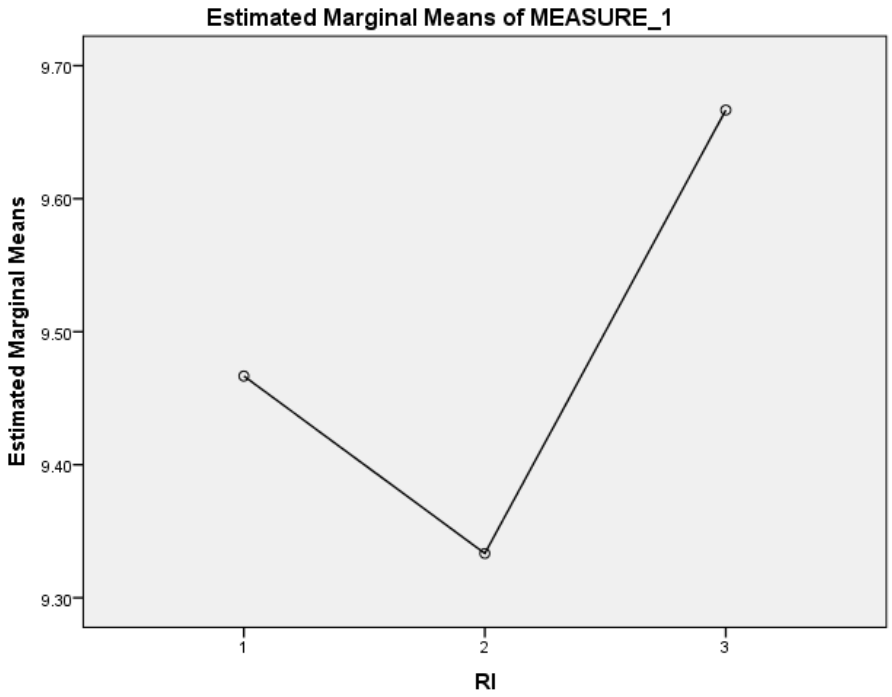


Figure 4.4. Profile Plots Number of Repetitions during Bent over Row with Different Rest Intervals in Set 1

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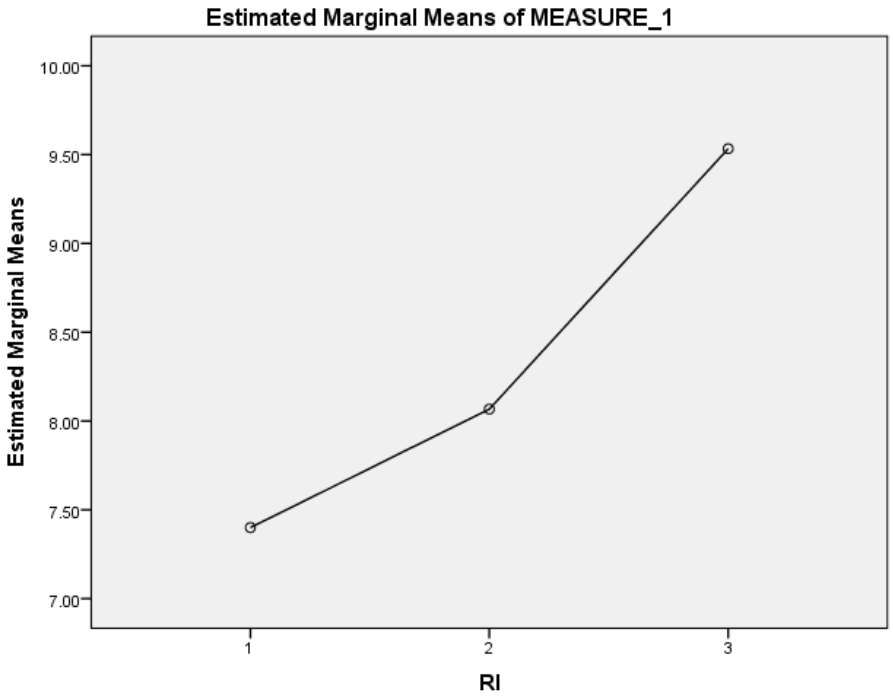


Figure 4.5. Profile Plots Number of Repetitions during Bent over Row with Different Rest Intervals in Set 2

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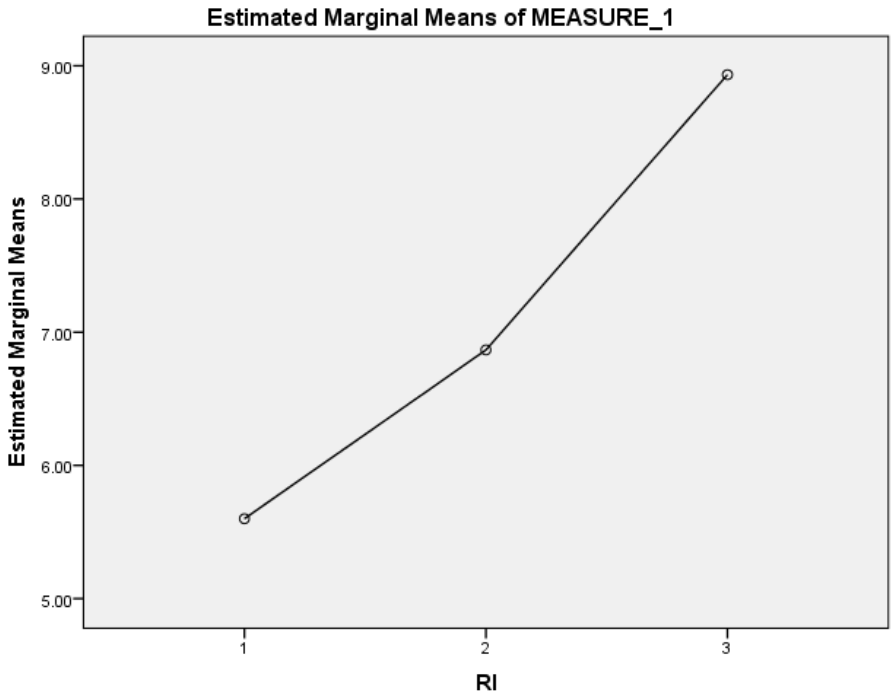


Figure 4.6. Profile Plots Number of Repetitions during Bent over Row with Different Rest Intervals in Set 3

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4.4 The Result of Different Rest Intervals on Muscle Activation of Latissimus Dorsi during Bent over Row Exercise

Table 4.3

Muscle Activation of Lattisimus Dorsi during Bent over Row Exercise with Different Rest Intervals

Time(s)/Set	Set 1	Set 2	Set 3
60	78.098±8.674	63.597±5.939	50.755±6.479
90	76.913±8.629	71.139±8.999	59.970±9.245
120	77.380±8.436	75.136±7.128	67.835±8.430

The results of the one way repeated-measures ANOVA showed that there was significant difference between sets (Set1, Set2 and Set 3) on the muscle activation during bent over row with 60 seconds [$F(2,28) = 146.758$, $p < 0.05$], 90 seconds [$F(1.243,17.396) = 35.607$, $p < 0.05$] and 120 seconds rest interval [$F(1.436,20.104) = 18.857$, $p < 0.05$].

Bonferroni post hoc tests showed that muscle activation was significantly decrease from set 1 (mean = 78.098; SD = 8.674) to set 2 (mean = 63.597; SD = 5.939), $p < 0.05$ and continues to decrease in set 3 (mean = 50.755; SD = 6.497), $p < 0.05$ during bent over row with 60 seconds. Bent over row with 90 seconds also get same result that muscle activation significantly decrease from set 1 (mean = 76.913; SD = 8.629) to set 2 (mean = 71.139; SD = 8.999), $p < 0.05$ and continues to decrease in set 3 (mean = 59.970; SD = 9.245), $p < 0.05$. However, it was contrast with 120 rest interval that there was no significantly difference on muscle activation between set 1 (mean= 77.380; SD= 8.436) and set 2 (mean = 75.136; SD = 7.128), $p > 0.05$ and started significantly decrease on set 3 (mean= 67.835; SD= 8.430), $p < 0.05$.

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Besides, profile plots clearly showed that muscle activation of latissimus dorsi was decrease from set 1 to set 2 and continues decrease in set 3 during bent over row with 60 seconds and 90 seconds. However, it was contrasts with 120 seconds rest interval that no reduction of muscle activation during exercise until set 2. Thus, this evidence has rejected the null hypothesis that there was no significant difference between on muscle activation of latissimus dorsi during bent over row with 60, 90 and 120 seconds rest interval.

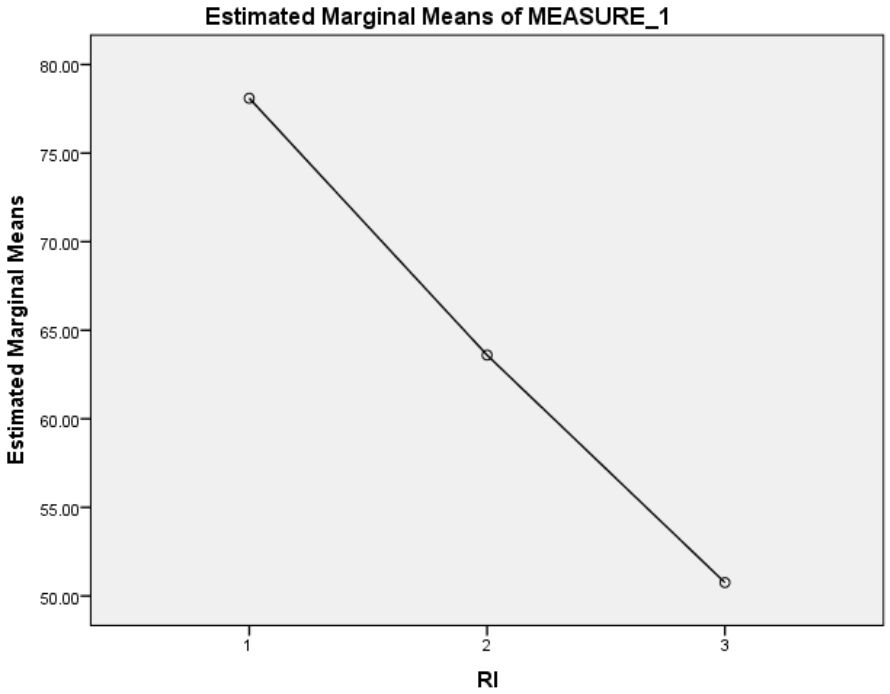


Figure 4.7. Profile Plots Muscle Activation of Latissimus Dorsi during Bent over Row with 60 seconds Rest Interval

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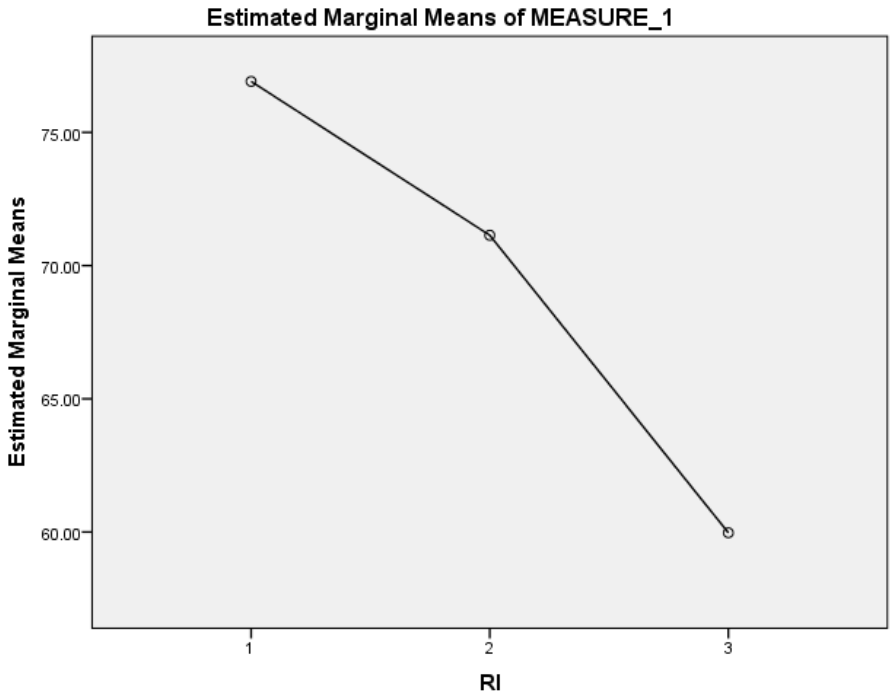


Figure 4.8. Profile Plots Muscle Activation of Latissimus Dorsi during Bent over Row with 90 seconds Rest Interval

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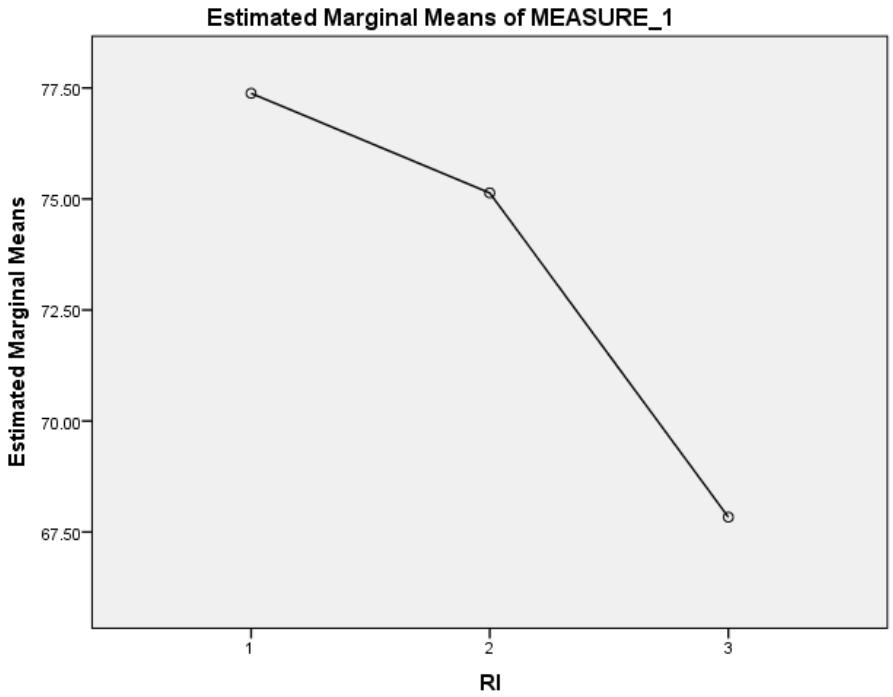


Figure 4.9. Profile Plots Muscle Activation of Latissimus Dorsi during Bent over Row with 120 seconds Rest Interval

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One way repeated-measures ANOVA was used to compare muscle activation of latissimus dorsi during bent over with different rest intervals in set 1, 2 and 3.The results showed that there was no significant difference on muscle activation of latissimus dorsi between rest intervals (60s, 90s and 120s) during bent over row in set 1 [$F(1.426,19.970) = .062$, $p > 0.05$]. However, the result test in set 2 [$F(2,28) = 21.340$, $p < 0.05$] and 3 [$F(2,28) = 23.493$, $p < 0.05$] showed significant difference.

Bonferroni post hoc tests showed that there was no significantly difference on muscle activation between 60s (mean = 78.098; SD = 8.674), 90s (mean = 76.913; SD = 8.629) and 120s (mean = 77.380; SD = 8.436), $p > 0.05$ in set 1. In set 2, bent over row with 120 seconds (mean = 75.136; SD = 7.128) significantly higher than 90 seconds (mean = 71.139; SD = 8.999) and 60 seconds (mean = 63.597; SD = 5.939), $p < 0.05$. The result also showed rest interval with 120 seconds (mean = 75.136; SD = 7.128) significantly higher than 90 seconds (mean = 71.139; SD = 8.999) and 60 seconds (mean = 63.597; SD = 5.939), $p< 0.05$ in set 3.

Profile plots also showed that latissimus dorsi muscle was more activated during bent over row with 120 seconds in set 2 and 3 than 90 seconds and 60 seconds rest interval.

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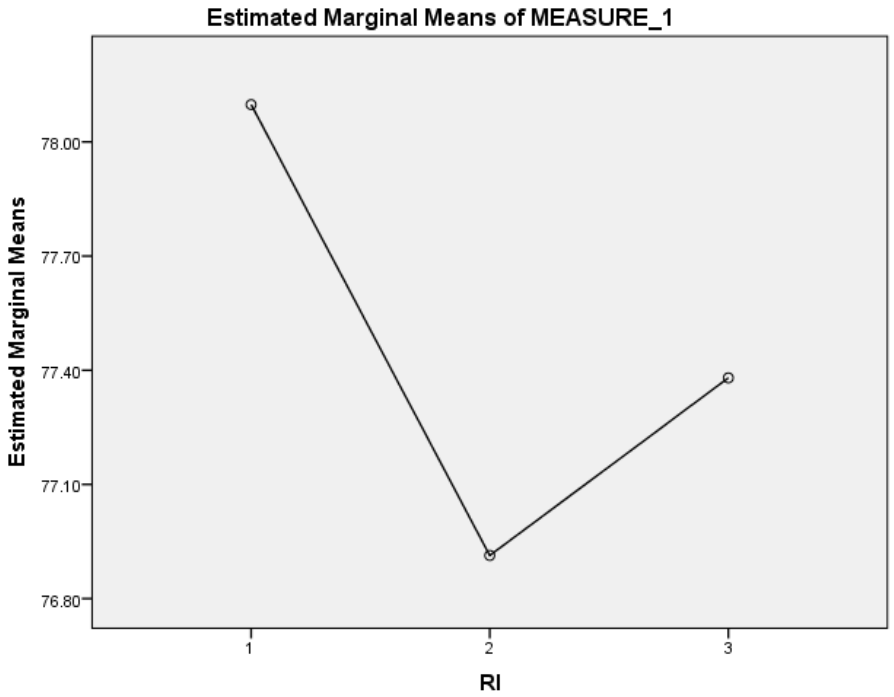


Figure 4.10. Profile Plots Muscle Activation of Latissimus Dorsi during Bent over Row with Different Rest Intervals in Set 1

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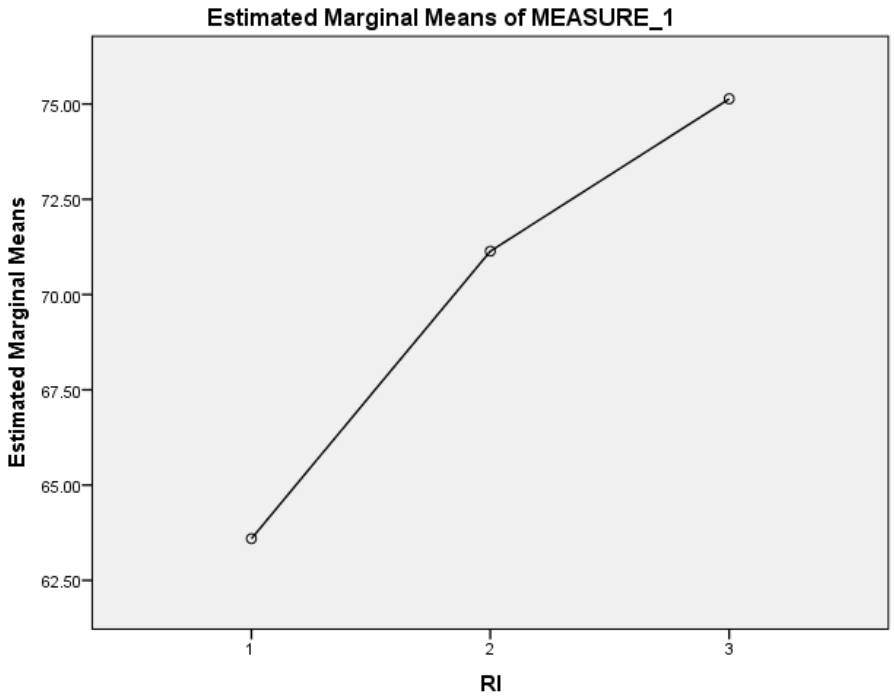
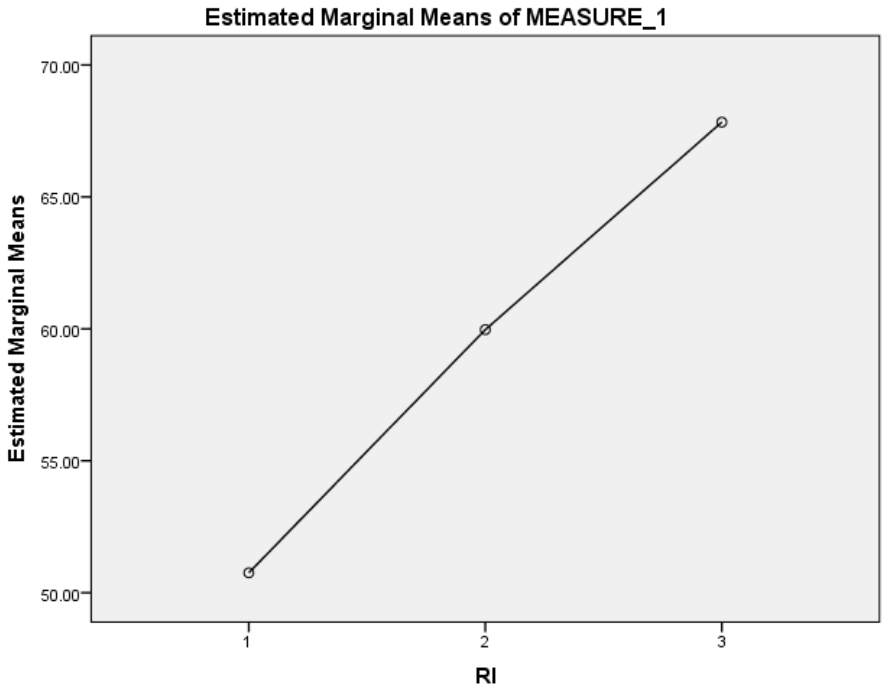


Figure 4.11. Profile Plots Muscle Activation of Latissimus Dorsi during Bent over Row with Different Rest Intervals in Set 2

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Figure 4.12. Profile Plots Muscle Activation of Latissimus Dorsi during Bent over Row with Different Rest Intervals in Set 3

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4.5 The Result of Different Rest Interval on Muscle Activation of Biceps Brachii during Bent over Row Exercise

Table 4.4

Muscle Activation of Biceps Brachii during Bent over Row Exercise with Different Rest Intervals

Time(s)/Set	Set 1	Set 2	Set 3
60	50.120±4.421	37.855±5.788	28.201±5.733
90	49.418±7.211	40.590±5.770	30.590±5.770
120	48.791±7.061	45.593±4.687	36.279±3.674

The results of the one way repeated-measures ANOVA showed that there was significant difference between sets (Set1, Set2 and Set 3) on the muscle activation of biceps brachii during bent over row with 60 seconds rest interval [$F(2,28) = 122.077$, $p < 0.05$], 90 seconds [$F(2,28) = 55.114$, $p < .05$] and 120 seconds [$F(2,28) = 36.182$, $p < 0.05$] .

