THE ACUTE EFFECTS OF EXERCISES ORDER DURING UPPER-LOWER BODY ALTERNATED SUPERSETS AMONG TRAINED MEN

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ABSTRACT

This research attempted to examine the acute effects of exercises order during upper-lower body alternated supersets among trained men. This study was conducted by using quantitative time series experimental design. Twenty resistance-trained men performed different exercises order of bench press and squat: (i) upper body to lower body (order A) and (ii) lower body to upper body (order B) in random arrangement for three sets with 120 seconds rest inter-set. All participants performed both exercises at 75% of their one repetition-maximum (1RM) value. Muscles activation, repetitions completed, heart rate and rating of perceived exertion (RPE) were recorded during both exercises order. Repeated measure analysis of variance (ANOVA) was used to analyse the different on all variables. Results showed order A produced higher upper body muscles activation (pectoralis major: $\rho < .05$, triceps brachii: $\rho < .05$) and number of repetitions completed ($\rho < .05$) in bench press for all three sets compared to order B. In contrast, order B showed higher lower body muscles activation (rectus femoris: $\rho < .05$, biceps femoris: $\rho < .05$) in squat compared to order A. Number of repetitions completed during squat were higher during order B compared to order A in the first set, $\rho < .05$. Heart rate was found to be greater during order B in the second and third set, $\rho < .05$. RPE was also found to be greater during order B in all three sets, $\rho < .05$. In conclusion, the results of this study suggested that the order of exercises performed in a resistance training session will determine the benefits gained. The findings of this study could be used as a guideline for individuals involved in strength and conditioning to plan a better resistance training program for achieving their own specific goals.

KESAN AKUT TURUTAN SENAMAN SEMASA *UPPER-LOWER BODY ALTERNATED SUPERSETS* DALAM KALANGAN LELAKI TERLATIH

ABSTRAK

Kajian ini bertujuan untuk mengkaji kesan akut turutan senaman semasa *upper-lower body alternated supersets* dalam kalangan lelaki terlatih. Kajian ini dijalankan dengan menggunakan reka bentuk percubaan siri masa kuantitatif. Dua puluh orang lelaki terlatih telah melakukan senaman *bench press* dan *squat* dengan turutan yang berbeza: (i) bahagian atas tubuh diikuti bahagian bawah tubuh (Turutan A) dan (ii) bahagian bawah tubuh diikuti bahagian atas tubuh (Turutan B) dalam susunan rawak sebanyak tiga set dengan 120 saat rehat di antara set. Kesemua peserta melakukan kedua-dua senaman pada 75% daripada nilai satu ulangan maksimum (1RM) mereka. Aktiviti otot, pengulangan yang lengkap, degupan jantung dan *rating of perceived exertion* (RPE) direkodkan semasa kedua-dua turutan senaman. *Repeated measure analysis of variance (ANOVA)* digunakan untuk menganalisis perbezaan keatas semua pembolehubah. Hasil kajian menunjukkan turutan A menghasilkan pengaktifan otot bahagian atas tubuh (*pectoralis major*: $\rho < .05$, *triceps brachii*: $\rho < .05$) dan jumlah pengulangan yang lengkap ($\rho < .05$) yang lebih tinggi ketika senaman *bench press* untuk ketiga-tiga set berbanding turutan B. Sebaliknya, turutan B menunjukkan pengaktifan otot bahagian bawah tubuh lebih tinggi (*rectus femoris*: $\rho < .05$, *biceps femoris*: $\rho < .05$) semasa latihan *squat* berbanding turutan A. Jumlah pengulangan yang lengkap semasa aktiviti *squat* adalah lebih tinggi semasa turutan B berbanding turutan A dalam set pertama, $\rho < .05$. Kadar degupan jantung pula didapati lebih tinggi ketika turutan B dalam set kedua dan ketiga, $\rho < .05$. RPE juga didapati lebih tinggi semasa turutan B bagi ketiga-tiga set, $\rho < .05$. Kesimpulannya, hasil kajian ini mencadangkan bahawa turutan senaman yang dilakukan dalam sesi latihan bebanan akan menentukan manfaat yang diperolehi. Penemuan kajian ini boleh digunakan sebagai garis panduan bagi individu yang terlibat dalam latihan kekuatan dan penyesuaian untuk merancang program latihan bebanan yang lebih baik untuk mencapai matlamat khusus mereka sendiri.

