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STUDY REGARDING THE EFFECTS OF EXERCISE VARIATION IN MUSCLE THICKNESS TO IMPROVE MUSCLE STRENGTH

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Abstract: The term "muscle confusion" has been used to describe the effects of constantly varying exercise selection as a means to provide a novel stimulus that enhances muscular adaptations. By most definitions, frequency of training pertains to the number of exercise sessions performed in a given period and is generally expressed on a weekly basis. However, another important aspect of frequency is the number of times a specific muscle group is trained over the course of a given week. Despite speculation on the topic, the optimal training frequency for a muscle group has yet to be determined. The subjects of our research are thirty healthy and physically active males from Salonta city from Romania volunteered joined for this study, with at least 2 years of experience with resistance training, 15 subjects are part of the experimental group (GExp) and 15 of the subjects are part of the control group (GCtrl). The main goal of this study was to investigate the impact of random exercise selection and range of repetitions on MT, body composition and strength, Thus, having said that, those who used the muscle confussion method experienced more consistent changes in body composition and centimeters gained on the perimetry side compared to the control group.

Key words: exercise variation, muscle confusion, resistance training, muscle, fitness

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INTRODUCTION

It is known that the human body is a complex and intelligent machine that adapts to external stimuli in order to survive, it constantly creates adaptations to cope with different tasks in daily life or in sports training (Lopez et al. 2018; Xu et al. 2023). That is why it is recommended to use new stimuli so that the body periodically adapts to external stimuli and produces results in

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accordance with the demands of sports training or everyday professional life and activity (Baz-Valle et al. 2019; Rauch et al. 2020).

The term “muscle confusion” has been used to describe the effects of constantly varying exercise selection as a means to provide a novel stimulus that enhances muscular adaptations (Fonseca et al. 2014a; Rauch et al. 2020; Schoenfeld et al. 2016). The American College of Sports Medicine (2009) and the National Strength and Conditioning Association have advocated that changing/including exercises between microcycles can also enhance strength gains. This recommendation is based on cross-sectional surface electromyography and functional MRI data indicating that different exercises aiming to activate the same muscle group (e.g., squat and leg press exercises) may promote distinct motor unit recruitment. We may say that changing/including exercises for the same muscle group within a training routine would optimize motor unit activation of the target muscle group, thus, maximizing gains in skeletal muscle strength and CSA over a given training period (Fonseca et al. 2014b)

Resistance training (RT), muscle contraction against external weight, potently increases muscle strength and mass (hypertrophy), improves physical performance, provides a myriad of metabolic-health benefits and combats chronic disease risk (Currier et al. 2023; Phillips and Winett 2010). Proper manipulation of (RT) variables is considered essential to optimize postexercise muscular adaptations. Is well-established that (RT) as an effective method to increase muscle mass, strength and overall health in different populations (Folland and Williams 2007; Rauch et al. 2020). It has been proposed that proper manipulation of RT variables may help to optimize muscular adaptations. Practitioners can manipulate a variety of RT variables to elicit desired muscular adaptations. These include both quantitative variables, such as training volume, frequency, rest intervals or cadence and qualitative variables, such as exercise selection. As a general rule, those involved in RT programs with hypertrophy as a primary goal train each muscle group relatively infrequently but perform a high volume of work per muscle group in a session (Hackett et al. 2013; Schoenfeld et al. 2016). This is accomplished using a split-body routine (SPLIT), where multiple exercises are performed for a specific muscle group in a training bout. Compared with full-body routines, it is believed that a split routine allows total weekly training volume per muscle group to be maintained with fewer sets performed per training session and greater recovery afforded between sessions (Currier et al. 2023; Dan Alexandru Szabo 2020; Gotshalk et al. 1997; Risfandi Setyawan 2021). In addition, working a muscle with a greater training volume in the same session helps to increase intramuscular metabolic stress which in turn may enhance the hypertrophic response to the exercise bout (Kraemer and Ratamess 2004; Wernbom et al. 2007).