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Bonferroni post hoc tests showed that muscle activation was significantly decrease from set 1 (mean = 50.120; SD = 4.421) to set 2 (mean = 37.855; SD = 5.788), $p < 0.05$ and continues to decrease on set 3 (mean = 28.201; SD = 5.733), $p < 0.05$ during bent over row with 60 seconds. Bent over row with 90 seconds also get same result that muscle activation significantly decrease from set 1 (mean = 49.418, SD = 7.211) to set 2 (mean = 40.590; SD = 5.770), $p < 0.05$ and continues to decrease on set 3 (mean = 30.372; SD = 5.083), $p < 0.05$. However, it was contrast with 120 rest interval that there was no significantly difference on muscle activation between set 1 (mean = 48.791, SD = 7.061) and set 2 (mean = 45.593; SD = 4.687), $p > 0.05$ and started to decrease in set 3 (mean = 36.279; SD = 3.674), $p < 0.05$.

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Beside that, profile plots clearly showed that muscle activation of biceps brachii during bent over row with 60 seconds and 90 seconds were decrease from set 1 to set 2 and continues decrease on set 3. However, it was contrasts with 120 seconds rest interval that no reduction of muscle activation during exercise until set 2. Thus, this evidence has rejected the null hypothesis that there was no significant difference between muscle activation of biceps brachii during bent over row with different rest intervals.

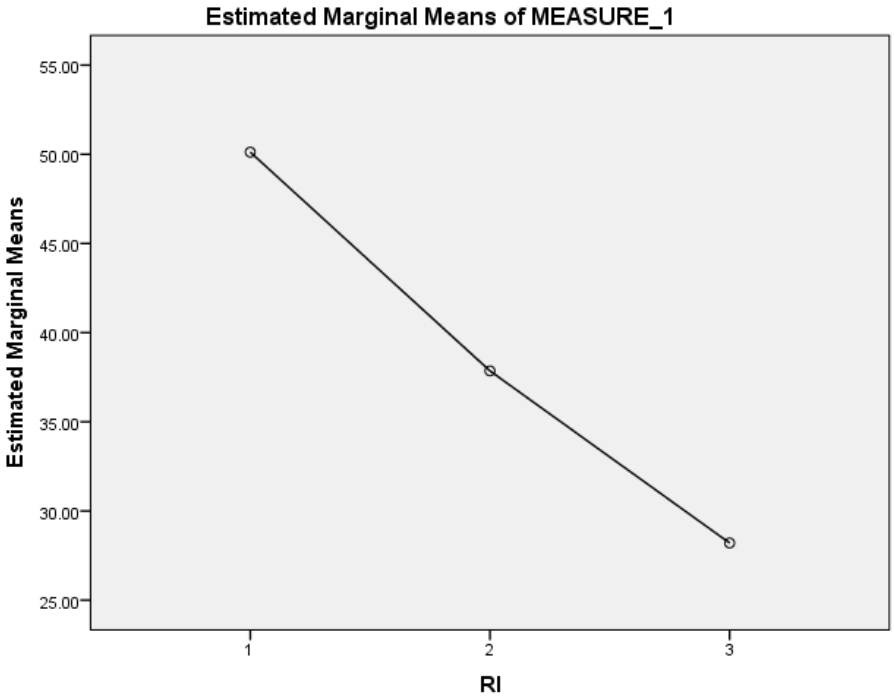


Figure 4.13. Profile Plots Muscle Activation of Biceps Brachii during Bent over Row with 60 seconds Rest Interval

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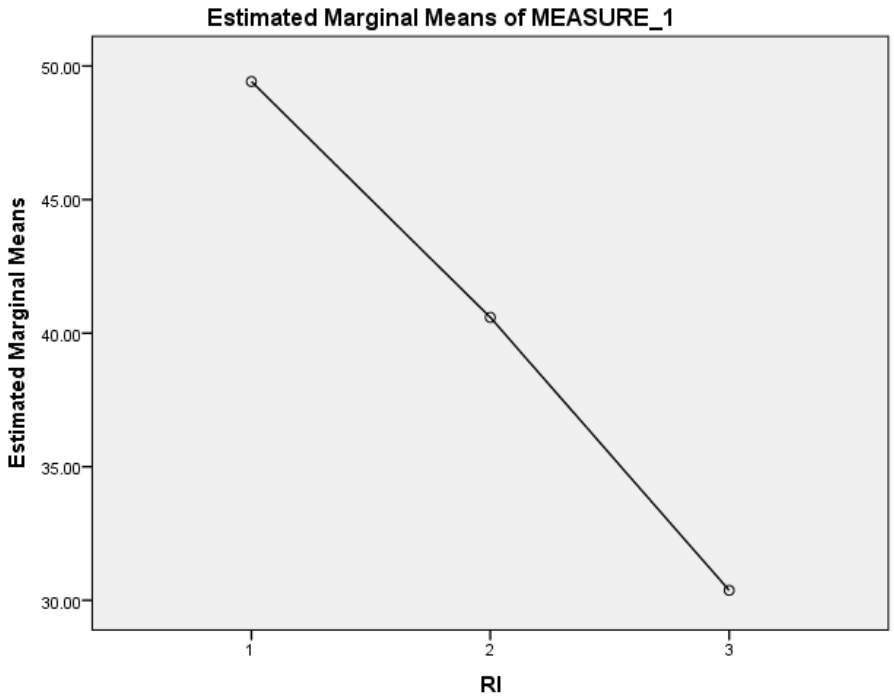


Figure 4.14. Profile Plots Muscle Activation of Biceps Brachii during Bent over Row with 90 seconds Rest Interval

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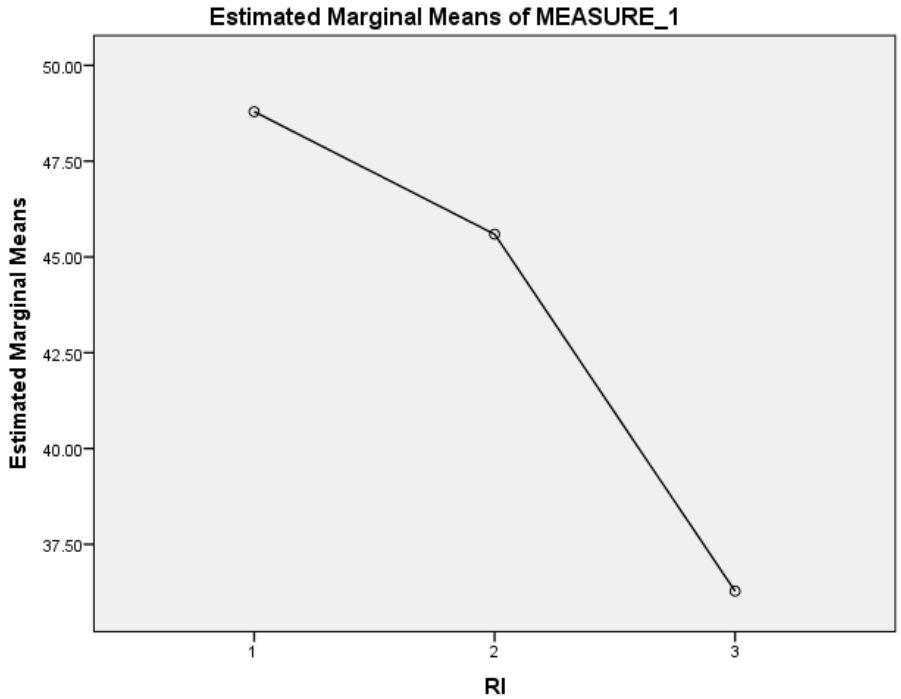


Figure 4.15. Profile Plots Muscle Activation of Biceps Brachii during Bent over Row with 120 seconds Rest Interval

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One way repeated-measures ANOVA was used to identify the effect of different rest intervals on muscle activation of biceps brachii at every each sets. The result showed that there was no significant difference on muscle activation of biceps brachii between rest intervals (60s, 90s and 120s) during bent over row in set 1 [$F(2,28) = 0.256$, $p > 0.05$]. However, there was significant different in set 2 [$F(2,28) = 16.298$, $p < 0.05$] and set 3 [$F(2,28) = 14.590$, $p < 0.05$].

Bonferroni post hoc tests showed that there was no significantly difference on muscle activation between 60s (mean = 50.121; SD = 4.421), 90s (mean = 49.418; SD = 7.221) and 120s (mean = 48.791; SD = 7.061), $p > 0.05$ in set 1. In set 2, there was no significant difference on muscle activation between 60s (mean = 37.855; SD = 5.788) and 90s (mean = 40.590; SD = 5.770), $p > 0.05$, and significant difference when compared with 120s (mean = 45.593; SD = 4.687), $p < 0.05$. In set 3, result showed there was no significant difference on muscle activation between 60s (mean = 28.201; SD = 5.733) and 90s (mean = 30.373; SD = 5.083), $p > 0.05$, and significant difference when compared with 120s (mean = 36.279; SD = 3.674), $p < .05$.

Profile plots also showed that biceps brachii muscle was more activated during bent over row with 120 seconds in set 2 and 3 than 90 seconds and 60 seconds rest interval.

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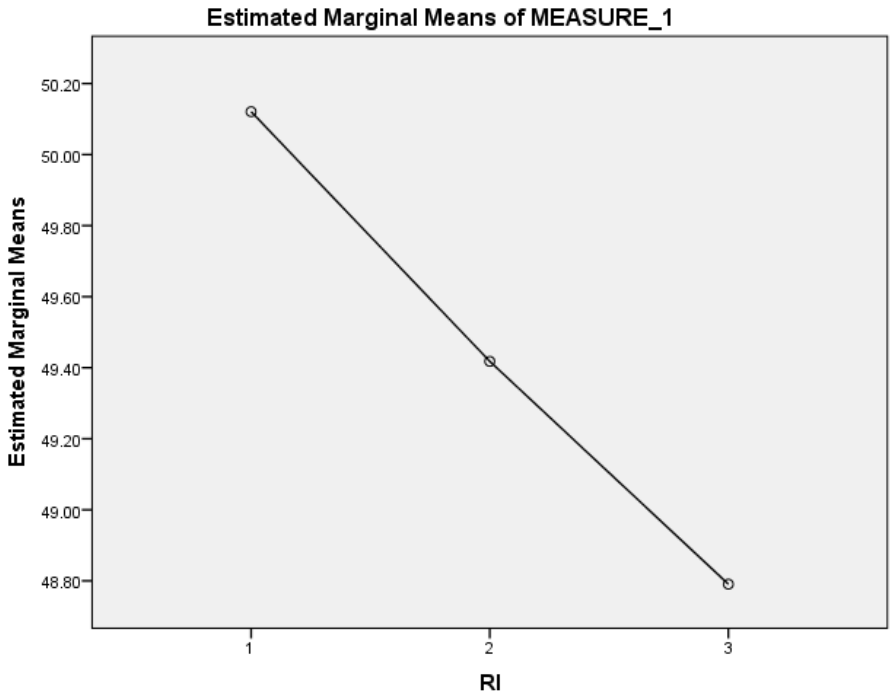


Figure 4.16. Profile Plots Muscle Activation of Biceps Brachii during Bent over Row with Different Rest Interval in Set 1

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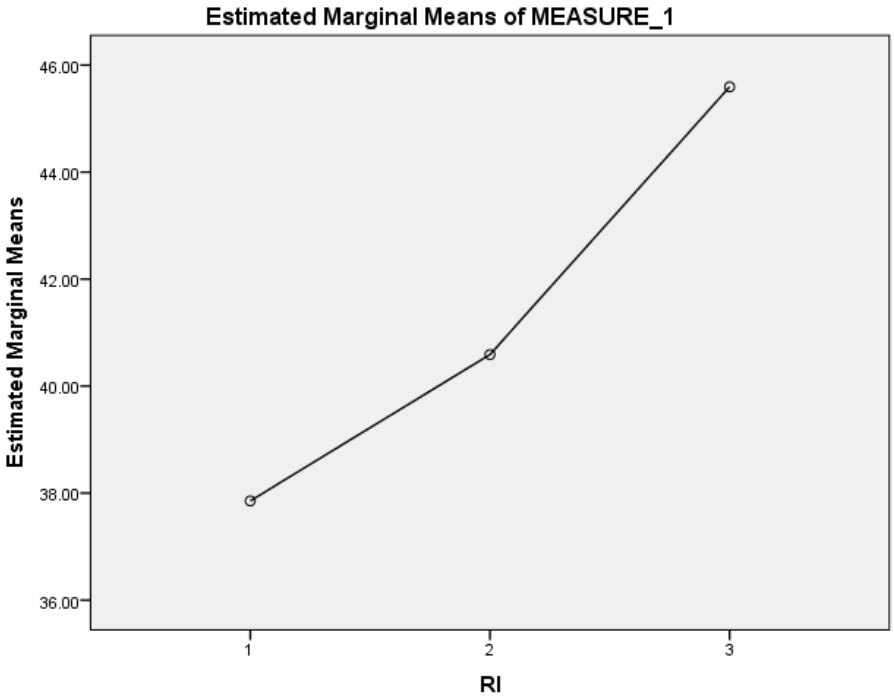


Figure 4.17. Profile Plots Muscle Activation of Biceps Brachii during Bent over Row with Different Rest Intervals in Set 2

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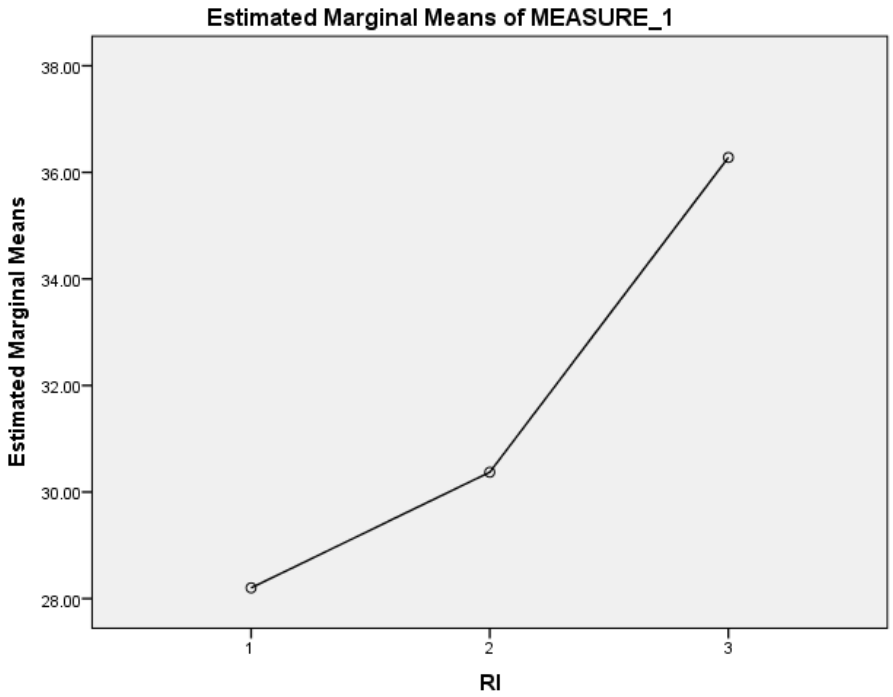


Figure 4.18. Profile Plots Muscle Activation of Biceps Brachii during Bent over Row with Different Rest Intervals in Set 3

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4.6 The Result of Different Rest Interval on Rating Perceive Exertion (RPE) during Bent over Row Exercise

Table 4.5

Rating Perceive Exertion (RPE) during Bent over Row Exercise with Different Rest Intervals

Time(s)/Set	Set 1	Set 2	Set 3
60	7.067±0.258	8.267±0.458	9.133±0.516
90	7.133±0.516	7.867±0.352	8.733±0.458
120	6.933±0.258	7.200±0.414	8.133±0.352

The results of the one way repeated-measures ANOVA showed that there was significant difference between sets (Set1, Set2 and Set 3) on RPE during bent over row with 60 seconds rest interval [$F(2,28) = 192.038$, $p < 0.05$], 90 seconds [$F(2,28) = 65.891$, $p < .05$] and 120 seconds [$F(2,28) = 79.830$, $p < 0.05$] .

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Bonferroni post hoc tests showed that RPE was significantly increase from set 1 (mean = 7.067; SD = 0.258) to set 2 (mean = 8.267; SD = 0.458), $p < 0.05$ and continues to increase in set 3 (mean = 9.133; SD = 0.516), $p < 0.05$ during bent over row with 60 seconds. Bent over row with 90 seconds also get same result that RPE significantly increase from set 1 (mean = 7.133, SD = 0.516) to set 2 (mean = 7.867; SD = 0.352), $p < 0.05$ and continues to increase in set 3 (mean = 8.733; SD = 0.458), $p < 0.05$. However, it was contrast with 120 rest interval that there was no significantly difference on RPE between set 1 (mean = 6.933, SD = 0.258) and set 2 (mean = 7.200; SD = 0.414), $p > 0.05$ and started to increase in set 3 (mean = 8.133; SD = 0.352), $p < 0.05$.

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Beside that, profile plots clearly showed that RPE level during bent over row with 60 seconds and 90 seconds were increased from set 1 to set 2 and continues increase in set 3. However, it was contrasts with 120 seconds rest interval that RPE level does not to increase during exercise until set 2. Thus, this evidence has rejected the null hypothesis that there was no significant difference between RPE levels during bent over row with different rest intervals.