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1RM	One repetition maximum
ANOVA	Analysis of variance
BF	Biceps Femoris
BMI	Body mass index
BP	Bench press
EMG	Electromyography
HR	Heart rate
kg	Kilogram
m	Meter
MVC	Maximum voluntary contraction
PM	Pectoralis major
r	Reliability
RF	Rectus Femoris
RPE	Rated Perceived Exertion (RPE) Scale
SD	Standard deviation
SPSS	Statistical Package of Social Science
SQ	Squat
TB	Triceps Brachii
ρ	Significant differences

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Strength has been featured as the most imperative bio-engine capacities and an essential for the advancement of numerous different capacities such as power, agility, and speed (Everett, 2007). Strength refers to the skeletal muscle's ability to contract and apply a force against a resistance (Everett, 2007). Strength also has been defined by McArdle et al., (2006) as the maximum force, torque, or pressure created by a particular muscle or muscle group. There are a wide range of techniques to evaluate strength. According to Everett (2007), he stated that strength is transferable while maximal strength is at the core of strength development and any increases in maximal strength will transfer to some degree to all types of strength.

In this era, people are very concerned about healthy lifestyle. Many activities can be done to be fit and healthy. Resistance training is one of the activities that suited for everyone either male or female to maintain their health, improve the level of fitness and to get an attractive body shape. Resistance training has expanded throughout the most recent decade not just among the athletic population, but also to wide range of population having their own priority interest (Hannie et al., 1995). A substantial extent of the dynamic population taking part in physical training as an aspect of their responsibilities, their calling, for recreational purposes, rehabilitative reasons and numerous others (Willardson & Burkett, 2006).

Resistance training based on weight loading has been widely used among the athletes. This training method is popular among professional and non-professional athletes and now forms part of most their training programmes due to its effectiveness in helping them to improve their performance (Faigenbaum, Lloyd, MacDonald, & Myer, 2016).

Resistance training typically used by the athletes as well as the normal population to maximize their physical appearance, performance and injury prevention approach. Most of the time, athletes were given the physical training program that utilized free weight and machines. Appropriately arranged the training program and activity determination were seen as important elements that may affect the training results (Grieco et al., 2012).

Currently, resistance training forms part of training programmes for athletes regardless of the sport, the specific sport will definitely control the intensity and frequency of resistance training with regard to how critical it is to performance. For these particular and general reasons it is important to know how to optimize strength gains.

Resistance exercise training, also known as resistance exercise, resistance training, or strength training, is a type of exercise that involves the voluntary activation of specific skeletal-muscle groups against external resistance (Fleck & Kraemer, 2014). Resistance training has become a popular form of exercise and is recommended by many health organizations, including the American College of Sports Medicine (ACSM), the American Heart Association, and the American Geriatrics Society.

From a physiological perspective, resistance training helps to strengthen the muscle groups and helps in expanding and strengthens ligament and tendon wisely if done appropriately and regularly. Resistance training can produce additional effects such as builds solid force abilities, saves and increasing bone compactness, and essentialness for maturing body. Resistance training also indicated to enhance mental well-being by expanding self-regard or self-esteem, decrease the potential danger of osteoporosis and the signs and manifestations of various ceaseless sicknesses such as coronary diseases, joint inflammation, and diabetes. Additionally, resistance training helps enhancing the quality of rest and decreasing discouragement or depression (Sequin & Nelson, 2003).

Resistance training is a modality of exercise that has grown in popularity over decades ago, particularly for its role in improving athletic performance by increasing muscular strength, power, speed, hypertrophy, local muscular endurance, motor performance, balance, and coordination (Harries, Lubans, & Callister, 2015; Willardson & Burkett, 2006). Traditionally, resistance training programme are usually designed to stimulate improvements in muscular strength, muscular power, muscular hypertrophy or muscular endurance (Bompa & Buzzichelli, 2015).

Based on The American Heart Association (AHA), resistance training was recommended, even for a person who had a heart disease problem. This is because, the heart rate reading will increases during the short blasts of efforts when lifting the loads. The strength of heart will improve as well as the other muscle during the resistance training. However, knowing the optimal heart rate is the most important things before doing resistance training program. It is an essential procedure for detecting whether people who want to carry out resistance training are in a state that is willing to increase the level of heart fitness. Besides that, it is also to prepare the suitable exercises that is appropriate with the heart rate to prevent the excessive strain on the heart. In addition, a person heart rate during resistance training session relies upon the age and general level of wellness (Haskell et al., 2007).

