COMPARISON BETWEEN TWO METHODS OF VARIABLE RESISTANCE TRAINING ON BODY COMPOSITION, MUSCULAR STRENGTH AND FUNCTIONAL CAPACITY AMONG UNTRAINED MALES

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Abstract

Several studies have shown a positive association between variable resistance training (VRT) and improvements in muscular performance. However, the effects of VRT on body composition among untrained individuals remain unclear. The objective of this study was to examine the comparison between of methods of VRT on body composition, muscular strength and functional capacity among untrained male adults. Fifty healthy untrained males (age: 21.5 ± 1.95 years) were selected randomly and assigned into three groups: combined weight and chain (WC), combined weight and elastic band (WE), and free-weight (CG). All three groups completed 12 weeks of high intensity resistance training (70-80% of one-repetition maximum) with three sets of 8-12 repetitions two times per week. Approximately 65% of the whole resistance was provided by free-weights, while the other 35% of the resistance was provided by chains and elastic bands for the WC and WE groups, respectively. Dependent variables including body composition, muscular strength and functional capacity using bioelectrical impedance analyzer, one-repetition maximum and maximum repetitions to muscular fatigue were measured, respectively in pre-test, post-test 1 (week 6) and post-test 2. Significance level was set at $P < 0.05$. No differences existed among all groups at baseline for depended variables. A mixed model ANOVA with repeated measurements analysis revealed that although there were not significant differences in body composition among the groups ($P > 0.05$), all groups showed a significant reduction in fat mass and significant increase in fat-free mass during and after the intervention ($P = 0.0001$), and these differences were insignificantly greater in WE and WC groups compared with CG group. Furthermore, all three groups showed significant improvements in muscular strength and functional capacity during and after intervention ($P = 0.0001$), and muscular strength and functional capacity were greater in WE and WC groups compared with the CG group, but there were not significant differences in muscular strength and functional capacity between WE and WC groups. However, the WE group showed insignificantly more improvement in muscular strength and functional capacity compared with the WC group during and after the intervention. The results of this study show that VRT has a slightly better effect than free-weight to improve body composition during and after 12 weeks intervention. Also, WE training had a slightly better effect than WC training in improving muscular strength and functional capacity during and after 12 weeks of VRT among untrained male adults.

Keywords: Bioelectrical impedance analyzer, combined weight and chain, combined weight and elastic band, maximum repetitions, one-repetition maximum, variable resistance training

Introduction

Recently, resistance training involving the attachment of elastic bands and chains with weights has been widely recognized and increasingly popular for enhancing muscular power and strength among athletes, but not among untrained people (Ghigiarelli et al., 2009; Larson et al., 2007; McCurdy, Langford, Ernest, Jenkerson, & Doscher, 2009; Shoepe, Ramirez, Rovetti, & Kohler, 2011). When training with weights or weight-machines, the amount of resistance on the joints is constant throughout the exercise, thus increasing the resistance during traditional isotonic resistance training via two methods: (1) by adding the load of chains to the barbell or (2) by attaching an elastic band to the barbell (Ghigiarelli et al., 2009). These methods are known as variable resistance training (VRT) and have been applied to traditional lifts and evaluated for the bench press and the squat (Bellar, Muller, & Barkley, 2011). When using a VRT technique, the resistance is reduced at the weakest points in the movement range and raised at the strongest points. Theoretically this will fully train the muscle if it is forced to act at higher constant percentage of its capacity throughout each point in its total movement range (Wilmore, Costill, & Kenney, 2008). However, a great number of individuals are beginning to do resistance training, but most of them stop training or turn to using illegal ergogenic aids because of a lack of improvement in body composition and progression in muscular function (Brzezianska, Domanska, & Jegie, 2014; Yager & O’Dea, 2014).

There are two methods of VRT: combined weight and chain (WC), and combined weight and elastic band (WE) (Ghigiarelli et al., 2009). At present, the most effective method remains unclear. It is important to find out which one of VRT methods is the most effective method to improve body composition, muscular strength and functional capacity in untrained individuals. In addition, most VRT studies focus on muscular strength and power (Anderson, Sforzo, & Sigg, 2008; Bellar et al., 2011; Colado et al., 2010; Ebben & Jensen, 2002; Ghigiarelli et al., 2009), and there are few studies focusing on developing and improving body composition and muscular functional capacities other than strength and power (Colado & Triplett, 2008; Ghigiarelli et al., 2009; Kim, 2004; Kwon et al., 2010; Thiebaud et al., 2013).