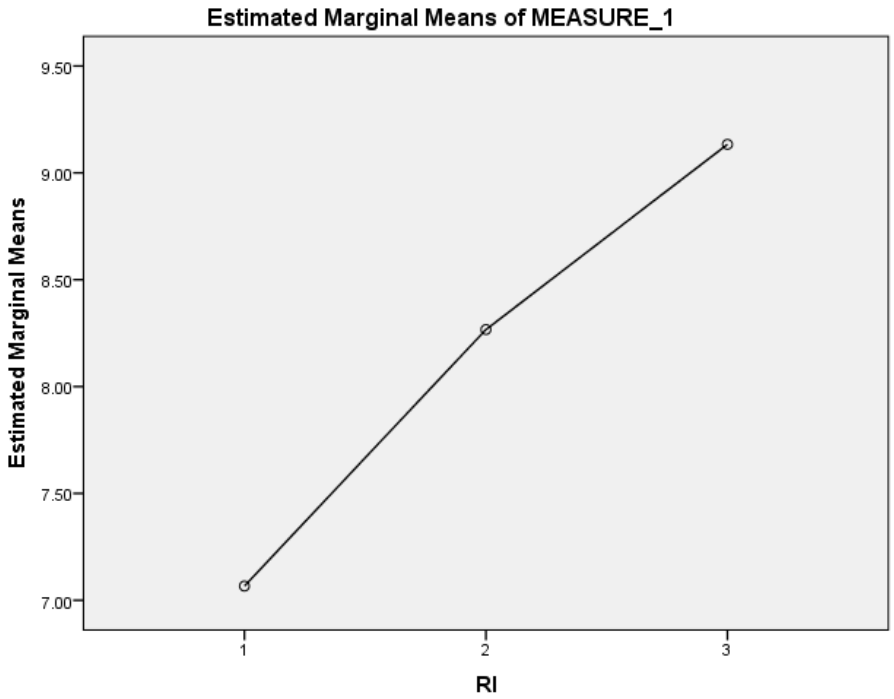


Figure 4.19. Profile Plots Rating of Perceive Exertion (RPE) during Bent over Row with 60 seconds Rest Interval

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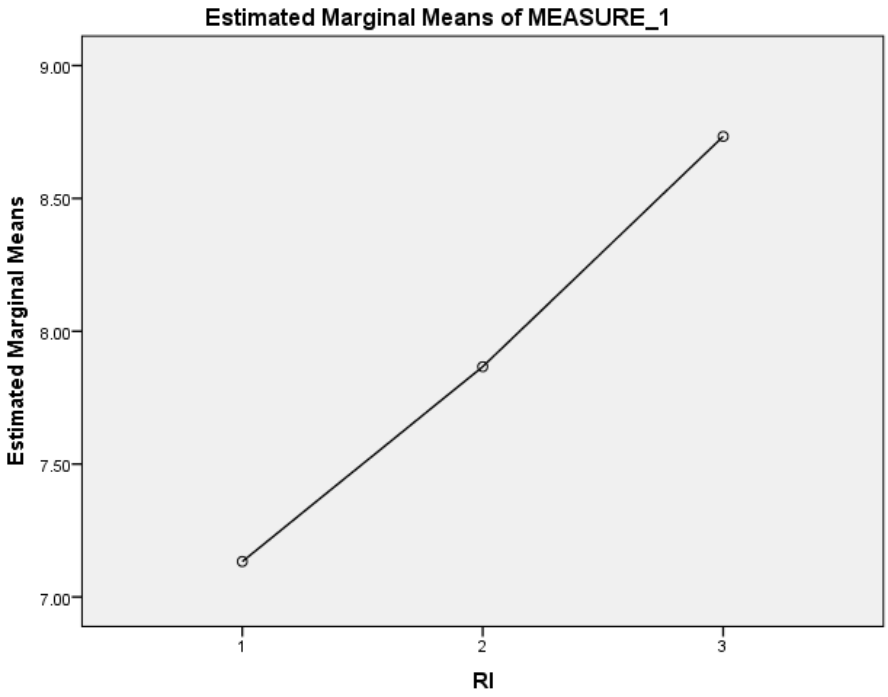


Figure 4.20. Profile Plots Rating of Perceive Exertion (RPE) during Bent over Row with 90 seconds Rest Interval

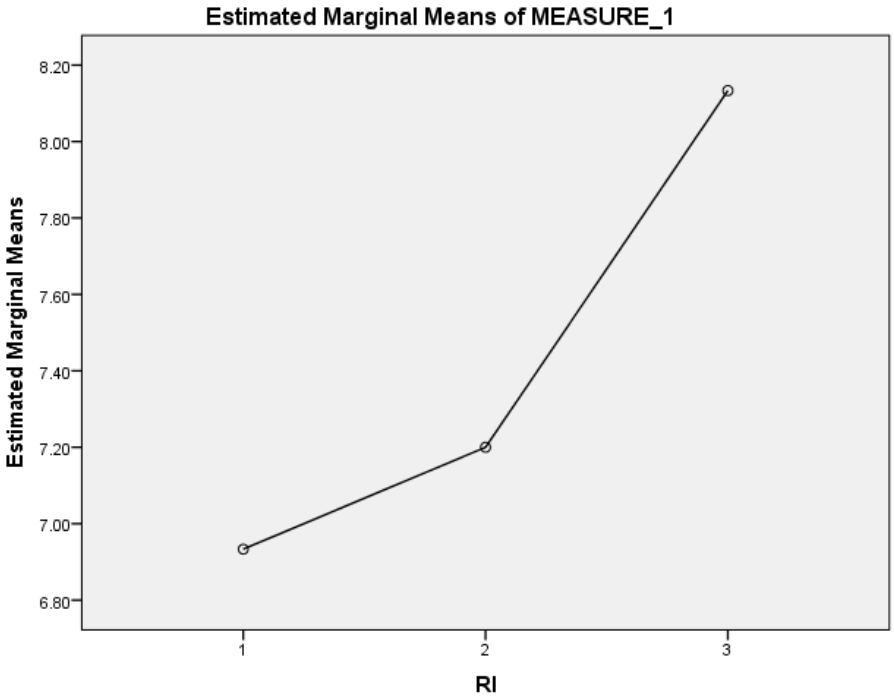


Figure 4.21. Profile Plots Rating of Perceive Exertion (RPE) during Bent over Row with 120 seconds Rest Interval

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One way repeated-measures ANOVA was used to identify the effect of different rest intervals on RPE at every each sets. The result showed that there was no significant difference on RPE between rest intervals (60s, 90s and 120s) during bent over row in set 1 [$F(2,28) = 1.181$, $p > 0.05$]. However, there was significant different in set 2 [$F(2,28) = 23.059$, $p < 0.05$] and set 3 [$F(2,28) = 16.625$, $p < 0.05$].

Bonferroni post hoc tests showed that there was no significantly difference on RPE between 60s (mean = 7.067; SD = 0.258), 90s (mean = 7.133; SD = 0.516) and 120s (mean = 6.933; SD = 0.258), $p > 0.05$ in set 1. In set 2, there was no significant difference on RPE between 60s (mean 8.267; SD = 0.458) and 90s (mean = 7.867; SD = 0.352), $p > 0.05$, and significant difference when compared with 120s (mean = 7.200; SD = 0.414), $p < 0.05$. In set 3, result showed there was no significant difference on RPE between 60s (mean = 9.133; SD = 0.516) and 90s (mean = 8.733; SD = 0.458), $p > 0.05$, and significant difference when compared with 120s (mean = 8.133; SD = 0.352), $p < .05$.

Profile plots also showed that RPE was lower during bent over row with 120 seconds in set 2 and 3 compared to 90 seconds and 60 seconds rest interval.

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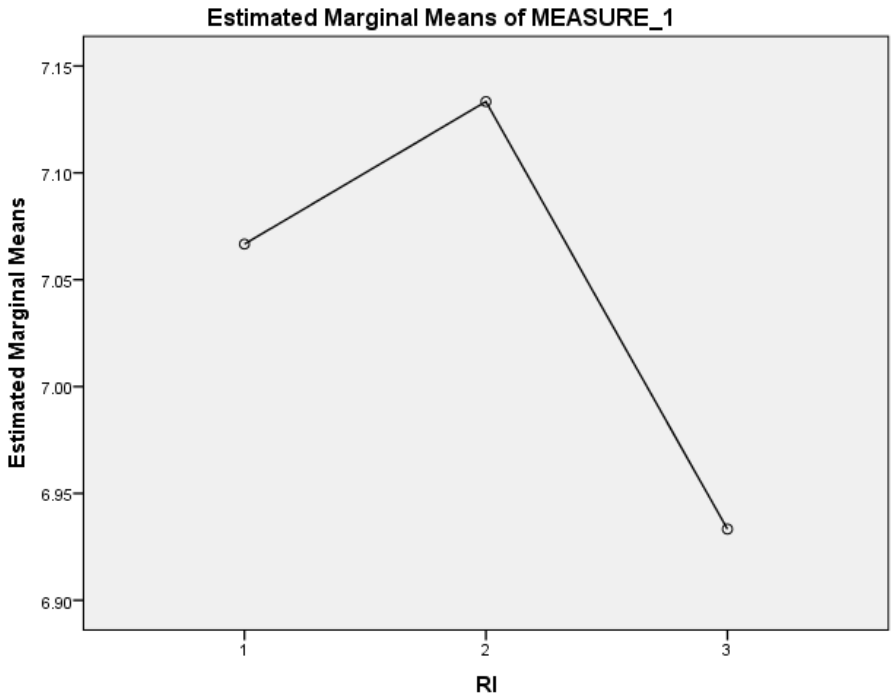


Figure 4.22. Profile Plots RPE during Bent over Row with Different Rest Intervals in Set 1

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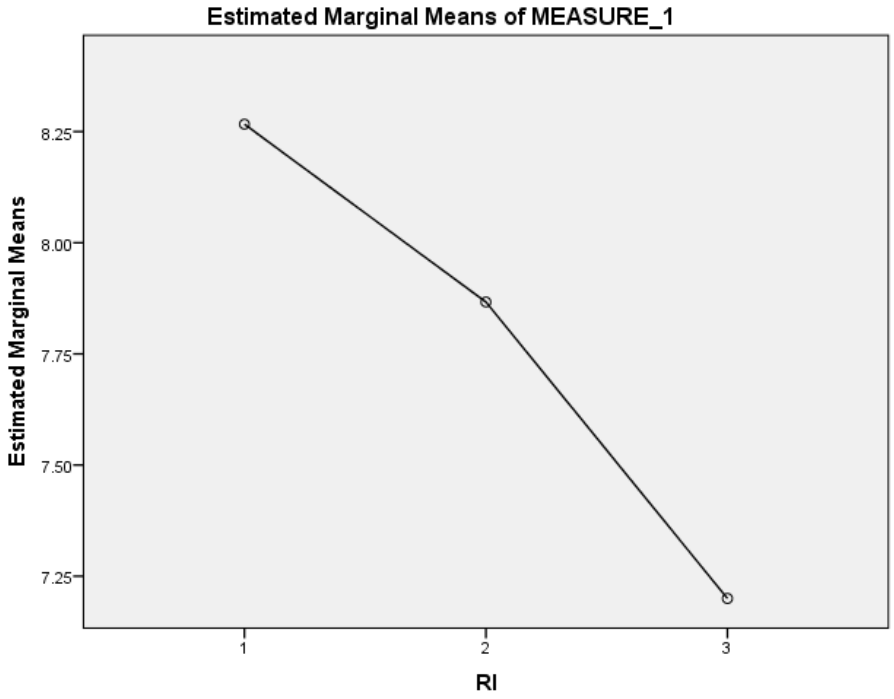


Figure 4.23. Profile Plots RPE during Bent over Row with Different Rest Intervals in Set 2

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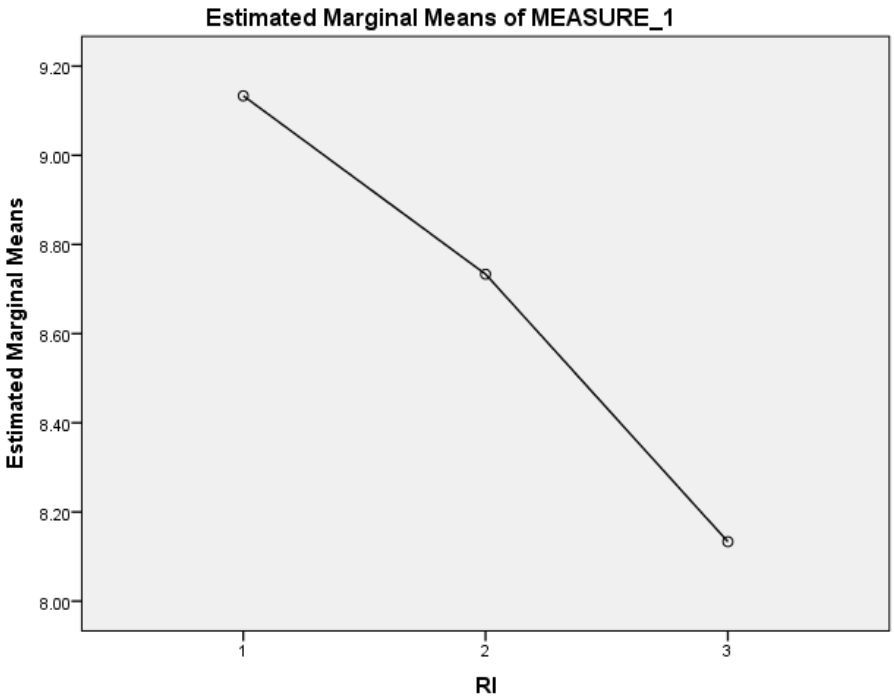


Figure 4.24. Profile Plots RPE during Bent over Row with Different Rest Intervals in Set 3

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4.7 The Result of Different Rest Interval on Heart Rate during Bent over Row Exercise

Table 4.6

Heart Rate during Bent over Row Exercise with Different Rest Intervals

Time(s)/Set	Set 1	Set 2	Set 3
60	121.333±2.469	142.200±10.073	152.133±6.770
90	122.667±3.677	134.667±9.700	143.933±5.982
120	123.000±4.914	126.933±3.654	135.733±11405

The results of the one way repeated-measures ANOVA showed that there was significant difference between sets (Set1, Set2 and Set 3) on the heart rate during bent over row with 60 seconds rest interval [$F(2,28) = 82.921$, $p < 0.05$], 90 seconds [$F(2,28) = 30.095$, $p < .05$] and 120 seconds [$F(1.338,18.735) = 11.111$, $p < 0.05$] .

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Bonferroni post hoc tests showed that heart rate was significantly increase from set 1 (mean = 121.333; SD = 2.469) to set 2 (mean = 142.200; SD = 10.073), $p < 0.05$ and continues to increase in set 3 (mean = 152.133; SD = 6.770), $p < 0.05$ during bent over row with 60 seconds. Bent over row with 90 seconds also get same result that heart rate significantly increase from set 1 (mean = 122.667, SD = 3.677) to set 2 (mean = 134.667; SD = 9.700), $p < 0.05$ and continues to increase in set 3 (mean = 143.933; SD = 5.982), $p < 0.05$. However, it was contrast with 120 rest interval that there was no significantly difference on heart rate between set 1 (mean = 123.000, SD = 4.914) and set 2 (mean = 126.933; SD = 3.654), $p > 0.05$ and started to increase in set 3 (mean = 135.733; SD = 11.405), $p < 0.05$.

Beside that, profile plots clearly showed that heart rate during bent over row with 60 seconds and 90 seconds were increased from set 1 to set 2 and continues increase in set 3. However, it was contrasts with 120 seconds rest interval that heart rate does not increase during exercise until set 2. Thus, this evidence has rejected the null hypothesis that there was no significant difference between RPE levels during bent over row with different rest intervals.

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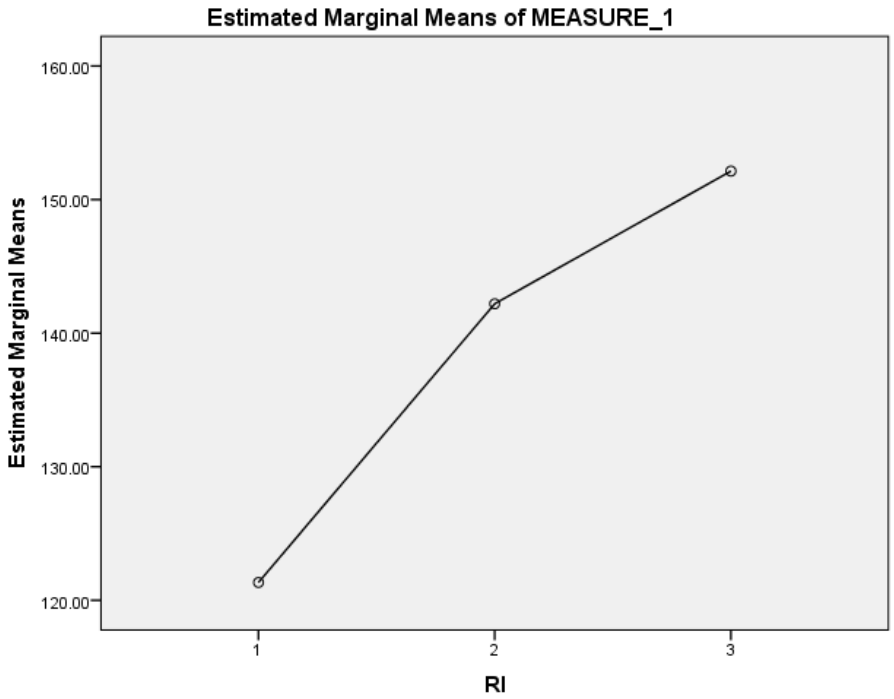


Figure 4.25. Profile Plots Rating of Heart Rate during Bent over Row with 60 seconds Rest Interval

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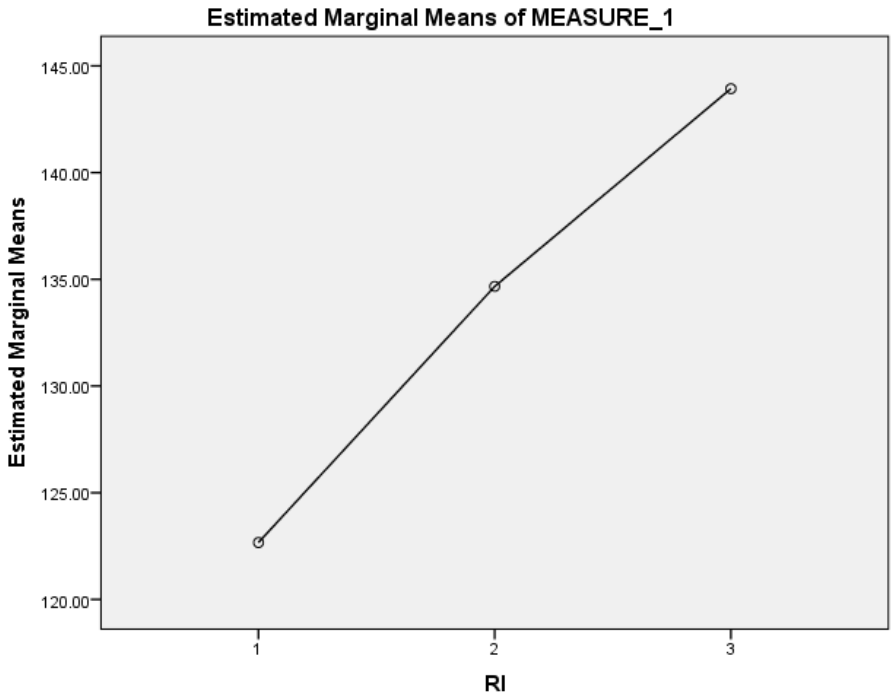


Figure 4.26. Profile Plots Rating of Heart Rate during Bent over Row with 90 seconds Rest Interval

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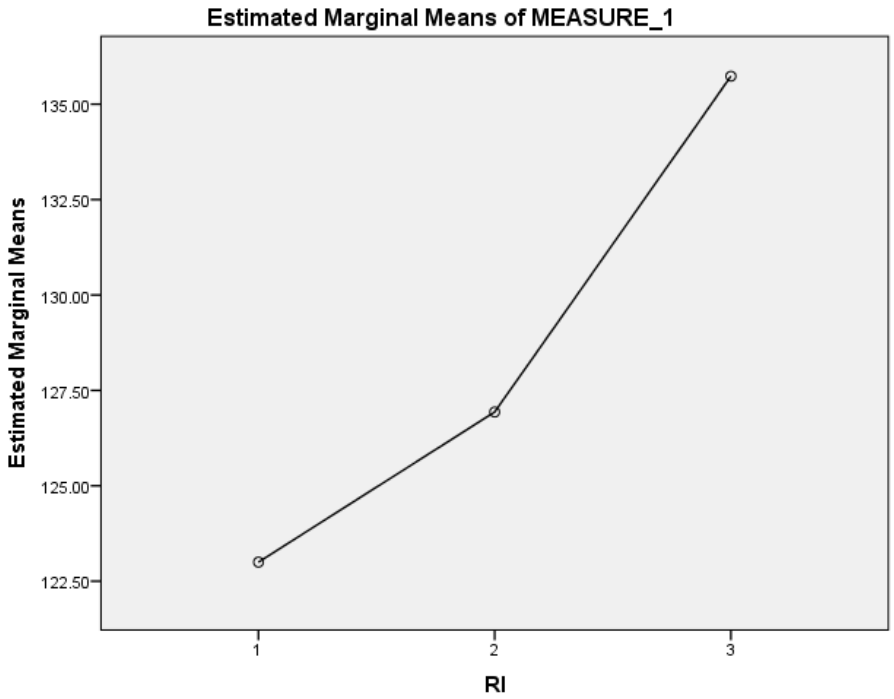


Figure 4.27. Profile Plots Rating of Heart Rate during Bent over Row with 120 seconds Rest Interval

One way repeated-measures ANOVA was used to identify the effect of different rest intervals on heart rate every sets. The result showed that there was no significant difference on RPE between rest intervals (60s, 90s and 120s) during bent over row in set 1 [$F(2,28) = 1.256$, $p > 0.05$]. However, there was significant different in set 2 [$F(2,28) = 13.350$, $p < 0.05$] and set 3 [$F(2,28) = 20.532$, $p < 0.05$].