Although strength training (ST) has been widely recommended as an effective method to increase muscle strength and mass. Regarding the structure of an ST program, a positive relationship between training volume and gains in muscle strength and hypertrophy has been suggested supporting the concept that training volume should be increased throughout an ST program to maximize its functional and phenotypical adaptations (Fonseca et al. 2014b; Sperandei et al. 2016)

By most definitions, frequency of training pertains to the number of exercise sessions performed in a given period and is generally expressed on a weekly basis. However, another important aspect of frequency is the number of times a specific muscle group is trained over the course of a given week. Despite speculation on the topic, the optimal training frequency for a muscle group has yet to be determined (Currier et al. 2023; Gjestvang et al. 2023; Wernbom et al. 2007)

Arnold Schwarzenegger, a name with resonance in the world of fitness and bodybuilding, who throughout his career has accumulated 4 titles of "Mr.Universe", 8 titles of "Mr. Olympia" the most important and prestigious bodybuilding competition, holding some important titles in powerlifting competitions as well, refers to the "muscle confusion" method through the famous line "shocks the muscle", a line that still resonates in the minds of young practitioners and supporters of this movements called fitness. Based on this dogma, Arnold achieved impressive results throughout his career, he managed to bring a new concept regarding the physical appearance that a bodybuilder should have (edited by Michael Butter 2011).

Dorian Yates, 7-time champion in the "Mr. Olimpia", 7 times winner of the "IFBB-Grand Prix" competition and 2 times champion of the "IFBB Night Of The Champions" competitions, a man who revolutionized the professional bodybuilding of that time with his incredible looks, made his competitors to seem small next to it. Dorian Yates, like Arnold, used the "muscle confusion" method in his training to avoid ceiling and build that impressive muscle mass. Even today, his training is structured based on this principle and in several conferences he refers to this method by saying.

The purpose of this study was, to compare the effects of a traditional training program (fixed exercises and repetition ranges) to a training program where exercises and repetition ranges were randomized on a session-by-session basis on markers of muscular adaptations (muscle confusion or exercise variation), to investigate the effects of different combinations of training intensities and exercises selection. We hypothesized that the exercise variation (random selection) would increase in muscle mass and strength.

MATERIAL AND METHODS

Thirty healthy and physically active males from Salonta city from Romania volunteered joined for this study, with at least 2 years of experience with resistance training. We splitit the sample in two groups, one experiment groupe (GExp) of 15 subjects (age = 18 ± 1.4 years; body-mass = 74 ± 5.1kg; body-height = 177 ± 5.3 cm; BMI = 23 ± 0.14) and 15 subjects in control groupe (GCtrl) (age = 19 ± 1.3 years; body-mass = 74 ± 10 kg; body-height = 179 ± 1,2 cm; BMI = 22 ± 0.25). Subjects were experienced with RT and were asked to refrain from any additional physical training during the experimental period. They have confirmed that they do not use anabolic steroids or any other illegal agents known to increase muscle size. Written informed consent was obtained from each participant after a thorough explanation of the testing protocol, the possible risks involved, and the right to terminate participation at will.

Training program, subjects were randomly divided into two groups, an experimental group (GExp) and a control group (GCtrl). Subjects from the GCtrl group carried out an 12-week resistance training or strength training, program consisting of 4 sets of 8 exercises performed 4 times per week. On Monday and Thursday, participants performed an upper-body workout, while on Tuesday and Friday they performed a lower-body workout, for a total of 48 RT and ST sessions. Upper body exercises in GCtrl group included latpull down, bench-press, pendlay row, shoulder press, dumbbell fly and dumbbell pull-over, while the lower body exercises included back squat, deadlift, leg press, hip thrust, leg extension and leg curl. Training load was linearly periodized by reducing the number of repetitions per set every 2 weeks, from 12RM to 6RM. See Table 1 for more details.

Subsects from GExp group they did as well a RT program with the same duration and sessions per week as GCtrl, but with exercises randomly chosen each session from a c database of 70 tipe of exercises.

All subjects took part in at least 95% of the training sessions.