The key factor to successful resistance training at any level of fitness or age is appropriate program design. Program design entails proper exercise instruction, goal setting, a method of evaluation of training progress toward training goals, the correct prescription of the acute program variables, and the inclusion of specific methods of progression targeting particular areas of muscular fitness. It is important that

resistance training been supervised by qualified professionals for the prevention of injury and for maximizing the health and performance benefits (Huisinga, Filipi, & Stergiou, 2012).

Resistance training programs may be designed to obtain different types of muscular adaptations, such as strength, power, hypertrophy, or endurance (Baechle & Earle, 2008). Many variables must be considered and manipulated in order to achieve the proper responses during the planning of resistance training program. In order to accurately manipulate training variables, the goals of the individual participating in the resistance training program must be determined. This is because, if the manipulation of training variables is not suitable, overtraining syndrome could occur during resistance training session (Rahimi, 2005). Manipulation of specific training variables determines the degree to which these characteristics of strength are increased and the manipulation is dictated by the goal orientation of the individual (Willardson & Burkett, 2006).

Effective resistance training exploits the training variables and principles of training to optimize the stress on the muscle in order to achieve the desired response. The principle of overload reflects the increment of loading muscle should exert relative to the 1-RM. Muscular overload is often referred to as training intensity and is quantified as a percentage of the 1-RM and represents the most important principle in determining strength development (McArdle et al., 2006).

According to the American College of Sports Medicine (ACSM), the main methodological variables of resistance training prescription are the load, volume, rest interval between sets and exercises, frequency of sessions, exercise modality, repetition velocity, and exercise order (Kraemer, Ducan, & Volel, 1998; Swain, Brawner, & Medicine, 2014).

Among such variables, the exercise order was believed to be among the least been studied. ACSM also indicated that the exercise order is an important variable that affect both acute responses and chronic adaptations to resistance training programs and this may have a vital impact on the quality of the constituent exercise performed within a training session.

Exercise order refers to the sequence of exercises in a given training session. Exercises involving large-muscle groups had been recommended to be placed at the beginning of the training sessions, because this exercise sequence results in the ability to use the heaviest resistances possible when performing the exercises of the large-muscle group and may result in great long term strength gains (Kraemer & Ratamess, 2004). The sequences of exercises also allow the use of training resistances and volumes that optimize training adaptations (Bird, Tarpenning, & Marino, 2005).

Traditional exercise order recommends that large muscle group or multi joint exercises are performed before small muscle group or single joint exercises (Fleck & Kraemer, 2014). By exercising the large muscles first, it was thought that at the end of the session, the work done by the various muscle groups would be proportionate to their size (Kraemer & Ratamess, 2004). Studies involving exercises order have

reported that the exercise sequence acutely influences the number of repetitions and the total work volume of resistance training exercises performed late in the session (Simao, Farinatti, Polito, Viveiros & Fleck, 2007).

Studies involving exercises order have reported that the exercise order acutely influences the number of repetitions and the total work volume of resistance training exercises performed late in the session. Therefore, the authors recommend that priority exercises must be performed first in the session based on the targeted muscle group (Torres et al., 2014).

The current research focuses on several variables influenced by the acute effects of the exercises order during resistance training. The variables that were chosen for this study were muscles activation, number of repetitions, reading of heart rate and Rated Perceived Exertion (RPE) Scale.

Previous studies found that, exercises that compared multi-joint and one-joint exercises greatly affect some of the acute training response, such as maximal number of repetitions, neuromuscular activity (EMG), neuromuscular fatigue, oxygen consumption, and rating of perceived exertion (RPE) (Simao et al., 2012; 2007; Figueiredo et al., 2011). However, the current research was focussing on the comparison of multiple-joint exercises for upper and lower body.