Bonferroni post hoc tests showed that there was no significantly difference on heart rate between 60s (mean = 121.333; SD = 2.469), 90s (mean = 122.667; SD = 3.678) and 120s (mean = 123.000; SD = 4.914), $p > 0.05$ in set 1. In set 2, there was no significant difference on RPE between 60s (mean 142.200; SD = 10.073) and 90s (mean = 134.667; SD = 9.700), $p > 0.05$, and significant difference when compared with 120s (mean = 126.933; SD = 3.654), $p < 0.05$. In set 3, result showed there was significant difference on heart rate between 60s (mean = 152.133; SD = 6.770) and 90s (mean =

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143.933; SD = 5.982), $p < 0.05$, and significant difference when compared with 120s (mean = 135.733; SD = 11.405), $p < .05$.

Profile plots also showed that heart rate was lower during bent over row with 120 seconds in set 2 and 3 compared to 90 seconds and 60 seconds rest interval.

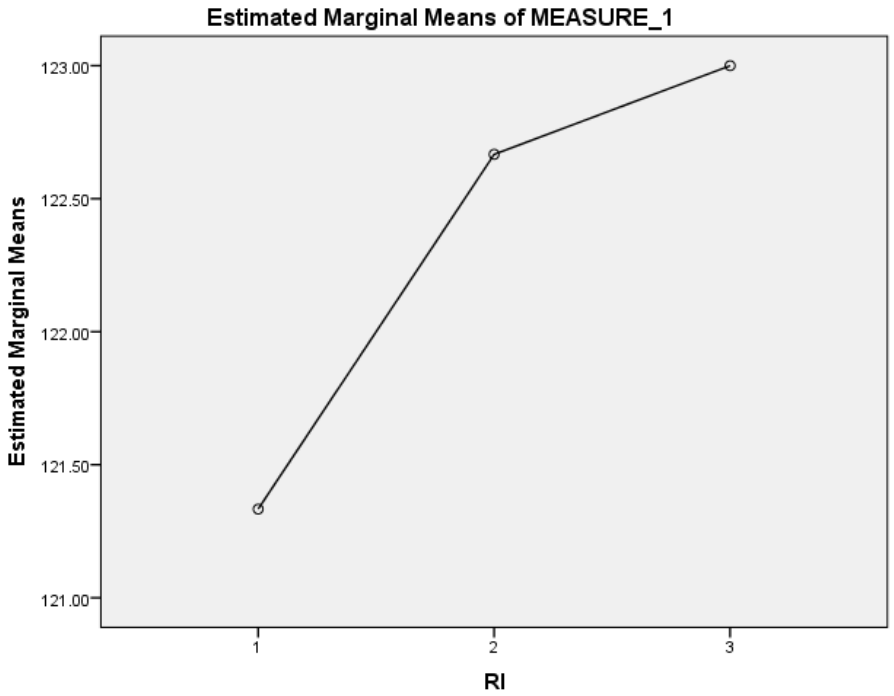


Figure 4.28. Profile Plots heart rate during Bent over Row with Different Rest Intervals in Set 1

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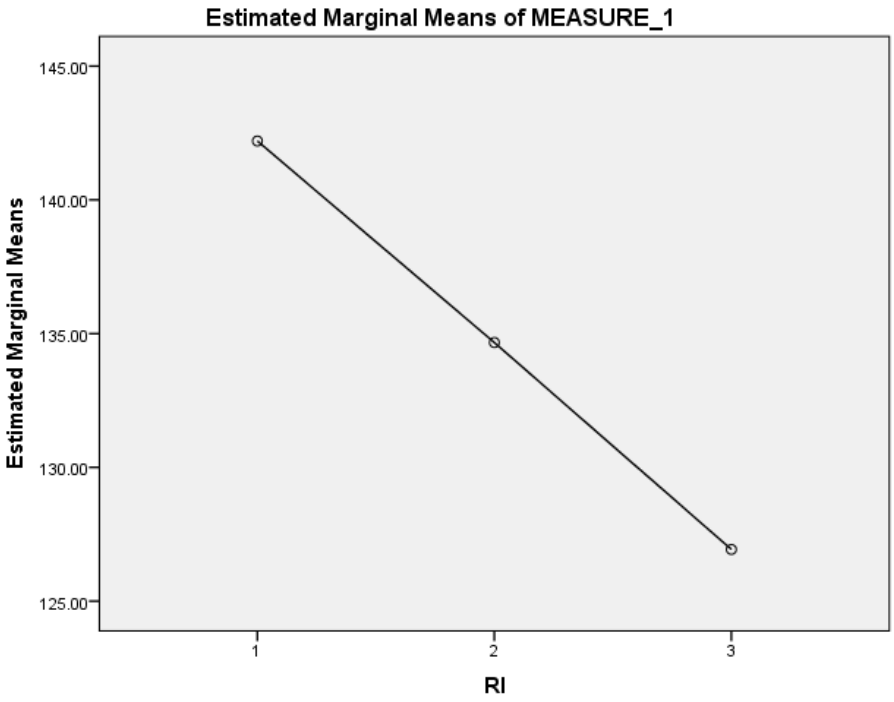


Figure 4.29. Profile Plots heart rate during Bent over Row with Different Rest Intervals in Set 2

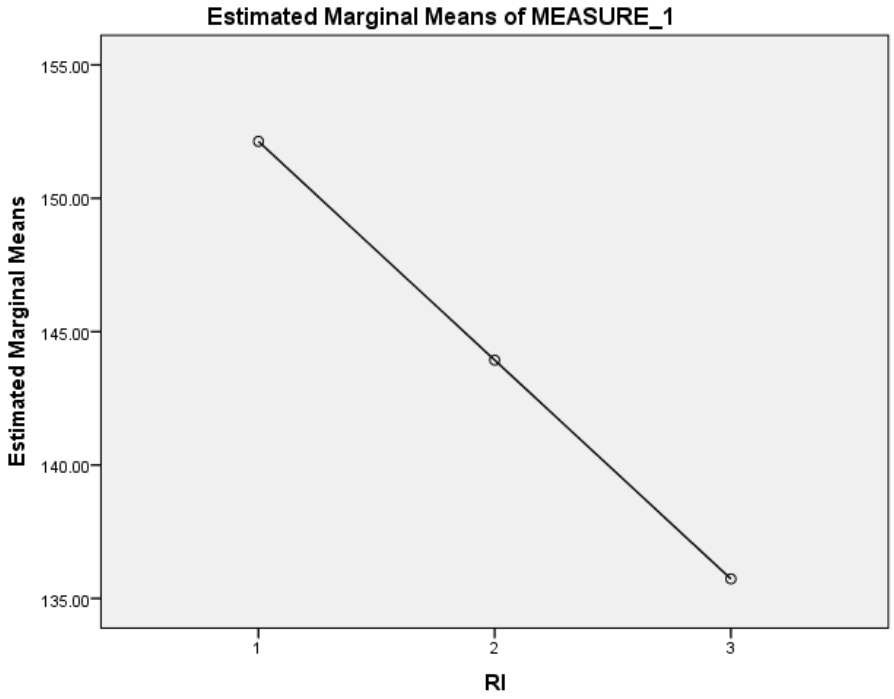


Figure 4.30. Profile Plots heart rate during Bent over Row with Different Rest Intervals in Set 3

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4.8 The Result of Different Rest Intervals on Number of Repetitions during Biceps Exercise

Table 4.7

Number of Repetitions during Biceps Curl Exercise with Different Rest Intervals

Time(s)/Set	Set 1	Set 2	Set 3
60	9.867±0.352	8.067±0.704	5.867±1.060
90	9.733±0.458	9.400±0.737	7.267±0.704
120	9.800±0.414	9.600±0.737	8.867±0.516

The results of the one way repeated-measures ANOVA showed that there was significant difference between sets (Set1, Set2 and Set 3) on the number of repetitions during bent over row with 60, 90 and 120 seconds rest interval [$F(2,28) = 203.903$, $p < 0.05$], [$F(2,28) = 134.333$, $p < 0.05$] and [$F(1.363,19.075) = 29.636$, $p < 0.05$].

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Bonferroni post hoc tests showed that number of repetitions for biceps curl with 60 seconds rest interval was significantly decrease from set 1 (mean = 9.867; SD = 0.352) to set 2 (mean = 8.067; SD = 0.704), $p < 0.05$ and continues to decrease on set 3 (mean = 5.867; SD = 1.060), $p < 0.05$. However, biceps curl with 90 seconds showed different result that number of repetitions no significantly decrease from set 1 (mean = 9.733; SD = 0.458) to set 2 (mean= 9.400; SD= 0.737), $p > 0.05$ and started to decrease in set 3 (mean= 7.267; SD= 0.704), $p < 0.05$. Biceps curl with 120 rest interval also get the same result that there was no significantly difference on number of repetitions between set 1 (mean= 9.800; SD= 0.414) and set 2 (mean = 9.600; SD = 0.737), $p > 0.05$ and started to decrease in set 3 (mean= 8.867; SD= 0.516), $p < 0.05$.

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Beside that, profile plots clearly showed biceps curl with 60 seconds rest interval showed that the number of repetitions was decrease from set 1 to set 2 and continues decrease on set 3. However, it was contrast for 90 seconds and 120 seconds rest interval. Thus, this evidence has rejected the null hypothesis that there was no significant difference between numbers of repetitions during biceps curl with 60, 90 and 120 seconds rest interval.

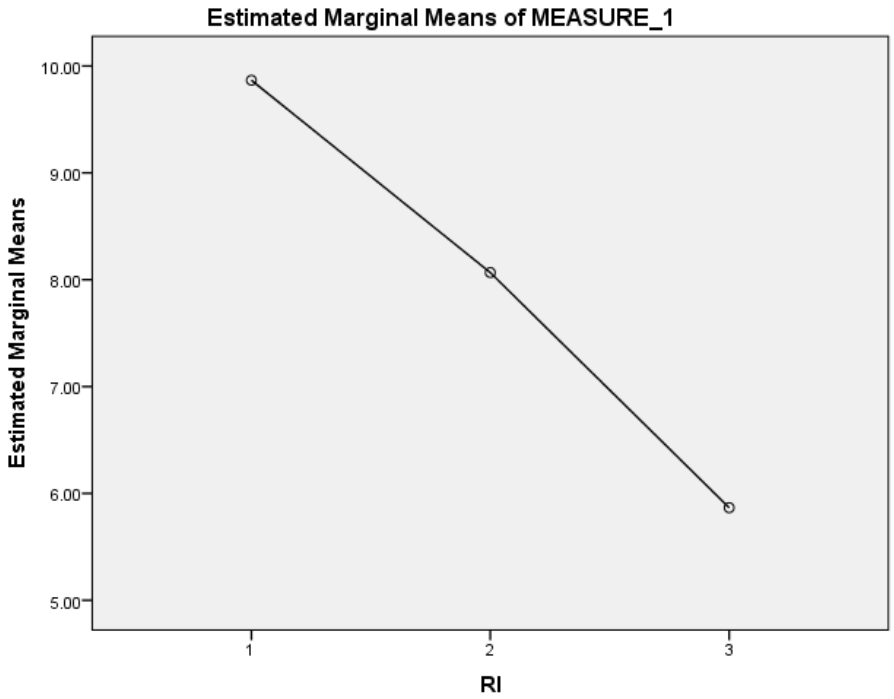


Figure 4.31. Profile Plots Number of Repetitions during Biceps Curl with 60 seconds

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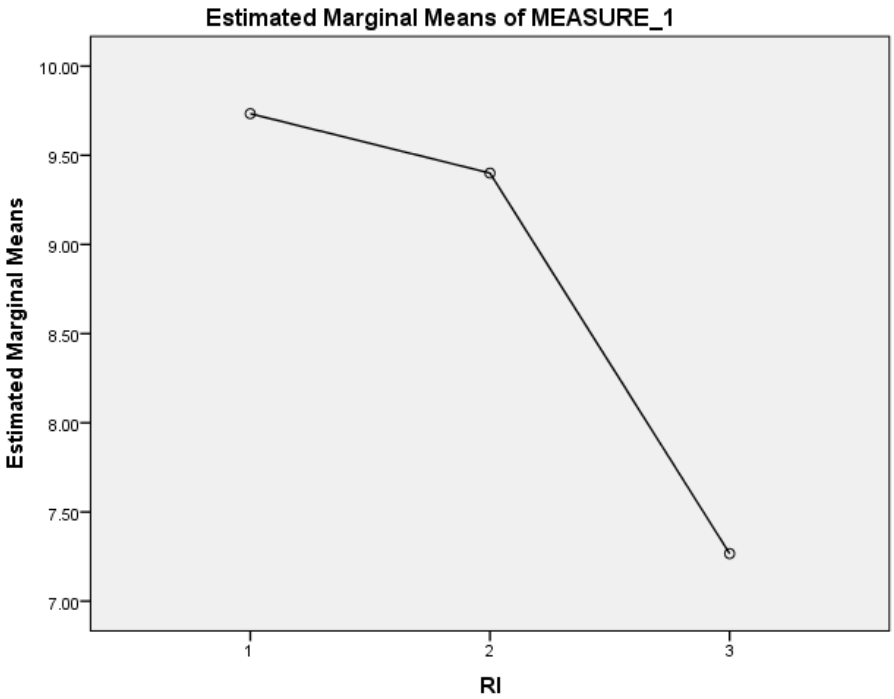


Figure 4.32. Profile Plots Number of Repetitions during Biceps Curl with 90 seconds

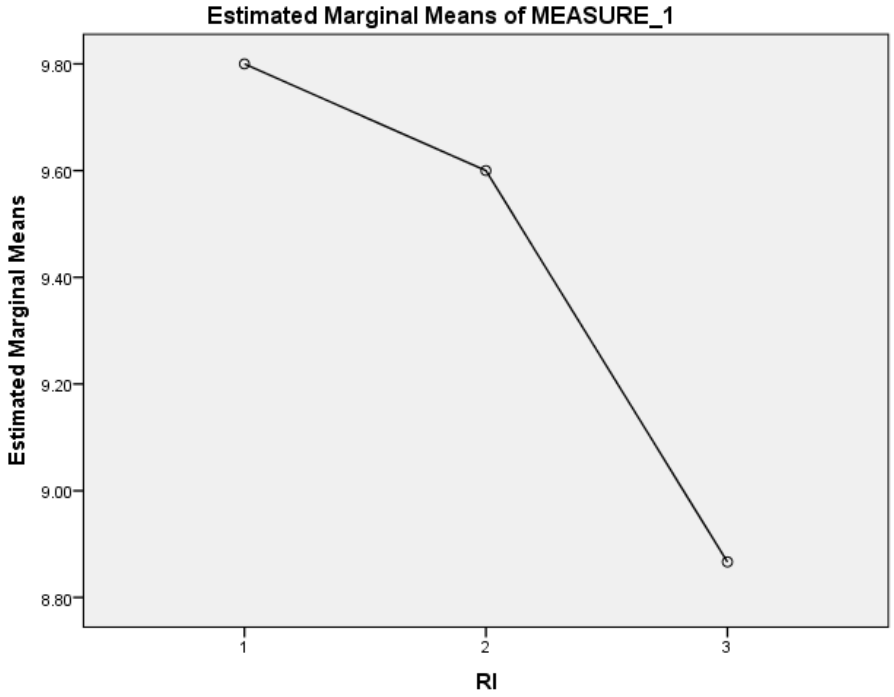


Figure 4.33. Profile Plots Number of Repetitions during Biceps Curl with 120 seconds

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One way repeated-measures ANOVA was used to compare number of repetitions during biceps curl with different rest intervals in set 1, 2 and 3. The result showed that there was no significant difference on number of repetitions in set 1 [$F(2,28) = 0.583$, $p > 0.05$ between rest intervals (60 seconds, 90 seconds and 120 seconds). However, in set 2, there was significant difference [$F(2,28) = 23.367$, $p < 0.05$] and followed by set 3 [$F(2,28) = 60.153$, $p < 0.05$].

Bonferroni post hoc tests showed that there was no significantly difference on number of repetitions between 60 seconds (mean = 9.867; SD = 0.352), 90 seconds (mean = 9.733; SD = 0.458) and 120 seconds (mean = 9.800; SD = 0.414), $p > .05$ in set 1. In set 2, there was significant difference on number of repetitions between 60s (mean = 8.067; SD = 0.704) and 90s (mean = 9.400; SD = 0.737), $p < 0.05$ and 120s (mean = 9.600; SD = 0.737), $p < 0.05$. The result showed there was no significantly difference between 90s and 120s, $p < 0.05$. In set 3, result showed that there was significant difference on number of repetitions between 60 seconds (mean= 5.867; SD= 1.060), 90 seconds (mean = 7.267; SD = 0.704), $p < .05$, and 120 seconds (mean = 8.867; SD = 0.516), $p < 0.05$. The result also showed there was significantly difference between 90 seconds and 120 seconds, $p < 0.05$.

Profile plots also showed that the number of repetitions was no significant difference between 60s, 90s and 120s in set 1. In set 2 and 3, exercise with 90 seconds and 120 seconds rest interval produced higher number of repetitions during biceps curl than 60 seconds rest interval.