Anthropometric measurements, height (cm), with help of a tallyometer or a tape measure, a scale graduated in cm can be glued to the wall and, at least, with subdivisions of 0.5 cm, body weight (kg), it is recorded in kg and sub-units of kg (from hundredths to hundredths of grams). Body Mass Index (BMI) was calculated as follows: total body mass (in kg) / stature (in m^2)

Body composition using InnerScan Body Composition Monitor, Tokyo, Japan, this device is safe, fast, portable, non-invasive and monitors segmented body composition analysis, differentiating between fat and muscle. Tanita's accuracy, innovation and durability are backed by extensive clinical research and an independent medical advisory board. Here we were shown both the adipose tissue in percentages and in kg, the muscle mass of these in percentages and kg, the hydration they had in the body, the bone mass, visceral fat , the degree of obesity, but also the metabolic age at which the subjects were functioning and where everything had an optimal value. We measured the circumference using a centimeter tape in (cm), neck circumference, chest circumference, abdominal circumference, suprailiac circumference, arm and forearm circumference, thigh and calf circumference, we mesurd 5 times.
Tests for measuring force: beanch press 10 RM test, dead lift 10 RM test, squat 10 RM test, Pull up max rep test, dips max rep test. On the day of the tests, the subjects had no other sports activities, apart from the daily routine

Statistical analyses, data are presented as mean with standard deviations (SD). An independent samples T-test was carried out on pre-intervention muscle thickness data to check for potential differences between groups. Cohen's d effect size (ES) with 95% CIs were calculated to analyze the magnitude of the potential pre-post intervention differences, both within and between groups. The following criteria were employed for interpreting the magnitude of the ES: trivial (<0.2), small (0.2–0.6), moderate (0.6–1.0) and large (>1.0). All calculations were performed using JASP 0.9.2 for Mac (University of Amsterdam, Netherlands). The level of significance was set as $p< 0.05$.

RESULTS

Characteristics of the subjects, we cannot observe major differences between the initial and final testing in age and Hight (table 1), the subjects gained weight from 74 ± 5.1 to 77 ± 4.9 in GExp and 74 ±10.0 to 75 ± 8.8 GCtrl, BMI also increased in both groups from 23 ± 0.14to 23 ± 0.14 in GExp and 22 ± 0.25 to 23 ± 0.22 GCtrl,

Table 1. Characteristics of the subjects

	GExp		GCtrl	
	IT ± SD	FT ± SD	IT ± SD	FT ± SD
Age (**year**)	18 ± 1.4	18 ± 5.4	19 ± 1.3	19 ±4.1
Hight (cm)	177 ± 5.3	178 ± 1.2	179 ±1.2	180 ±1.2
Body-mass (kg)	74 ± 5.1	77 ± 4.9	74 ±10.0	75 ±8.8
BMI	23 ± 0.14	24 ± 0.14	22 ± 0.25	23 ± 0.22
IT = initial test, **FT** = final test**, BMI =** Body Mass Inde**x**				

Body composition, in the initial testing, the experimental group obtains in the initial testing an average of 18 ± 4.02 % of adipose tissue in the final testing we obtain an average of 17 ± 4.9 % adipose tissue, GCtrl obtains an average of 12 ± 3.73 % of adipose tissue and in the final testing obtains an average of 12 ± 3.73 % of adipose tissue, masscle mass the GExp obtains an average of 61 ± 5.8 kilograms of muscle mass during the initial testing and in the final testing we obtain an average of 65 ± 6.2 kilograms of muscle mass, GCtrl obtains an average of 41 ± 10.74 kilograms of muscle mass, and during the final testing it obtains an average of 45 ± 10. 47 kilograms of muscle mass, bone mass GExp obtains an average of 3265 ± 249 kilograms of bone mass at the initial tests, and in the final tests we obtain an average of 3267 ± 249 kilograms of bone mass, GCtrl in initial tests obtains an average of 3075 ± 340 kilograms of, and in the final tests it obtains an average of 3077 ± 341 kilograms of mass, for visceral fat, the device we used shows us this indicator in 5 levels, level 1 being without any risk, our subjects having nickel 1 both at the initial and final testing, we must take into account that our subjects are subjects fitness practitioners

Table 2. Body composition

	GExp		GCtrl	
	IT ± SD	FT ± SD	IT ± SD	FT ± SD
adipose tissue (%)	18 ± 4.02	17 ± 4.9	12 ± 3.73	12 ± 3.73
muscle mass (kg)	61 ± 5.8	65 ± 6.2	41 ± 10.74	45 ± 10. 47
bone mass (kg)	3265 ± 249	3267 ± 249	3075 ± 340	3077 ± 341
Visceral fat (lvl)	1 ± 0	1 ± 0	1 ± 0	1 ± 0
IT = initial test, **FT** = final test**,**				