Multiple-joint exercises, such as bench press and back squat, require more complex neural responses, considering the high number of active muscles (Simao et al., 2012). The rationale for an exercises order lies in increased motor unit recruitment

during neuromuscular fatigue, resulting in greater muscle activation for subsequent multi-joint exercises. Bench press exercise targeted the upper body muscles such as pectoralis major, triceps brachii, anterior deltoid and biceps brachii (Saeterbakken, Mo, Scott, & Andersen, 2017). While squat exercise had represented the lower body muscles such as quadriceps, hamstring, tibialis anterior and gastrocnemius (Gullett, Tillman, Gutierrez, & Chow, 2009; Robertson, Wilson, & Pierre, 2008; Schoenfeld, 2010).

The amount of repetitions in a set appears to be more influential than an entire set number as a prescribed training variable. This is due to the fact that stress is actually formed by load and amount of repetitions, and thus why repetition number is very significant in achieving a training goal (Simão et al., 2010; Spinetti et al., 2010). In this research, the amount of repetitions was recorded to compare the acute effect of different exercises order.

The cardiac muscle is innervated by sympathetic and parasympathetic fibers, which stimulate secretion of norepinephrine and acetylcholine, respectively (Pecanha et al., 2017). The sinoatrial nodule generates electrical signals, which depolarize and repolarize the synaptic membranes, which leads to rhythmicity of the heart and also known as heart rate variability (Ferreira & Zanesco, 2016; Kovacs & Baggish, 2016). Heart rate is considered an important indicator of cardiovascular fitness or risk and can be modulated by resistance exercise (Nakamura et al., 2015; Pecanha et al., 2017; Vilamitjana, Lentini, Perez & Verde, 2014).

Rating of perceived exertion (RPE) scale was a typical method that was used to survey the intensity of exercises. It was closely related to the total number of repetitions that was for estimating the level of strain or heaviness experienced during resistance training besides may precisely reflect the intensity of an activities session (Foster, 1998; Foster et al., 1996; 2001; Day et al., 2004; McGuigan et al., 2004; Noble & Robertson, 1996; Egan, 2004).

1.2 Problem Statement

As a way to save time, superset is a method of training that can be implemented in a resistance training session. There are many types of supersets, and one of these includes the circuits alternated supersets. Circuits alternated superset is a method where an individual perform two unrelated exercise back to back without rest in between. The example of this is performing bench press (upper body) followed by squat (lower body).

For a total body workout, bench press is among of the most recommended exercises to be performed for upper body while squat for the lower body. Finishing bench press for three sets followed by three sets of squats may take some times as there are other exercises to be performed too. Thus, implementing an alternated supersets might be a better way to reduce time of training.

The question arise now, if the alternated supersets want to be implemented, which exercise need to be performed first? Is there any different of effects if the order of exercises is been manipulated? Until now, as to the author's knowledge, very little or lack of studies have been conducted on investigating the muscle activation, reading of heart rate, reading of rated perceived exertion (RPE) scale and number of repetitions that can be completed during the alternated supersets, in which, the value of all variables are important as it will provide possible future adaptations such as hypertrophy and strength adaptations of the trained muscles.

1.3 Research Hypothesis

In this study, the main hypothesis are:

i. There is no significant difference between upper-lower and lower-upper exercise order on muscles activation during alternated supersets training.
ii. There is no significant difference between upper-lower and lower-upper exercise order on number of repetitions completed during alternated supersets training.
iii. There is no significant difference between upper-lower and lower-upper exercise order on the heart rate reading during alternated supersets training.

iv. There is no significant difference between upper-lower and lower-upper exercise order on the reading of Rated Perceived Exertion (RPE) Scale during alternated supersets training.

1.4 Research Questions

The research questions in this study are:

i. Is there any significant difference of muscles activation between upper-lower and lower-upper exercise order during alternated supersets training?

ii. Is there any significant difference of number of repetitions completed between upper-lower and lower-upper exercise order during alternated supersets training?

iii. Is there any significant difference of heat rate reading between upper-lower and lower-upper exercise order during alternated supersets training?

iv. Is there any significant difference of the reading of Rated Perceived Exertion (RPE) Scale between upper-lower and lower-upper exercise order during alternated supersets training?