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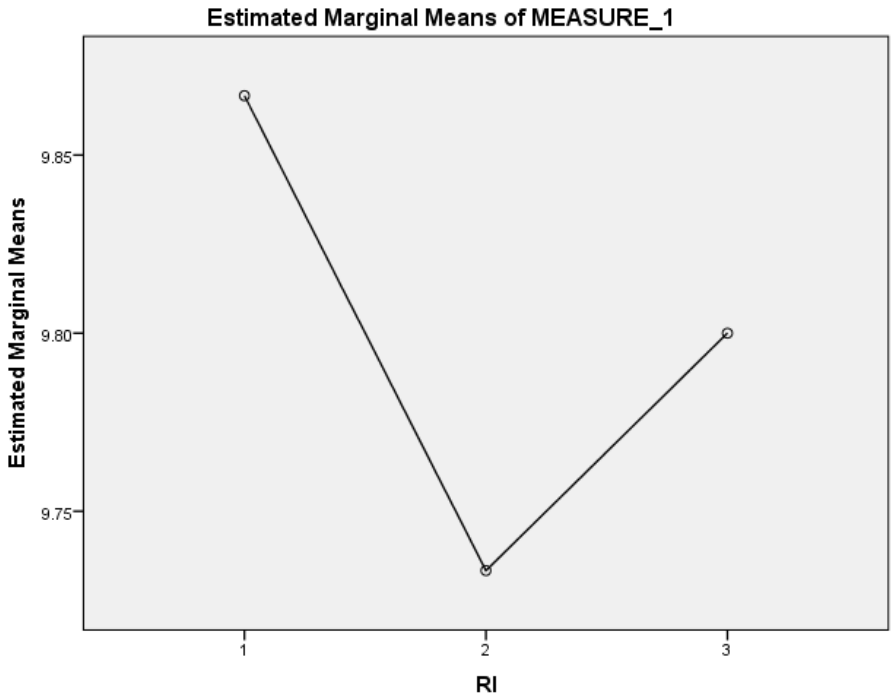


Figure 4.34. Profile Plots Number of Repetitions during Biceps Curl with Different Rest Intervals on Set 1

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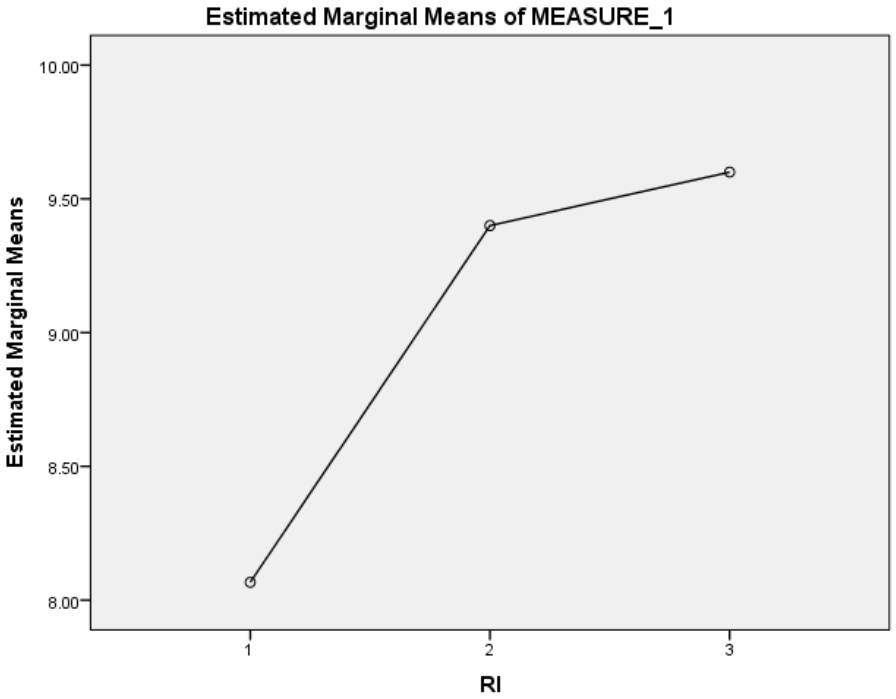


Figure 4.35. Profile Plots Number of Repetitions during Biceps Curl with Different Rest Intervals on Set 2

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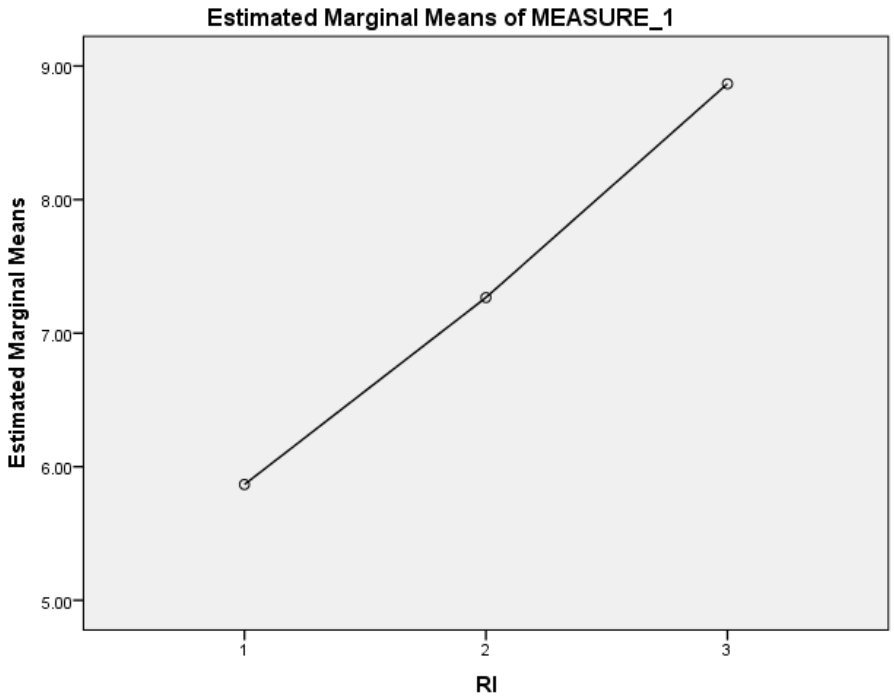


Figure 4.36. Profile Plots Number of Repetitions during Biceps Curl with Different Rest Intervals on Set 3

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4.9 The Result of Different Rest Intervals on Muscle Activation of Biceps Brachii during Biceps Curl Exercise

Table 4.8

Muscle Activation of Biceps Brachii during Biceps Curl Exercise with Different Rest Intervals

Time(s)/Set	Set 1	Set 2	Set 3
60	71.139±10.327	60.574±8.749	43.146±18.953
90	73.458±8.892	70.480±7.442	55.480±10.366
120	75.977±11.007	73.603±8.062	67.477±5.301

The results of the one way repeated-measures ANOVA showed that there was significant difference between sets (Set1, Set2 and Set 3) on the muscle activation during biceps curl with 60 seconds [$F(2,28) = 32.452$, $p < 0.05$], 90 seconds [$F(1.243,17.396) = 33.739$, $p < 0.05$] and 120 seconds rest interval [$F(1.436,20.104) = 17.772$, $p < 0.05$].

Bonferroni post hoc tests showed that muscle activation was significantly decrease from set 1 (mean = 71.139; SD = 10.327) to set 2 (mean = 60.574; SD = 8.749), $p < 0.05$ and continues to decrease on set 3 (mean = 43.1460; SD = 18.953), $p < 0.05$ during biceps curl with 60 seconds. Result of biceps curl with 90 seconds showed that no significantly decrease on muscle activation from set 1 (mean = 73.458; SD = 8.892) to set 2 (mean = 70.480; SD = 7.442), $p > 0.05$ and started to decrease in set 3 (mean = 55.561; SD = 10.366), $p < 0.05$. Biceps curl with 120 rest interval also showed that there was no significantly difference on muscle activation between set 1 (mean= 75.977; SD= 11.007) and set 2 (mean = 73.603; SD = 8.062), $p > 0.05$ and started significantly decrease on set 3 (mean= 64.477; SD= 5.301), $p < 0.05$.

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Besides, profile plots clearly showed that muscle activation of biceps brachii was decrease from set 1 to set 2 and continues decrease in set 3 during biceps curl with 60 seconds. However, it was contrasts with 90 seconds and 120 seconds rest interval that no reduction of muscle activation during exercise until set 2. Thus, this evidence has rejected the null hypothesis that there was no significant difference between on muscle activation of biceps brachii during biceps curl with 60, 90 and 120 seconds rest interval.

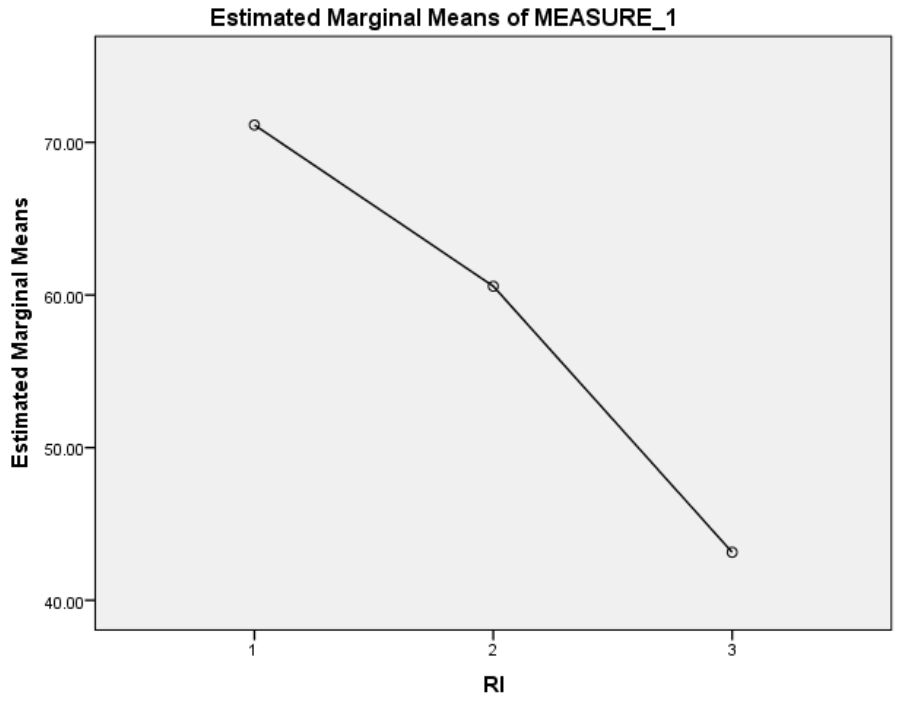


Figure 4.37. Profile Plots Muscle Activation of Biceps Brachii during Biceps Curl with 60 seconds Rest Interval

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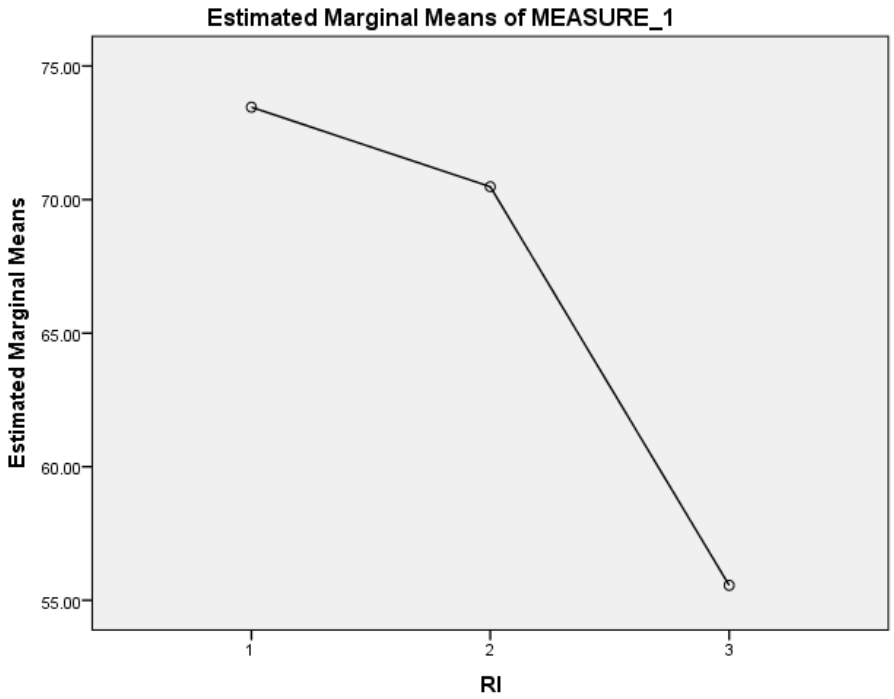


Figure 4.38. Profile Plots Muscle Activation of Biceps Brachii during Biceps Curl with 90 seconds Rest Interval

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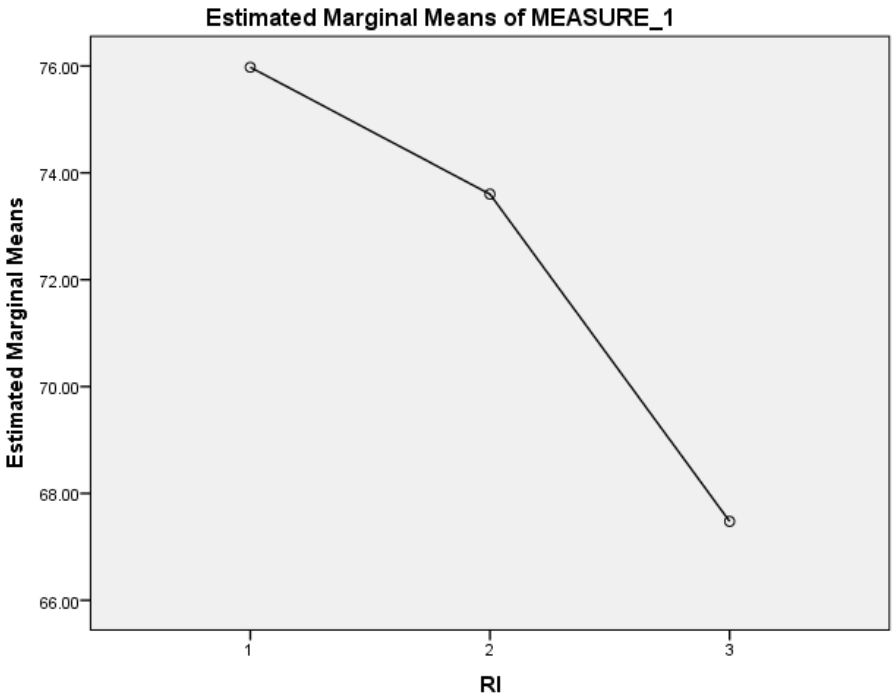


Figure 4.39. Profile Plots Muscle Activation of Biceps Brachii during Biceps Curl with 120 seconds Rest Interval

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One way repeated-measures ANOVA was used to compare muscle activation of biceps brachii during biceps curl with different rest intervals in set 1, 2 and 3.The results showed that there was no significant difference on muscle activation of biceps brachii between rest intervals (60s, 90s and 120s) during biceps curl in set 1 [$F(2,28) = 0.892$, $p > 0.05$]. However, the result test in set 2 [$F(2,28) = 11.020$, $p < 0.05$] and 3 [$F(1.389,143.026) = 22.350$, $p < 0.05$] showed significant difference.

Bonferroni post hoc tests showed that there was no significantly difference on muscle activation between 60 seconds (mean = 71.139; SD = 10.3268), 90 seconds (mean = 73.458; SD = 8.892) and 120 seconds (mean = 75.977; SD = 8.436), $p > 0.05$ in set 1. In set 2, bent over row with 90 seconds (mean = 70.480; SD = 7.442) was no significantly different with 120 seconds (mean = 73.603; SD = 8.062) and significantly higher than 60 seconds (mean = 60.574; SD = 8.749), $p < 0.05$. The result also showed rest interval with 120 seconds (mean = 67.477; SD = 5.301) significantly higher than 90 seconds (mean = 55.477; SD = 10.366) and 60 seconds (mean = 43.146; SD = 18.953), $p< 0.05$ in set 3.

Profile plots also showed that biceps brachii muscle was more activated during biceps curl with 90 seconds and 120 seconds in set 2. However, rest interval with 120 seconds produced more muscle activation than 60 seconds and 90 seconds rest interval.

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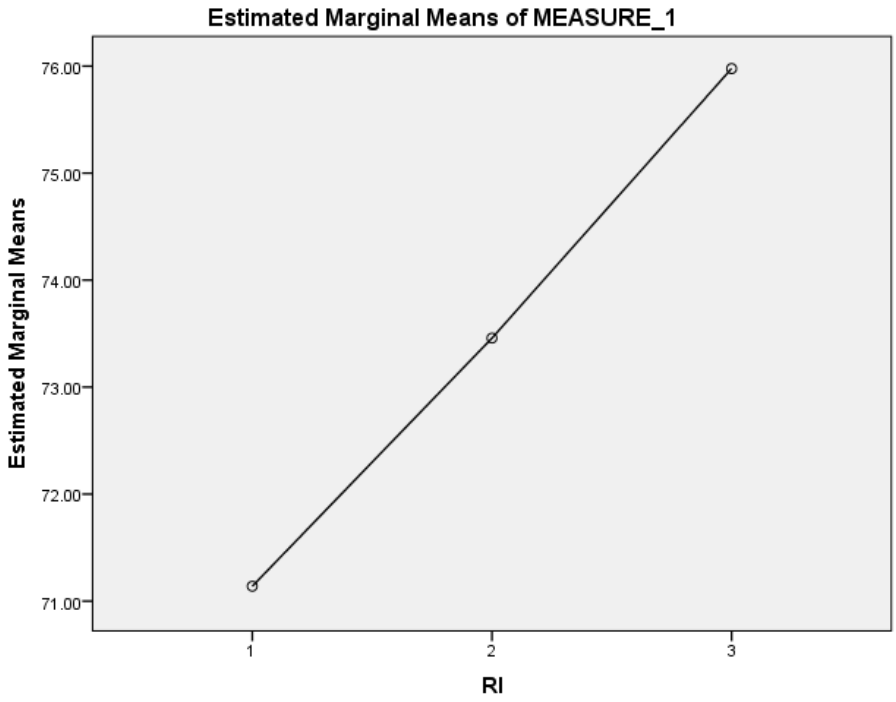


Figure 4.40. Profile Plots Muscle Activation of Biceps Brachii during Biceps Curl with Different Rest Intervals on Set 1

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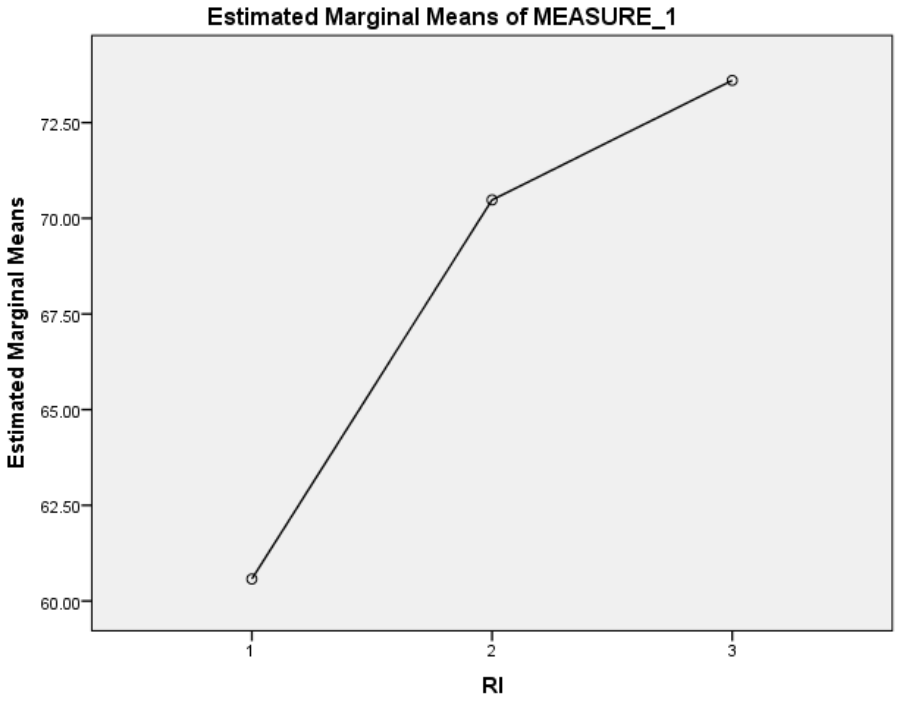


Figure 4.41. Profile Plots Muscle Activation of Biceps Brachii during Biceps Curl with Different Rest Intervals in Set 2

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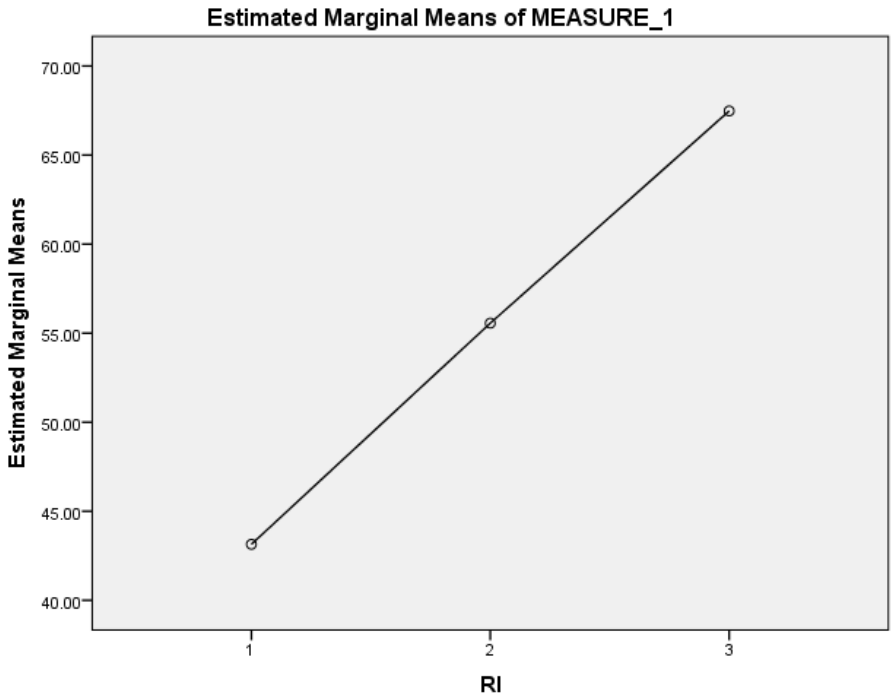


Figure 4.42. Profile Plots Muscle Activation of Biceps Brachii during Biceps Curl with Different Rest Intervals on Set 3

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4.10 The Result of Different Rest Interval on Rating Perceive Exertion (RPE) during Biceps Curl

Table 4.9

Rating Perceive Exertion (RPE) during Biceps Curl Exercise with Different Rest Intervals

Time(s)/Set	Set 1	Set 2	Set 3
60	7.067±0.258	7.933±0.258	9.267±0.594
90	7.067±0.258	7.333±0.488	8.067±0.258
120	6.867±0.352	7.133±0.352	7.600±0.632

The results of the one way repeated-measures ANOVA showed that there was significant difference between sets (Set1, Set2 and Set 3) on RPE during biceps curl with 60 seconds rest interval [$F(1.378,19.920) = 100.052$, $p < 0.05$], 90 seconds [$F(2,28) = 42.949$, $p < .05$] and 120 seconds [$F(2,28) = 11.128$, $p < 0.05$] .