Tests, the experimental group records in the IT an average of beanch press (kg) 63 ± 7.1, and in FT 76 ± 6.1 kilograms, Ctrl group it obtains in IT an average of 55 ± 10.2 kilograms, in FT 65 ± 9.763 kilograms, dead lift (kg) Exp group obtains an average of 58 ± 13 kilograms at IT, and 77 ± 15 kilograms in FT, Ctrl group obtains in IT 50 ± 14.9 kilograms, FT 63 ± 12.7 kilograms, squat (rep) Exp group obtains an average of 8 ± 3 repetitions, and 16 ± 5.7 repetitions in FT, Ctrl group obtains in IT 6 ± 3.4 repetitions and at FT 12 ± 3.3 repetitions, pull up max (rep) Exp group obtains 10 ± 2.8 repetitions, and 23 ± 6.9 repetitions at FT, Ctrl group obtains in IT 10 ± 6.1 repetitions, FT 16 ± 5.6 repetitions, dips max (kg) Exp group obtains an avarage of 56 ± 13.4 kilograms, and 83 ± 20.1 kilograms in FT, Ctrl group obtains IT 56 ± 20.1 kilograms, in FT 16 ± 5.6 kilograms (table 3).

Table 3. The avarage of physical test

	GExp		GCtrl	
Tests	IT ± SD	FT ± SD	IT ± SD	FT ± SD
beanch press **(kg)**	63 ± 7.1	76 ± 6.1	55 ± 10.2	65 ± 9.7
dead lift **(kg)**	58 ± 13	77 ± 15	50 ± 14.9	63 ± 12.7
Squat (rep)	8 ± 3	16 ± 5.7	6 ± 3.4	12 ± 3.3
Pull up max **(rep)**	10 ± 2.8	23 ± 6.9	10 ± 6.1	16 ± 5.6
dips max **(kg)**	56 ± 13.4	83 ± 20.1	56 ± 20.1	72 ± 23.3
IT = initial test, **FT** = final test				

Effect size (ES) the experimental group obtains a high ES value, namely 1.9 for the beanch press test with the chest barbell, and the control group obtains an average value, namely 0.7. For the barbell squat test, the experimental group obtains a large ES namely 0.14 and the control group obtains a large effect namely 0.8. For the traction test at the fixed bar g. Experiment obtains a high ES namely 1.8 as well as in the case of the control group but the value is 1.7. For the test of parallel push-ups g.

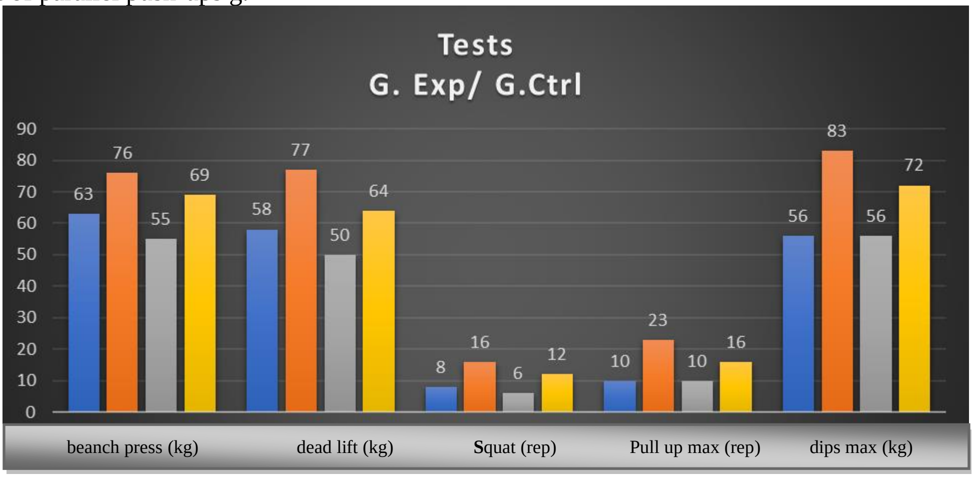

Figure 1. The avarage of physical test

The experiment obtains a high EF of 2.6 and the control group also obtains a high EF with the value of 1 and for the test of straightening with the standing barbell g. The experiment obtains a high EF of 1 and the control group obtains a certain average EF, 0.6. (fig. 2)