1.5 Research Objectives

In this study, some of the objectives have been outlined as the guideline for the researcher to conduct the study. The main objectives for this research was to study the effects of exercises order between two large muscles group for both upper and lower body during upper-lower body exercise alternated supersets. Then, the specific objectives in this research are as follows:

i. To determine and compare the muscles activation between upper-lower and lower-upper exercise order during alternated supersets training.
ii. To determine and compare the number of repetitions completed between upper-lower and lower-upper exercise order during alternated supersets training.
iii. To determine and compare the heat rate reading between upper-lower and lower-upper exercise order during alternated supersets training.
iv. To determine and compare the reading of Rated Perceived Exertion (RPE) Scale between upper-lower and lower-upper exercise order during alternated supersets training.

1.6 Significance of Study

This research attempt to study the acute effects of exercises order during upper and lower body exercise alternated supersets training program on muscle activation, number of repetitions completed, reading of heart rate, and rated perceived exertion (RPE) Scale.

Exercise order is one of the key variables in designing resistance training that may affect physiological and functional muscle characteristics. The selection of exercises with suitable order that be carried out during the resistance training session is an important consideration in program design (Bean, 2015). Besides that, when combined properly with other resistance training variables, it can lead to more efficiency, safety, and finally lead to more effective resistance training on increasing strength, power and hypertrophy (Zatsiorsky & Kraemer, 2006).

Therefore, findings of this research will help coaches, sports practitioners, personal trainers, instructors, and all that have interest in resistance training to develop a training program related to fitness, rehabilitation and strength training in every level of athletes. The positive finding of this study may provide useful knowledge to athletes and coaches about the effect of exercises order during unrelated supersets training program on muscle activation, number of repetition**,** reading of heart rate, and rated perceived exertion (RPE) Scale. The findings from this study may help in improving the quality of training methods such as using the appropriate exercises order during resistance training program.

1.7 Delimitations

The delimitations of this study are:

i. The participants in this study were delimited to recreationally active, resistance-trained men in Universiti Pendidikan Sultan Idris (UPSI) populations. All participants were within the age of 20-25 years old.
ii. The participants were delimited to those who are free of any lower and upper limb injuries, musculoskeletal or neuromuscular limitation, or disease that would prevent the participant from performing the training sessions.
iii. All the assessments were conducted at the Sports Biomechanics Laboratory, Faculty of Sports Science and Coaching, UPSI.

1.8 Limitations

Limitations are factors that may influence the results of this research. There are several limitations in this research that can identified, which are:

i. There was insufficient information on the effect of exercises order during unrelated supersets training program on muscle activation and number of repetition.
ii. Each participant is uniquely different from other and may respond differently towards the resistance exercises.

iii. The participant that involved in this training programme must give full commitment and effort in order to produce good results in this research.

1.9 Definition of terms

In this study, the following terminologies shall have its own definition in the context of study.

1.9.1 Exercises Order

Exercise order refers to the sequence of exercises in a given training session. It based on several principles, including larger muscle groups before small ones, multiple-joint exercise before single-joint exercise, less complex movement before basic ones, higher intensity before lower intensity when training individual muscle groups, and rotating upper and lower body movements or opposing between agonist and antagonist relationship muscle groups.

1.9.2 Resistance Training

Resistance training is a form of exercise that improves muscular strength and endurance by moving specific part of body against anything that acts as a resistance.

1.9.3 Supersets Training

A superset is performing at least two different exercises back to back with little or no rest in between.

1.9.4 Circuits Alternated Supersets Training

A type of supersets training in which two unrelated exercises were trained back to back to target different muscles group such as started with upper body exercise followed by lower body exercise.

1.9.5 Resistance-trained Men

Trained men are referring to those that currently active and have more than six months experiences involving in systematic resistance training and also have good technique in performing every resistance exercises. Besides that, every participant also should have some knowledge about the resistance training programme.

1.9.6 Electromyography (EMG)

EMG is a device that measures the amount of muscles activation when the body moves, or attempt to perform something.

1.9.7 Number of Repetitions Completed

Repetitions defined as the number of times a person can perform an exercise. For example, if a person able to perform squat for 12 times, the 12 will be considered as the number of repetitions completed.

1.9.8 Heart Rate Reading

The speed of the heartbeat measured by the number of contractions of the heart and it also known as beats per minute (bpm). The heart rate can vary according to the body's physical needs, including the need to absorb oxygen and excrete carbon dioxide.

1.9.9 Rated Perceived Exertion (RPE) Scale

The RPE scale is used to measure the intensity of your exercise. The RPE scale runs from 0 to 10 where the numbers were related to phrases used to rate how easy or difficult an activity is.