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Bonferroni post hoc tests showed that RPE was significantly increase from set 1 (mean = 7.067; SD = 0.258) to set 2 (mean = 7.933; SD = 0.258), $p < 0.05$ and continues to increase in set 3 (mean = 9.267; SD = 0.594), $p < 0.05$ during biceps curl with 60 seconds. Bent over row with 90 seconds showed there was no significantly different on RPE between set 1 (mean = 7.067, SD = 0.258) and set 2 (mean = 7.333; SD = 0.488), $p > 0.05$ and started increase in set 3 (mean = 8.067; SD = 0.258), $p < 0.05$. Biceps curl with 120 rest interval also showed that there was no significantly difference on RPE between set 1 (mean = 6.867, SD = 0.352) and set 2 (mean = 7.133; SD = 0.352), $p > 0.05$ and started increase in set 3 (mean = 7.600; SD = 0.632), $p < 0.05$.

Beside that, profile plots clearly showed that RPE level during bent over row with 60 seconds was increased from set 1 to set 2 and continues increase in set 3. However, it was contrasts with 90 seconds and 120 seconds rest interval, RPE level does not to increase during exercise until set 2. Thus, this evidence has rejected the null hypothesis that there was no significant difference between RPE levels during biceps curl with different rest intervals.

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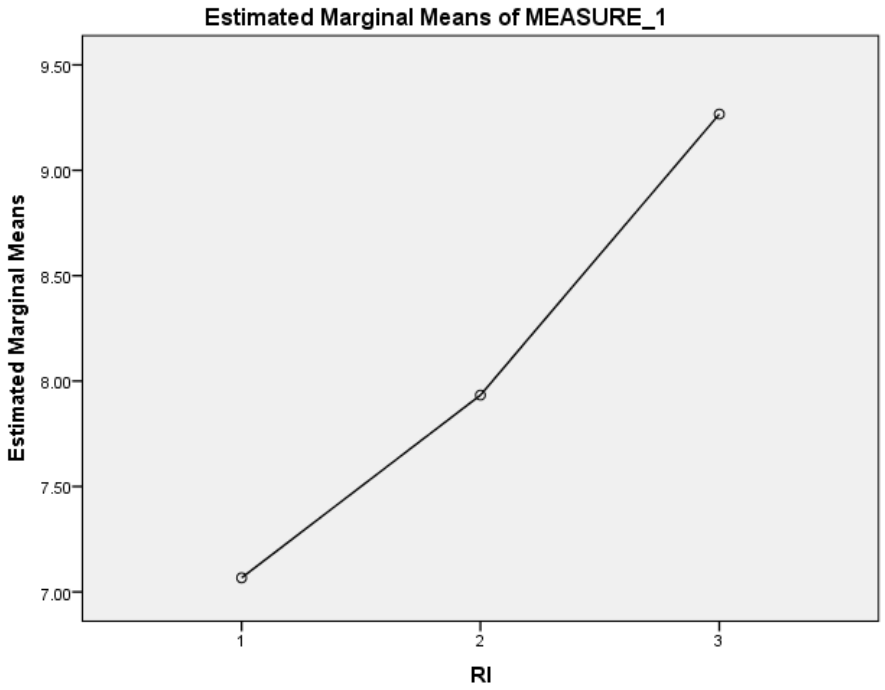


Figure 4.43. Profile Plots Rating of Perceive Exertion (RPE) during Biceps Curl with 60 seconds Rest Interval

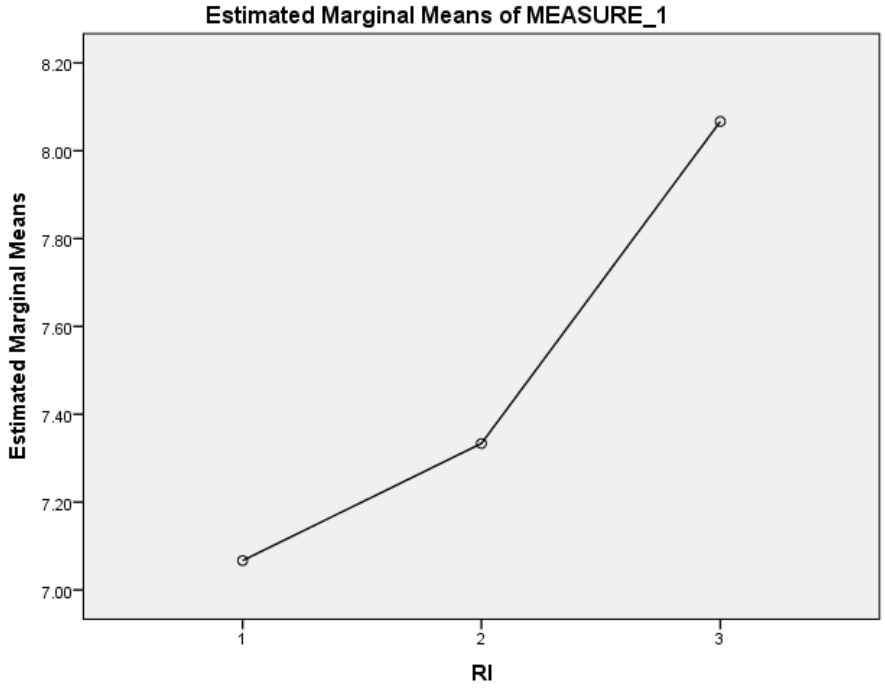


Figure 4.44. Profile Plots Rating of Perceive Exertion (RPE) during Biceps Curl with 90 seconds Rest Interval

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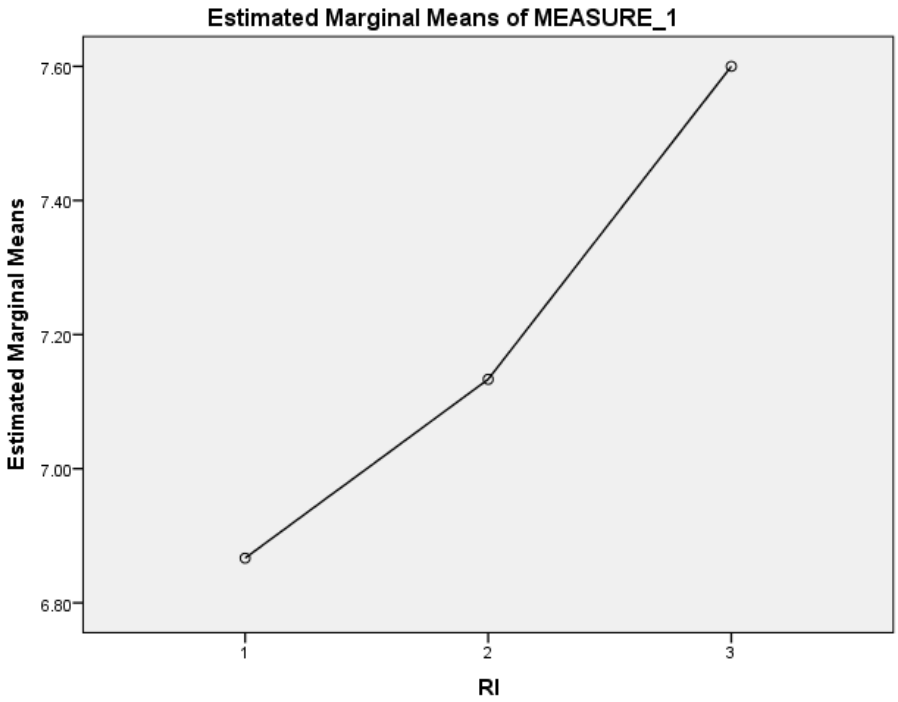


Figure 4.45. Profile Plots Rating of Perceive Exertion (RPE) during Biceps Curl with 120 seconds Rest Interval

One way repeated-measures ANOVA was used to identify the effect of different rest intervals on RPE at every each sets. The result showed that there was no significant difference on RPE between rest intervals (60s, 90s and 120s) during biceps curl in set 1 [$F(2,28) = 1.909$, $p > 0.05$]. However, there was significant different in set 2 [$F(2,28) = 21.000$, $p < 0.05$] and set 3 [$F(2,28) = 36.576$, $p < 0.05$].

Bonferroni post hoc tests showed that there was no significantly difference on RPE between 60s (mean = 7.067; SD = 0.258), 90s (mean = 7.067; SD = 0.258) and 120s (mean = 6.867; SD = 0.352), $p > 0.05$ in set 1. In set 2, there was no significant difference on RPE value during biceps curl with 90 seconds (mean = 7.333; SD = 0.489) and 120 seconds (mean = 7.133; SD = 0.352) were significant lower than 60 seconds (mean 7.933; SD = 0.258). However, result showed that RPE value with 120 seconds

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(mean = 7.600; SD = 0.632) rest interval produced significantly lower than 60s (mean = 9.267; SD = 0.594) and 90s (mean = 8.067; SD = 0.258), $p < 0.05$ in set 3.

Profile plots also showed that RPE was lower during biceps curl with 90 seconds and 120 seconds in set 2. However, rest interval with 120 seconds produced the lowest RPE value in set 3.

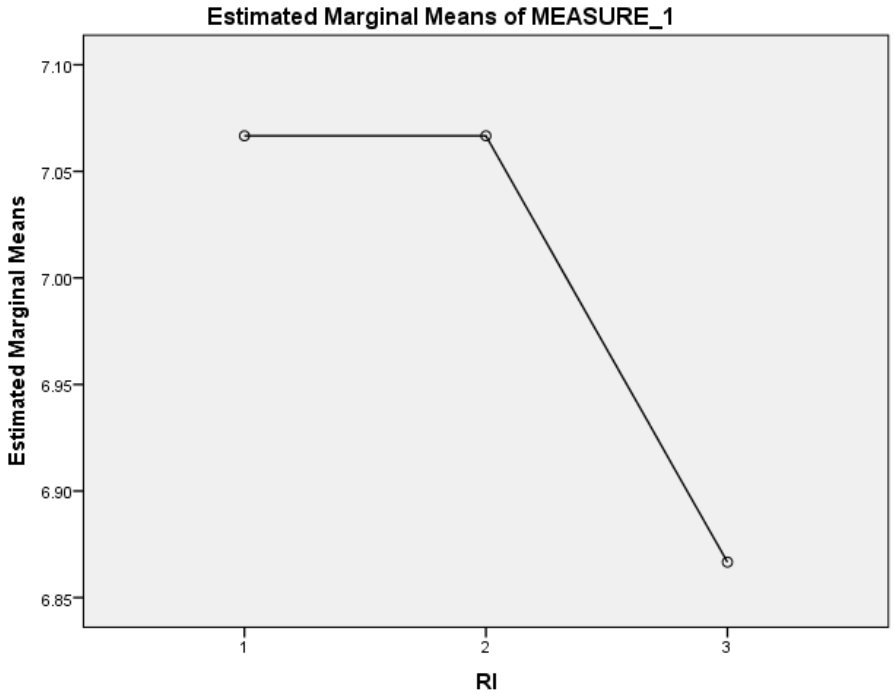


Figure 4.46. Profile Plots RPE during Biceps Curl with Different Rest Intervals in Set 1

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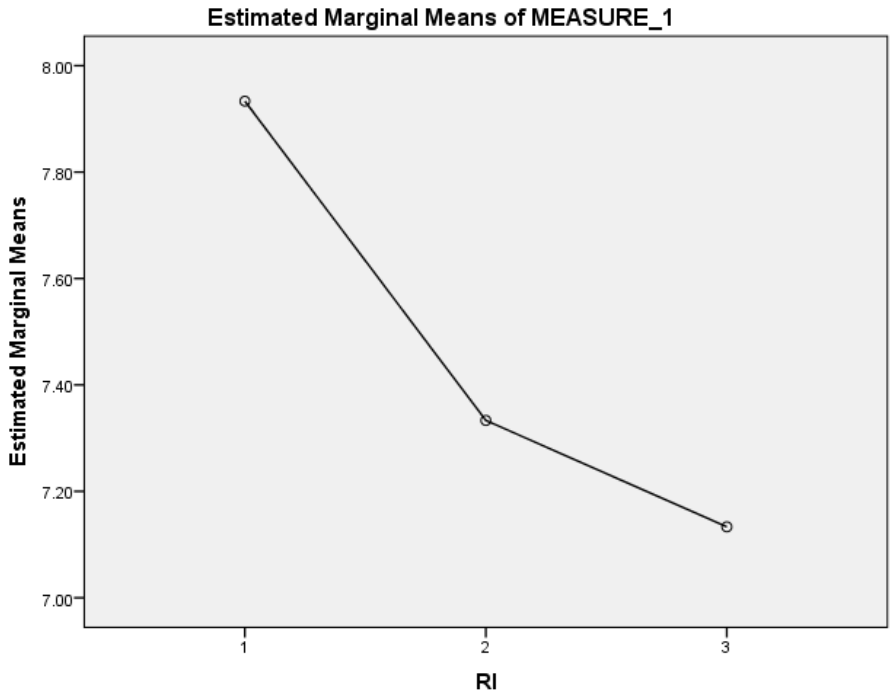


Figure 4.47. Profile Plots RPE during Biceps Curl with Different Rest Intervals in Set 2

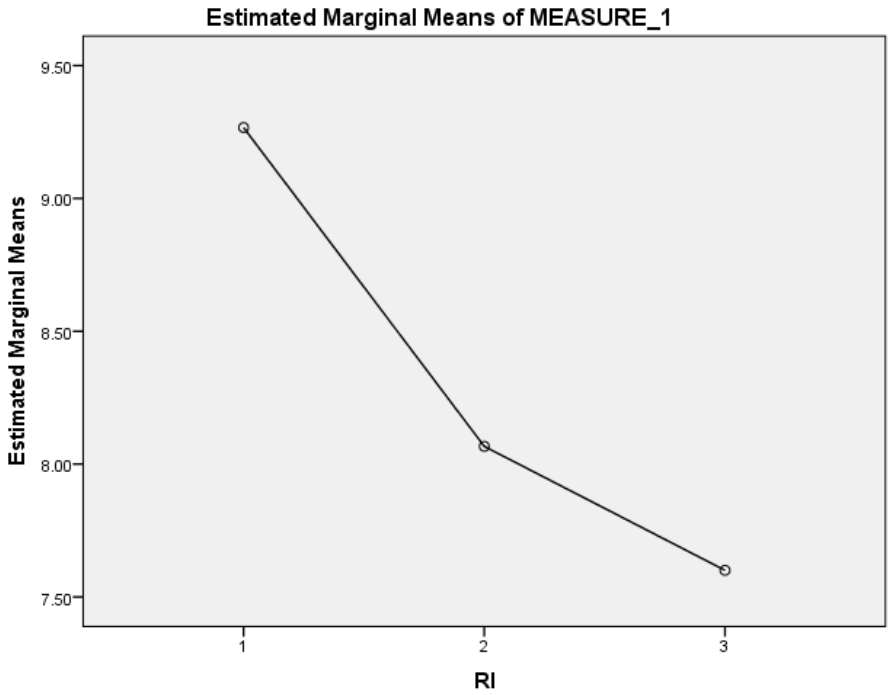


Figure 4.48. Profile Plots RPE during Biceps Curl with Different Rest Intervals in Set 3

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4.11 The Result of Different Rest Interval on Heart Rate during Biceps Curl Exercise

Table 4.10

Heart Rate during Biceps Curl Exercise with Different Rest Intervals

Time(s)/Set	Set 1	Set 2	Set 3
60	125.067±4.008	132.467±5.027	148.800±8.587
90	121.933±2.052	123.067±2.738	135.200±5.199
120	122.133±2.825	124.333±3.331	133.067±5.650

The results of the one way repeated-measures ANOVA showed that there was significant difference between sets (Set1, Set2 and Set 3) on the heart rate during biceps brachii with 60 seconds rest interval [$F(1.444,20.219) = 64.790$, $p < 0.05$], 90 seconds [$F(1.154,16.158) = 85.140$, $p < .05$] and 120 seconds [$F(1.411,19.759) = 39.296$, $p < 0.05$] .

Bonferroni post hoc tests showed that heart rate was significantly increase from set 1 (mean = 125.067; SD = 4.008) to set 2 (mean = 132.467; SD = 5.027), $p < 0.05$ and continues increase in set 3 (mean = 148.800; SD = 8.587), $p < 0.05$ during biceps curl with 60 seconds. Biceps curl with 90 seconds showed there was no significantly different on heart rate between set 1 (mean = 121.933, SD = 2.052) and set 2 (mean = 123.067; SD = 2.738), $p > 0.05$ and started increase in set 3 (mean = 135.200; SD = 5.199), $p < 0.05$. Biceps curl with 120 rest interval also showed that there was no significantly difference on heart rate between set 1 (mean = 122.133, SD = 2.825) and set 2 (mean = 124.333; SD = 3.331), $p > 0.05$ and started increase in set 3 (mean = 133.067; SD = 5.650), $p < 0.05$.

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Beside that, profile plots clearly showed that heart rate during biceps curl with 60 seconds was increased from set 1 to set 2 and continues increase in set 3. However, it was contrasts with 90 seconds and 120 seconds rest interval, heart rate does not to increase during exercise until set 2. Thus, this evidence has rejected the null hypothesis that there was no significant difference between heart rate levels during biceps curl with different rest intervals.