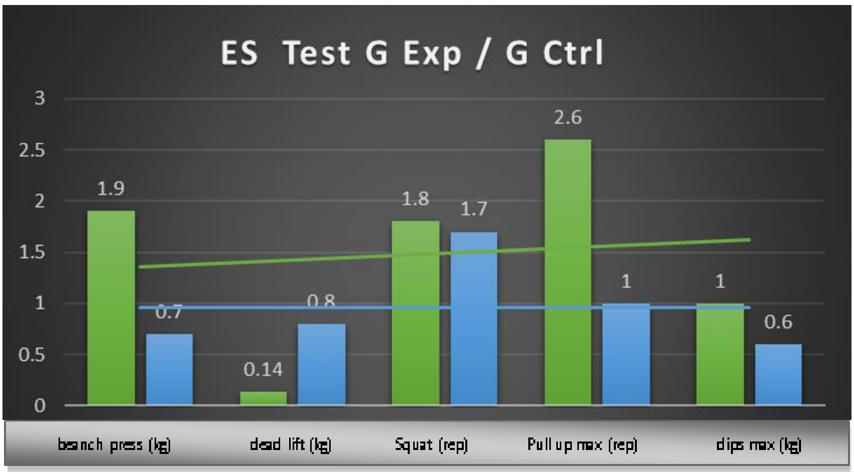

Figure 2. Effect size in physical tests

Effect size (ES) on segment circumference measurements in the case of the experimental group we obtain an ES of 0.6 and the control group obtains a value of 0 for the neck perimeter, for the chest perimeter in the experimental group we obtain an ES value of 1.5 and for the control group a value of 0.2, the abdominal circumference has an ES value of 0.2 and in the case of the control group we have the value 0, the iliac circumference has an ES value of 0.2 for the experimental group and for the control group the value is 0. The arm circumference has a value of 1.5 for the experimental group and 0.3 for the control group, the forearm perimeter has an ES value of 1.5 for the experimental group and for the control group the value of 0.5. The thigh circumference for the experimental group has an ES value of 0.7 and for the control group the value of 0.2, the calf circumference has an ES value of 0.9 and the value for the control group is 0.

In case of experimental groups, the ES value is medium for neck circumference, high for chest circumference, low for abdominal circumference, low for iliac circumference, high for arm and forearm circumference, medium for thigh circumference and high for calf circumference.

In the control group, ES value is small for neck circumference, small for chest circumference, small for abdominal circumference, small for iliac circumference, medium for arm circumference, medium for forearm circumference, small for thigh circumference and small for calf circumference (Fig. 3).