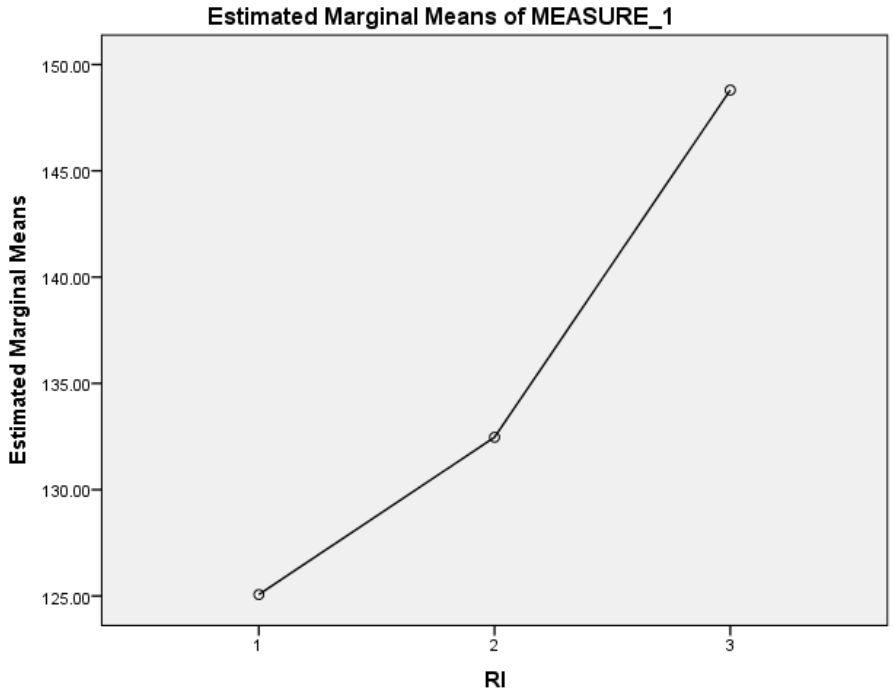


Figure 4.49. Profile Plots Rating of Heart Rate during Bent Curl with 60 seconds Rest Interval

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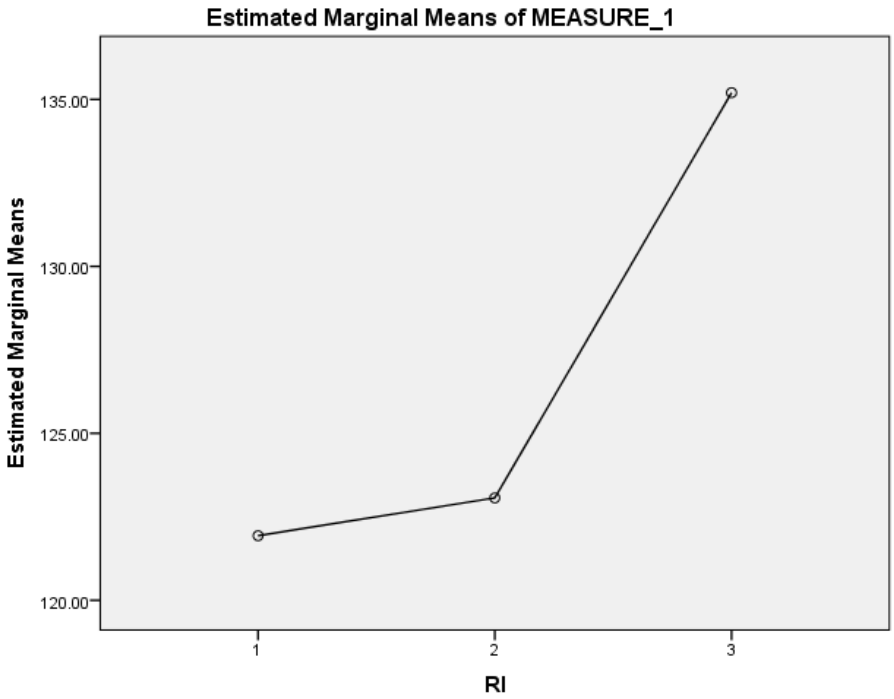


Figure 4.50. Profile Plots Rating of Heart Rate during Bent Curl with 90 seconds Rest Interval

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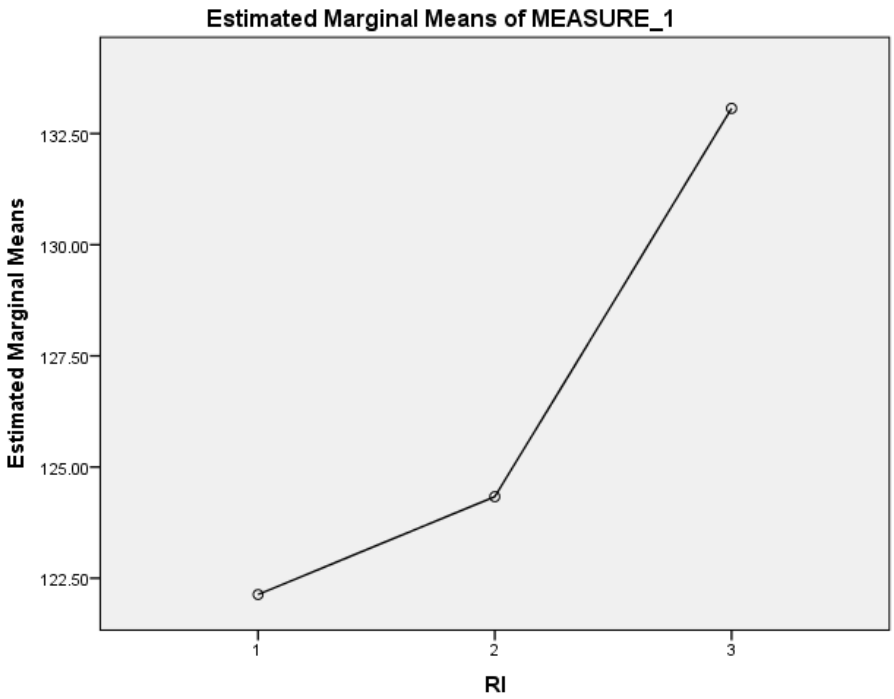


Figure 4.51. Profile Plots Rating of Heart Rate during Bent Curl with 120 seconds Rest Interval

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One way repeated-measures ANOVA was used to identify the effect of different rest intervals on heart rate at every each sets. The result showed that there was no significant difference on heart rate between rest intervals (60s, 90s and 120s) during biceps curl in set 1 [$F(2,28) = 4.390$, $p > 0.05$]. However, there was significant different in set 2 [$F(2,28) = 26.180$, $p < 0.05$] and set 3 [$F(2,28) = 20.773$, $p < 0.05$].

Bonferroni post hoc tests showed that there was no significantly difference on heart rate between 60s (mean = 125.067; SD = 4.008), 90s (mean = 121.933; SD = 2.052) and 120s (mean = 122.133; SD = 2.825), $p > 0.05$ in set 1. In set 2, there was no significant difference on heart rate during biceps curl with 90 seconds (mean = 123.067; SD = 2.738) and 120 seconds (mean = 124.333; SD = 3.0331), $p > 0.05$ and was significant lower than 60 seconds (mean 132.467; SD = 5.027), $p < 0.05$. In set 3, result also showed that there was no significant difference on heart rate during biceps curl with 90 seconds (mean = 135.200; SD = 5.199) and 120 seconds (mean = 133.067; SD = 5.650), $p > 0.05$ and was significant lower than 60 seconds (mean 148.800; SD = 8.587), $p < 0.05$.

Profile plots also showed that heart rate was lower during biceps curl with 90 seconds and 120 seconds than 60 seconds in set 2 and set 3.

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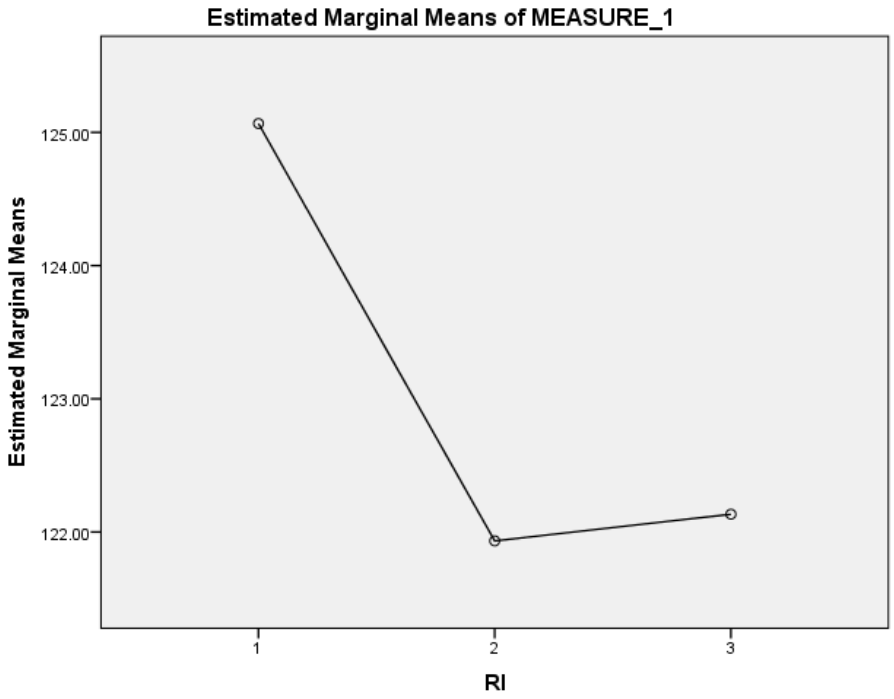


Figure 4.52. Profile Plots heart rate during Biceps Curl with Different Rest Intervals in Set 1

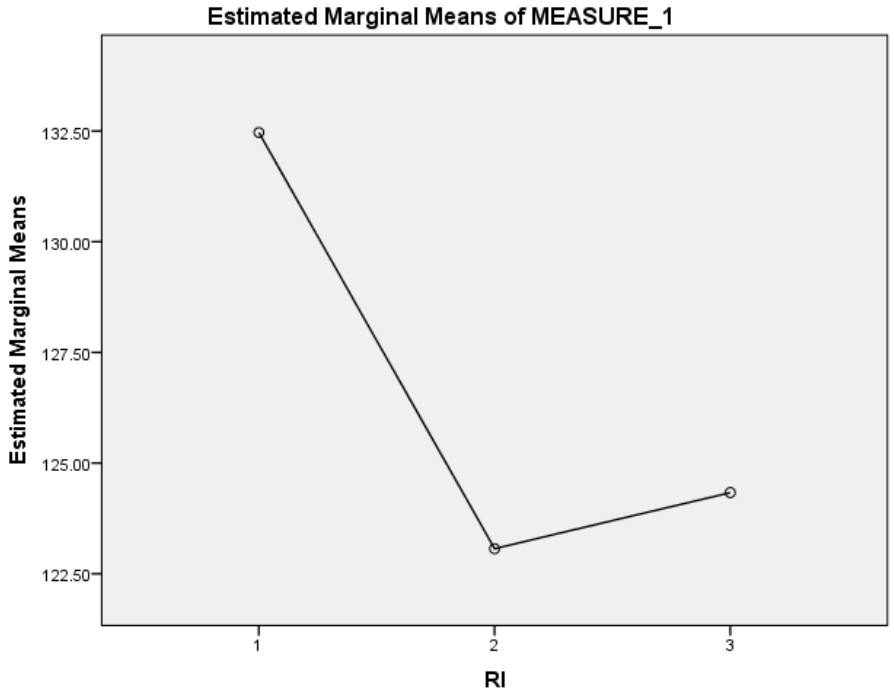


Figure 4.53. Profile Plots heart rate during Biceps Curl with Different Rest Intervals in Set 2

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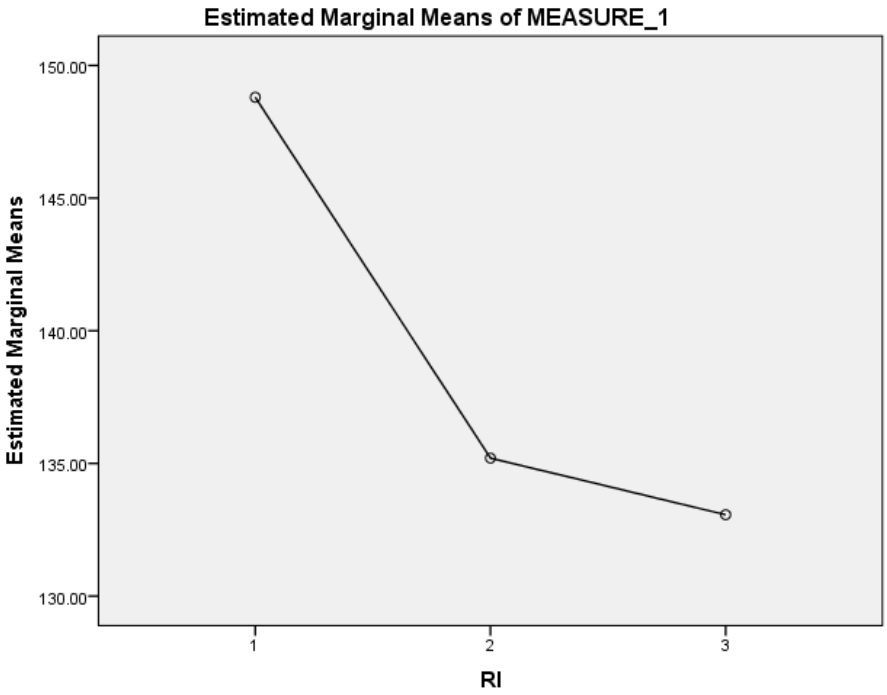


Figure 4.54. Profile Plots heart rate during Biceps Curl with Different Rest Intervals in Set 3

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CHAPTER 5

DISCUSSIONS

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5.1 Introduction

This acute study was done to compare three different rest intervals between sets which were 60 seconds, 90 seconds and 120 seconds on the number of repetitions, muscle activations, rating of perceived exertion and heart rate during bent over row and biceps curl exercises among the people that were experienced in resistance training. In this chapter, the findings of this study and why such results were obtained would be discussed. The details of this study were discussed in the following subtopics:

- The Effect of Different Rest Interval on Repetitions during Bent over Row and Biceps Curl Exercise
- The Effect of Different Rest Interval on Muscle Activation during Bent over Row and Biceps Curl Exercise

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- The Effect of Different Rest Interval on Rating of Perceived Exertion (RPE) during Bent over Row and Biceps Curl Exercise
- The Effect of Different Rest Interval on Heart Rate (HR) during Bent over Row and Biceps Curl Exercise
- Conclusion
- Recommendations

5.2 The Effect of Different Rest Interval on Repetitions during Bent over Row and Biceps Curl Exercise

In this study, the number of repetitions for each set was counted after the bent over row exercise was completed. These data were compared between three different rest intervals which were 60 seconds, 90 seconds and 120 seconds. The rest interval that had given the optimum effect on the number of repetitions for each set and total number of repetitions was identified.

The strength of participants can be measured by the number of repetitions and total number of repetitions with different rest interval in between each set. Before the exercises were initiated, participants were reminded to perform the right technique of bent over row and to give their fullest commitment during the test. The participants were asked to do the exercises with maximum possible number of repetitions with 10RM as a load. The repetitions would be counted once the participants pull the barbell towards the upper abdomen.

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The analysis of the result in this study showed that the total number of repetitions for bent over row exercise with 120 seconds rest interval was the highest amongst all followed by 90 seconds and 60 seconds. Based on this analysis, participants that have done bent over row exercise with 120 seconds rest interval produced higher total number of repetitions compared to the other rest interval.

When the number of repetitions between sets was analysed, it showed that 15 trained men who performed bent over row exercise with 120 seconds rest interval were able to successfully maintain the number of repetition until set 2. However, the repetitions started to drop in set 3. This was contrary to the one with 60 and 90 seconds rest interval that already started to drop the repetition number in set 2 and continuously declining in set 3.

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When the number in each set between three different rest intervals was compared, it showed that there was no significant difference on the number of repetitions between 60 seconds, 90 seconds and 120 seconds in set 1. In set 2, the number of repetitions was the highest when participants performed bent over row with 120 seconds and followed by 90 seconds and 60 seconds. The result in set 3 also showed the same result portrayed in set 2. The reading obtained still indicates that the number of repetition was the highest when bent over row was performed with 120 seconds rest interval and resulted as the lowest with 60 seconds of rest interval.

The result for total number of repetitions during biceps curl exercise showed that during 15 trained men has the highest number of total repetitions when 120 seconds of rest interval given followed by 90 seconds and 60 seconds respectively. The

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participants that performed biceps curl with 120 seconds rest interval successfully maintain the repetition until set 2 and the repetitions once again started to drop in set 3. This result obtained was also similar where the rest interval is 90 seconds. However, contrary to the 90 and 120 seconds interval, the declining number of repetitions started in set 2 and further dropped in set 3 for the 60 seconds rest interval.

When the number of repetitions that were lifted by participants between different rest intervals in set 1 was compared, it showed that there was no significant difference between 60 seconds, 90 seconds and 120 seconds rest interval. The difference began to appear in set 2 where biceps curl with 60 seconds rest interval between each set was significantly lower than the rest interval of 90 seconds and 120 seconds. However, there was no significant difference on the number of repetitions between 90 seconds and 120 seconds rest interval in set 2. In set 3, the result was still similar with set 2 that indicates the biceps curl with 60 seconds was the lowest among all number of repetitions.

Based on the finding of this current study, the best rest interval between sets for maintaining number of repetitions while performing bent over row was 120 seconds and for biceps curl exercise is at least 90 seconds rest between sets. Bent over row exercise is a type of exercise that involves more than one joint and demand more energy to lift the load while biceps curl is single joint exercise. Exercises in hypertrophy mode were high intensity types that need optimal rest interval that is not too long and not too short. In this current study, short rest interval such as 60 seconds and 90 seconds gave the negative effect on the number of repetitions. Hypertrophy training is high intensity training that needed fast-twitch muscle fibres to lift the load for generated the sufficient

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force. Force will re-exist when there is enough recovery time to produce energy. 60 seconds and 90 seconds rest length between sets was not enough for the bent over row exercise and 60 seconds for biceps curl to recover and re-produce energy through anaerobic glycolytic system. The synthesis of adenosine trio phosphate (ATP) would increase the acidic content and produce more hydrogen ions (H^+) which causes muscle fatigue. The rest period would give the opportunity to remove lactic acid proceeding with devolution of hydrogen (H^+) ion from energy metabolism and replenishment of the ATP-CP system (Ratamess et al., 2012)

This finding was strongly supported by the ACSM (2009) that recommends at least two minute to three minutes of rest interval. This is in particular for exercise that involves multiple joint and this current finding does not support the view that needs rest interval at least one to two minute for single joint exercise. Besides that, ACSM (2009) also stated that the 2 minute rest interval is suitable for those who want to achieve optimum level in strength and hypertrophy. The result of study by Ratamess et al. (2007) obtained the similar result for this current study which previous research has tried to investigate the effect on different rest interval lengths upon number of repetitions with eight trained men has performed 10 randomized protocols with 5 sets at 75% or 85% of 1RM over 10 repetitions and 5 repetitions. Previous research also found out that 2 minutes of rest interval can maintain the number of repetitions until set 2 and will start declining in set 3 while bench press activity with 1 minute of rest interval start to drop in set 2.

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In addition, the study by Goessler and Polito (2013) was carried out to compare the rest interval of 1 minute, 2 minutes and self-suggested rest interval with average (157±37 seconds). The finding presented that 2 minutes of rest interval between sets can most likely to help maintaining and providing more repetitions with each set of exercise. Furthermore, more repetition would increase mechanical tension caused by force generation and stretch that may help muscle growth (Goldspink, 2002; Hornberger & Chien, 2006 & Vandenburgh, 1987). Moreover, 2 minutes of rest interval also helped to increase the body's anabolic environment to be on higher level than 3 minutes of rest interval (Schoenfeld, 2010). Apart from that, 2 minutes rest interval between sets also increase muscle growth resulting from encouraged production of higher hypoxia (Toigo, & Boutellier, 2006), greater metabolic build up and sudden increase anabolic hormonal concentration after workout (Kraemer et al., 1990).

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Bent over row with 60 seconds and 90 seconds rest interval between sets results in higher reduction in repetitions because it did not has enough time for recovery to lift the load for next set. Previous study also supported the finding of this current study such as the study by Miranda et al. (2007). It reported that rest interval of 1 minute between sets would give negative effect to reduce the amount of repetitions while performing wide grip lat pull-down, close grip pull-down, machine seated row, barbell row lying on a bench, dumbbell seated arm curl and machine seated arm curl over 3 set and 8RM. Study by Tibana et al (2013) showed that for two different rest interval (e.g 1.5 minute and 3 minutes rest intervals) producing different number of repetitions during Smith machine bench press. Ten volunteers that was experienced in resistance training performed 5 sets with 60% load of 1RM until reaching fatigue. The finding showed that 1.5 minutes of rest interval give lower amount of repetition number.

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However, the previous studies by Willardson & Burkett (2006) did not obtain similar finding as the present study where they found that at least 3 minutes of rest length period between sets was needed to maintain and increase the number of repetitions during exercise. This statement also was supported by Kraemer, (1997), Richmond and Godard, (2004) and Willardson and Burkett, (2005). The justification of this statement was due to the fact that 3 minutes of rest interval would allow restoration of energy and removal of metabolic by-products that can cause fatigue such as hydrogen (H^+) ion and inorganic phosphate. Thus, it will give full recovery of strength between sets for athletes to lift the maximal load and train maximum force capacity (Miranda et al., 2007). Based on this, number of repetitions can be maintained for every sets but the level of metabolic stress is quite suspicious (Kraemer et al., 1991; Kraemer et al., 1990). This may not give the maximal hypertrophy response because bluntly of anabolic drive (Schoenfeld, 2010).

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This current finding for biceps curl exercises was supported by the statement of ACSM (2009) that stated at least 1 minute to 2 minute rest interval was enough to increase strength development during single-joint exercise. However, there are some previous research finding that is not in line with previous study of Scudese et al. (2015) that compared the different length of rest between sets (1 minute, 2 minute, 3 minute, and 5 minute) on number of repetitions when doing machine chest fly (MCF). Fourteen trained men randomly performed 3 sets with 10RM as a load with different rest length between sets. The finding showed that 1 minute and 2 minute rest length was not enough to maintain the number of repetitions until set 2.

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5.3 The Effect of Different Rest Interval on Muscle Activation during Bent over Row and Biceps Curl Exercise

Muscle activation on this study was measured by using the electromyography (EMG). In this study, EMG activity was observed to compare the three different rest intervals between sets such as 60 seconds, 90 seconds and 120 seconds during bent over row and biceps curl exercise. For bent over row exercise, electrode has been placed on latissimus dorsi and biceps brachii and for biceps curl exercise, electrode has been placed at biceps brachii only. The data of both exercises was then analysed.

The finding of this study showed that bent over row with 120 seconds rest interval successfully maintained the activity of muscle of latissimus dorsi and biceps brachii until set 2 while the rest interval of 60 seconds and 90 seconds started to drop the muscle activation in set 2. When the muscle activation was compared between different rest intervals in each set, the finding showed that there was no significant difference between 60 seconds, 90 seconds and 120 seconds on muscle activation while performing bent over row in set 1. In set 2, the differences begin to appear with this current finding presented that muscle activation of latissimus dorsii and biceps brachii during bent over row with 120 seconds rest interval between sets was higher than 60 seconds and 90 seconds. This finding remains until Set 3, where Latissimus Dorsi and Biceps Brachii were most activated while doing bent over row with 120 seconds rest interval.

The result of muscle activation on biceps curl with 90 seconds and 120 seconds rest interval showed that it could maintain at higher rate until set 2 and start decreasing in activation of set 3 while 60 seconds rest interval started to decrease in set 2 and set

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3. While comparing different rest interval on muscle activation for each sets, it showed that there was no significant difference on activation of biceps brachii between 60 seconds, 90 seconds and 120 seconds of interval rest. In set 2, participants that performed biceps curl with 60 seconds rest interval produced lower muscle activation compared to 90 seconds and 120 seconds rest interval. However, in set 3, the rest interval of 120 seconds produced more activation on Biceps Bracchii than the one with 90 seconds and 60 seconds rest interval. Thus, from this finding, this current study stated that at least 90 seconds rest interval is sufficient for biceps curl exercise.

In this study, the length of resting period with 120 seconds was enough for the bent over row activity and 90 seconds and 120 seconds while doing biceps curl. Resting period length of 60 seconds could decrease in muscle activation on Latissimus Dorsi and Biceps Brachii where muscle cannot produce higher force when doing exercises. The amount of force depends on the amount of muscles fibres that were required. Hypertrophy training depends on anaerobic glycolysis system because it was an effective system to produce energy quickly with short rest interval in between sets. However, the rest length of 60 seconds and 90 seconds on bent over row activity and 60 seconds on biceps curl caused higher accumulation of hydrogen ions (H^+) and it may interrupt in the concentration gradients of other ions such as sodium ions (Na^+), potassium ions (K^+), calcium ions (Ca^{2+}), magnesium ions (Mg^{2+}) and chloride ions (Cl^-) (de Salles et al., 2009). Furthermore, inadequate rest time will give negative effect to clear the hydrogen (H^+) ions and may easily cause muscle fatigue. Muscle fatigue causing the ability to restore motor neuron firing rate to be stunned (Martin et al., 2006; de Salles et al., 2009). Therefore, exercises with inadequate rest interval length between sets cannot generate force maximally to increase muscle activation on the next sets.

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Moreover, Sajad et al. (2014) investigated the effect of different rest intervals on neuromuscular responses. Twelves trained men have performed 4 sets over 80% 1RM of knee extension to failure with random order at rest intervals of 60 seconds, 90 seconds and 120 seconds. In that study, electrode was placed at right femoral muscle to identify integrated electromyography (IEMG) before and immediately after exercise. The findings showed that knee extension with 60 seconds, 90 seconds and 120 seconds rest interval was on IEMG because of muscle fatigue. However, rest interval with 60 seconds presented more reduction on muscle activation compared to 90 seconds and 120 seconds. Muscle activation depends on the amount of recruitment muscle to contract while doing the exercises. Study by Miranda et al (2018) examined the acute effect on 1 minute, 3 minute and 5 minute rest intervals on surface electromyography (SEMG) spectral and amplitude indices of fatigue during 45° angled leg press exercises. 3 minutes of rest interval in between allowed fully recovery state in the context of neural activation over multiple sets.

5.4 The Effect of Different Rest Interval on Rating of Perceived Exertion (RPE) during Bent over Row and Biceps Curl Exercise

Rest interval between sets is one of the variables of training that must be given sufficient amount of attention because it can manipulate the training. The rating of perceived exertion (RPE) was used to determine the difficulty level during the training. It also can measure the intensity level of resistance training sets (Lagally, Amorose, & Rock, 2009). Bent over row with 60 seconds and 90 seconds demonstrated start increase in set 2 and continue in set 3 while bent over row with 120 seconds rest interval still maintained until set 2 and start increase in set 3. The finding of RPE for biceps curl

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exercise with 60 seconds showed an increase in set 2 and set 3 while rest interval with 90 seconds and 120 seconds demonstrated that RPE level started to increase in Set 3.

Besides, after comparing between the interval of 60 seconds, 90 seconds and 120 seconds in each set on RPE, it showed that the level of RPE in set 1 being still the same for all three rest intervals. In Set 2, differences begin to appear when RPE level on biceps curl with 60 seconds rest interval was higher than 90 seconds and 120 seconds, while no significant difference on RPE level and it continued to maintain until set 3. Through the analysis of the results, it became prominent that a minimum of 120 seconds rest interval between sets for bent over row and 90 seconds for biceps curl were necessary for controlling RPE level over 3 sets with 10RM loads.

In this study, exercises with 60 seconds rest interval make the participants uncomfortable during the exercises because the intensity of exercises was high and rest length between sets was short. 60 seconds rest length was short, which might have arrest full muscle recovery. Beside that Ratamess, et al. (2007) also stated that the length of rest interval can affect the recovery of muscle function after fatigue. Thus, it might be that 60 seconds of rest interval has limited the energy recovery from the exhaustment during the exercises. Furthermore, strength will decrease because blood lactate cannot recovered to the optimal level on short rest interval (Abdessemed, Duche, Hautier, Poumarat, & Bedu, 1999). Inadequate rest interval between set such as 60 and 90 seconds rest interval during bent over row and 60 seconds rest interval between sets during biceps curl would increase the anaerobic glycolysis process to produce more energy in shorter time. Lack of oxygen would cause glucose change to lactate and hydrogen ion (H^+) will increase rapidly. Thus, accumulation of H^+ in muscle will cause

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increase of acid lactate and pH of intracellular will decrease in which muscle will fatigue quickly. The afferent feedback produced from chemoreceptors muscle and nocireceptors can increase perception of exertion because central nervous system increase lungs aeration and motor unit intake (Senna et al., 2011).

This current finding is similar with previous study by Senna et al. (2016) indicating that there is significantly higher RPE with 1 minute of rest interval between sets. Fifteen men that had experienced at least 1 year in resistance training performed five sets of exercises with 3RM load on machine chest fly (MCF) and barbell bench press (BP) with 1 minute, 2 minutes, 3 minutes and 5 minutes. This finding showed that 1 minute of rest interval has higher RPE than other rest interval during MCF.

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In another study by de Freitas et al (2015) that indicated that there was no significant difference between 2 minute rest interval and 4 minute rest interval on RPE between sets during bench press and seated row exercises. The participants in this study performed 3 sets with 8RM loads. This finding supported the finding of the current study that 2 minute rest interval sufficient for maintained the RPE.

The present study showed that RPE during bicep curl with 60 seconds rest interval is higher on RPE scale in Set 2 and Set 3 while 90 seconds and 120 seconds rest interval started to be higher in Set 3. Based on this finding, it showed that at least 90 seconds of rest interval is suitable for bicep curl exercise to give optimal result. This finding was not supported by the statement of ACSM (2009) where at least 1 minute of rest interval needed for development strength and hypertrophy. The very short rest

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interval between set for 3 respective sets with 10RM load was not sufficient to recover energy and remove metabolic product that cause muscle soreness.

5.5 The Effect of Different Rest Interval on Heart Rate (HR) during Bent over Row and Biceps Curl

This acute study was conducted to compare three different rest intervals on heart rate (HR) while doing bent over row and biceps curl activities. Heart rate was measured by polar heart rate for every sets and the result was compared. The analysis showed that HR level on bent over row activities with 60 seconds and 90 seconds rest interval started to get higher in set 2 and continued to increase in set 3. Rest interval with 120 seconds can accommodate HR to increase in Set 2, but HR increase in Set 3. While comparing the different rest intervals in each set, it showed that no significant difference happen on HR in Set 1 between 60 seconds, 90 seconds and 120 seconds of interval rest. However, in Set 2, HR level for bent over row with 60 and 90 seconds rest interval significantly increased than 120 seconds and this movement pattern still remain the same in Set 3. Therefore, rest interval with 120 seconds can control HR from being increasely high and it was a sufficient rest length over three sets with 10RM loads.

As for biceps curl, it is an exercise that involved single joint for muscle contraction. Contraction of muscle generally cause muscle to become tired. Thus, muscle need rest period to recover and giving optimal performance for next set. Based on this study, biceps curl with 60 seconds rest interval increased dramatically in set 2 and continued to increase in set 3. However, the result of biceps curl with 90 seconds and 120 seconds were not same for 60 seconds rest interval. The exercise with 90

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seconds and 120 seconds can maintain the HR until set 2 but in set 3 HR started to increase. While comparing three different rest intervals in each sets, it showed that no significant difference happens on HR in set 1. However in set 2, biceps curl with 60 second increased on the HR rather than 90 seconds and 120 seconds. The same pattern movement of result occurred in Set 3. Therefore, through the analysis of the result, it showed that at least 90 seconds of rest interval was needed to control HR from increasing dramatically over three sets with 10RM load.

Heart rate tends to increase in every sets especially with 60 seconds rest intervals because high intensity exercises with short rest interval needed long time to recover the heart rate count. Muscle that has contracted produced waste product such as carbon dioxide and lactic acid that must be carried away from the muscles. At the same time, muscles needed nutrient from the blood. Thus, the heart was forced to pump blood rapidly to the muscles as much as possible and thus increasing heart rate was detected. Furthermore, 60 seconds was not a sufficient time for recovery, which leads to fatigue quickly. Fatigue occurred when hydrogen ion (H^+) did not replenished and pH of muscle become acidic. Besides, short rest interval between sets did not allow reproduction of energy and it also tend to increase the heart rate. This acute finding was supported by Ratamess et al. (2007). It stated that heart rate started to increase in set 2 until the final sets for both training programme for all rest intervals and both training program (5RM and 10RM) of bench press exercise.

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5.6 Conclusion

Rest interval between sets was one of the variables in resistance training that is crucial because it has a great influence on resistance training programme especially hypertrophy training. Based the current study, there was significant difference on number of repetition, muscle activation, rating of perceived exertion (RPE) and heart rate (HR) between participants that involved bent over row exercise with 60 seconds, 90 seconds and 120 seconds. Rest interval with 120 seconds was a sufficient length of rest to allow participants produce higher number of repetitions and recruit motor unit for activating the latissimus dorsi and biceps brachii in every set. Besides that, 120 seconds rest interval also showed lowest RPE and heart rate (HR) than 60 and 90 seconds. It showed that 120 seconds rest interval is enough for participating bent over row over 3 sets of 10RM load.

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The next exercise was biceps curl exercise that also resulted in significant difference on number of repetitions, muscle activation, rating of perceived exertion (RPE) and heart rate (HR) between 60 seconds and 90 seconds, 60 seconds and 120 seconds, while no significant difference was found between 90 seconds and 120 seconds. In this study, the researcher found that at least 90 seconds was needed to perform biceps curl and produced higher number repetition in order of allowing motor unit to recruit for muscle contraction. Rest interval with 90 seconds also gave way for participants to recover from fatigue and getting tired quickly, which showed that lower RPE and HR than 60 seconds rest interval. Therefore, at least 90 seconds rest interval was required for doing biceps curl over 3 set of 10RM load.

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5.7 Recommendation

The researcher would like to suggest the future research to study the effect on length of rest interval between sets on movement kinetics and kinematics while performing the exercises. The question arises whether length of rest intervals could affect the exercise techniques.

Besides that, the next study should be conducted to identify rest length between sets on more complicated and complex exercises such as clean and jerk. The question arises whether the effects of rest interval in the single and multiple joint exercises would be the same with more complex exercises that highly stressed the important of techniques.

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Next, future study should be conducted among many more populations such as untrained individuals to identify the pattern of muscle contraction with different moderate rest interval. The findings among trained individuals might be different compared to the untrained populations.

Lastly, next research can examine the chronic effects of different rest interval. It is unknown whether findings in the acute study will reflect the findings in the chronic study.

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APPENDIX

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Physical Activity Readiness Questionnaire - PAR-Q (revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO		
☐	☐	1.	**Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
☐	☐	2.	**Do you feel pain in your chest when you do physical activity?**
☐	☐	3.	**In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	4.	**Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	5.	**Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	6.	**Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
☐	☐	7.	**Do you know of any other reason why you should not do physical activity?**

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME _____

SIGNATURE _____ DATE _____

SIGNATURE OF PARENT or GUARDIAN (for participants under the age of majority) _____ WITNESS _____

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

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PAR-Q & YOU

CANADA'S Physical Activity Guide to Healthy Active Living

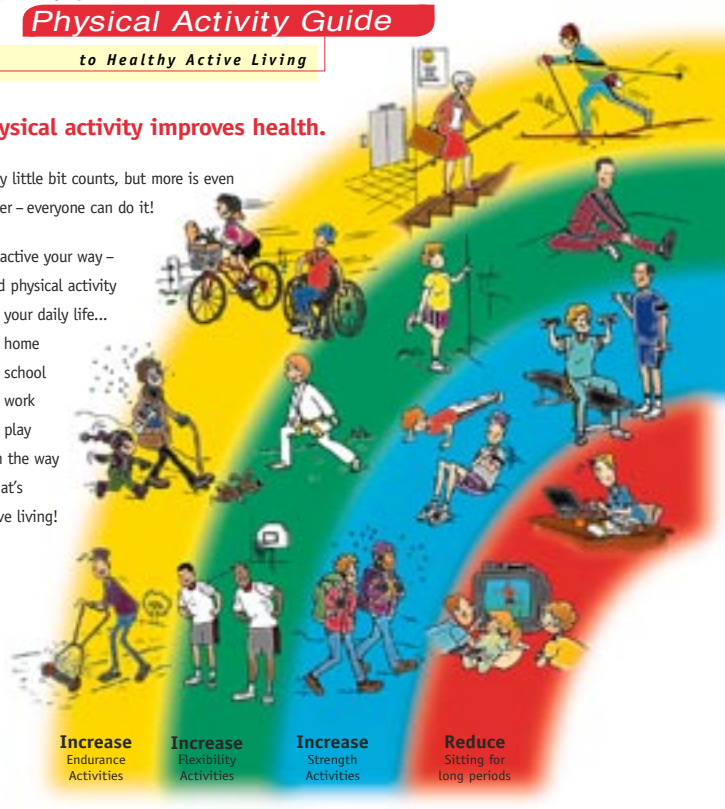
Physical activity improves health.

Every little bit counts, but more is even better – everyone can do it!

Get active your way – build physical activity into your daily life...

- at home
- at school
- at work
- at play
- on the way

...that's active living!



Choose a variety of activities from these three groups:

Endurance
4-7 days a week
Continuous activities for your heart, lungs and circulatory system.

Flexibility
4-7 days a week
Gentle reaching, bending and stretching activities to keep your muscles relaxed and joints mobile.

Strength
2-4 days a week
Activities against resistance to strengthen muscles and bones and improve posture.

Starting slowly is very safe for most people. Not sure? Consult your health professional.

For a copy of the *Guide Handbook* and more information: **1-888-334-9769**, or **www.paguide.com**

Eating well is also important. Follow *Canada's Food Guide to Healthy Eating* to make wise food choices.

Get Active Your Way, Every Day – For Life!

Scientists say accumulate 60 minutes of physical activity every day to stay healthy or improve your health. As you progress to moderate activities you can cut down to 30 minutes, 4 days a week. Add-up your activities in periods of at least 10 minutes each. Start slowly... and build up.

Time needed depends on effort

Very Light Effort	Light Effort *60 minutes*	Moderate Effort *30-60 minutes*	Vigorous Effort *20-30 minutes*	Maximum Effort
• Strolling • Dusting	• Light walking • Volleyball • Easy gardening • Stretching	• Brisk walking • Biking • Raking leaves • Swimming • Dancing • Water aerobics	• Aerobics • Jogging • Hockey • Basketball • Fast swimming • Fast dancing	• Sprinting • Racing

Range needed to stay healthy

You Can Do It – Getting started is easier than you think

Physical activity doesn t have to be very hard. Build physical activities into your daily routine.

- Walk whenever you can – get off the bus early, use the stairs instead of the elevator.
- Reduce inactivity for long periods, like watching TV.
- Get up from the couch and stretch and bend for a few minutes every hour.
- Play actively with your kids.
- Choose to walk, wheel or cycle for short trips.
- Start with a 10 minute walk – gradually increase the time.
- Find out about walking and cycling paths nearby and use them.
- Observe a physical activity class to see if you want to try it.
- Try one class to start – you don t have to make a long-term commitment.
- Do the activities you are doing now, more often.

Benefits of regular activity:	Health risks of inactivity:
• better health • improved fitness • better posture and balance • better self-esteem • weight control • stronger muscles and bones • feeling more energetic • relaxation and reduced stress • continued independent living in later life	• premature death • heart disease • obesity • high blood pressure • adult-onset diabetes • osteoporosis • stroke • depression • colon cancer

Health Canada Santé Canada

Canadian Society for Exercise Physiology

ACTIVE LIVING

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CANADA'S Physical Activity Guide to Healthy Active Living

Source: Canada's Physical Activity Guide to Healthy Active Living, Health Canada, 1998 http://www.hc-sc.gc.ca/hppb/paguide/pdf/guideEng.pdf

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FITNESS AND HEALTH PROFESSIONALS MAY BE INTERESTED IN THE INFORMATION BELOW:

The following companion forms are available for doctors' use by contacting the Canadian Society for Exercise Physiology (address below):

The **Physical Activity Readiness Medical Examination (PARmed-X)** – to be used by doctors with people who answer YES to one or more questions on the PAR-Q.

The **Physical Activity Readiness Medical Examination for Pregnancy (PARmed-X for Pregnancy)** – to be used by doctors with pregnant patients who wish to become more active.

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For more information, please contact the:

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Online: www.csep.ca

The original PAR-Q was developed by the British Columbia Ministry of Health. It has been revised by an Expert Advisory Committee of the Canadian Society for Exercise Physiology chaired by Dr. N. Gledhill (2002).

Disponible en français sous le titre «Questionnaire sur l'aptitude à l'activité physique - Q-AAP (revisé 2002)».

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