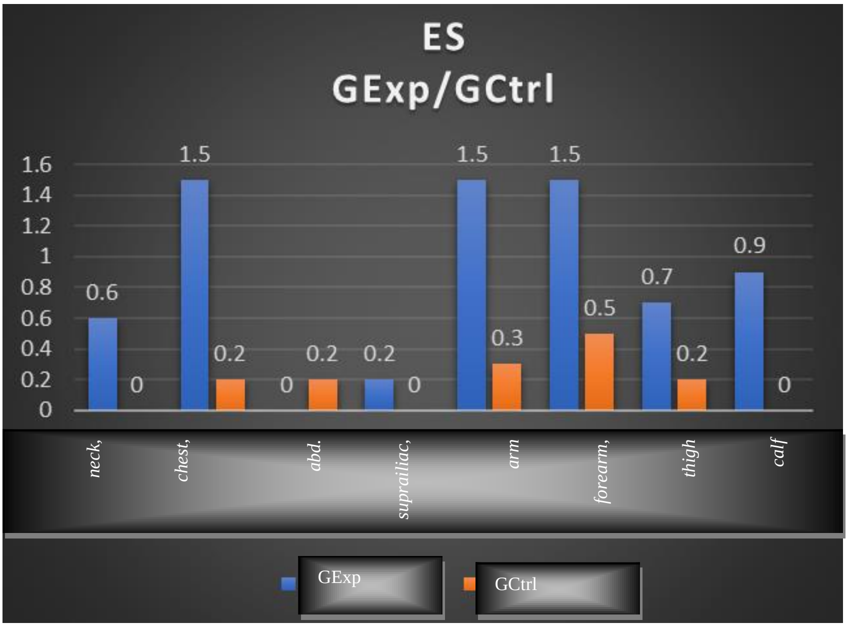

Figure 4. Effect size, circumference measurements

CONCLUSIONS AND DISCUTIONS

The main goal of this study was to investigate the impact of random exercise selection and range of repetitions on MT, body composition and strength.

We can see a progress after our study, the seame resolts we can observ in 2 sutdies of Fonesca from 2014 through this study, researchers investigated the correlation between exercise modification and increases in strength and muscle mass by measuring the transverse diameter of the thigh muscles and using the 1 MR test. Depending on how they used exercise, they divided the 49 subjects into 5 groups: constant intensity and constant exercise (CICE), constant intensity and varied exercise (CIVE), varied intensity and constant exercise (VICE), varied intensity and varied exercise (VIVE) and control group (C). Following the final results of the study, the cross-sectional area of the whole quadriceps muscle (CSA) increased significantly in all experimental groups from the initial testing to the final testing, in both the right and left leg: CICE: 11.6 and 12.0% ($p < 0.0001$); CIVE: 11.6 and 12.2% ($p < 0.0001$); VICE: 9.5 and 9.3% ($p < 0.0001$) and VIVE: 9.9 and 11.6% respectively ($p < 0.0001$). Comparisons between groups demonstrated that all experimental groups increased quadriceps cross section compared to group C ($p \leq 0.02$). There were no +differences in muscle CSA for group C after training ($p > 0.05$).(Fonseca et al. 2014b)

Also Eneko Baz-Valle in 2019 shows both conditions promoted large, statistically significant increases in the bench press and back-squat 1 repetition maximum without differences between groups. Muscle thickness (MT) measures for the individual quadriceps showed large, statistically significant increases in of the vastus lateralis and rectus femoris for both conditions, with no observed between-group differences. Although no between-group in MT were noted for the vastus intermedius, only the CON displayed significant increases from baseline. Participants in EXP showed a significant, moderate improvement in the intrinsic motivation to training, while participants in the CON group presented non-significant decreases in this variable..(Baz-Valle et al. 2019)

Rauch et al., 2020 who compared performing a predetermined list of exercises to self-selecting exercises based on individual preferences. Findings showed no between-group differences in LBM (as measured by DXA), although only the group that self-selected exercises showed significant increases from pre- to post-study. These results somewhat deviate from those in our study.

Our study had a few limitations that should be acknowledged. Finally we can compare the test measurements of the two groups in terms of effect size (ES), the experimental group has in terms of perimetry, 6 perimeters that have a biger effect size compared to the control group has effect sizes " medium' or 'small'.

For the force measurement tests the experimental group obtains 4 biger effect sizes and the control group obtains 5 biger effect sizes.

Looking at the perimetry graphs, the experimental group manages to outperform the control group in terms of centimeter gain and centimeter loss for iliac and abdominal circumferences.

As for body composition, the experimental group obtains higher scores and changes than the experimental group.

Thus, having said that, those who used the muscle confussion method experienced more consistent changes in body composition and centimeters gained on the perimetry side compared to the control group, instead on the strength side, even if the difference is only 1 effect size we can say that those who did not change their training had a higher ES than those who changed their training plans.

One thing observed during the study is that those who changed the workouts experienced a more pronounced "pumping" sensation which generated more enthusiasm and interest during the workouts compared to those who stayed with the same workout and supported at some point that training is boring and tedious.

We can said that, the training method can be considered to be effective in terms of gaining muscle mass and losing fat, and even for the development of several manifestations of strength motor quality.

Finally we can say that the hypothesis of the present study is confirmed.

We can say that, the rotation of exercises was performed randomly, without attention to individual needs and abilities. Individualized programming in which exercise selection is carefully manipulated to account for biomechanical, physiological, and anthropometric factors may further enhance muscle adaptations.

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