A decrease in fat mass (FM) due to resistance training has been observed in many studies (Sillanpää et al., 2009; Sipila & Suominen, 1995), and a majority of studies have demonstrated that subjects who are not trained show better performance than those who are trained in percentage of body fat reduced, while causing some decrease in the level of intramuscular fat due to resistance training (White, 2011). Variable resistance training can raise energy demands by increasing fat-free mass (FFM) and increasing metabolically active tissue. It is well accepted that this method of training has been widely recognized to significantly affect body composition (White, 2011). There are few studies that have compared WC and WE training (Ebben & Jensen, 2002; Ghigiarelli et al., 2009). Despite WE training, a few researchers have used WC training on muscular function results, because the heavy nature of chains influences the majority of research in this area using WC among athletes not among untrained individuals (Ebben & Jensen, 2002; Ghigiarelli et al., 2009).

Regardless of what has been mentioned above, not many investigations have been conducted to determine the effectiveness of the best method of VRT (Ghigiarelli et al., 2009). In a study by Colado et al. (2010the diverse resistances using combined weight and elastic band, combined weight and chain, and free-weights were investigated over a period of seven weeks, and no differences were found in using them interchangeably. However, some studies have found that training with attached elastic bands to weights produced better results compared to using weights only (Conlin, 2002; Naderi, Kazemzadeh, & Banaiifar, 2014). Also, another study by Colado and Triplett (2008) examined the usage of elastic band and the results showed no distinguishable differences, although at the beginning of the study there were more physiological superiorities like strength.

With determining the most effective method of VRT, if VRT shows to be an effective program for improvement of body composition and muscular performance, it can be introduced to the Ministry of Health, Ministry of Sport, health centers and fitness institutes and also using in physical education classes of schools and universities for health promotion. However, it is important to determine which of the VRT methods is more effective on body composition, muscular strength and functional capacity among untrained subjects.

Methodology

Participants and Experimental Overview

This study is a randomized controlled trial with two-arm (2 interventional groups and 1 control group). The dependent variables were body composition, muscular strength and functional capacity. The Dependent variables were measured three times during the intervention, which were at baseline, post-test 1 (week 6) and post-test 2 (week 12). The entire participants consisted of fifty four apparently healthy untrained male volunteers (with no previous experience performing resistance training) with normal BMI (body height: 177.3 ± 3.84 cm, body mass: 70 ± 5.16 kg) between 18 and 24 years of age (age: 21.5 ± 1.95 years) recruited from a fitness gym under supervision of Ministry of Sport in Iran. The sample size was determined using Cohen's interpretation guideline (1988) and a formula to calculate intervention group size, as suggested by Chan (2003), on the basis of the results of the maximal muscular strength performance in Naderi, Kazemzadeh, and Banaiifar (2014). All participants completed a health history questionnaire to ensure that they were healthy enough and eligible to perform all exercises in the study. They were excluded if they had metabolic, cardiovascular or musculoskeletal diseases, or had ingested any medications, anabolic steroids or nutritional supplements known to affect resistance training performance at least one year before this study. The participants were individually assigned randomly to one of the three groups which were: 1) combined free-weight and chain group (WC) (n=18), 2) combined free-weight and elastic band group (WE) (n=18), and 3) free-weight control group (CG) (n=18). Two participants from the free weight control group and two participants from WC and WE groups (one participant from the WC group and one participant from the WE group) were doped out during the study for several personal reasons. So, the study continued with 16 subjects for free weight control group and 17 subjects for each of WC and WE groups, respectively. During the study the participants were not allowed to start any additional exercise programs. The subjects were adequately informed about the risks and benefits involved in the study and provided written informed consent to participants. This study was approved by the research ethics committee, Universiti Putra Malaysia.

Anthropometry

The body height and mass of all participants were measured with a wall-mounted stadiometer and Bioelectrical Impedance Analyser (Tanita- SC-330 MA, USA), respectively. The body mass index (BMI) was calculated by dividing body mass (kg) by body height (m) squared (kg/m^2).

Body Composition Measurement

Overall body composition was recorded using a Bioelectrical Impedance Analyser (Tanita- SC-330 MA, USA). The relative values of FM and FFM (kg) were used in all analyses. Beck (2007), mentioned that the Tanita 330 model was suitable for valid body composition measurement of adults aged 18 to 25 years with normal to overweight BMI and with high reliability of bioelectrical impedance (R = 0.99). This analyzer measures individual body mass readings for the trunk, upper and lower body, and also offers some parameters of body composition, including BMI, FM and FFM. The participants were requested to fast for four hours before the testing and refrain from any form of exercise 24 hours prior to that. The pre- and post-training assessments were scheduled at least 72 hours before the first training session and after the final training sessions, respectively. They were instructed to urinate 30 minutes before the testing and also not to drink water before that. Following the recording of their age, height and gender, the analyzer system was programmed and the participants had to stand on the anterior and posterior electrode plates in their bare feet, and with minimal clothing, gripping with their left and right hands. The gap between the hands and trunk was 30 cm. The participants were required to stand still on the electrodes plate while the analyzer was turned on and off. While the tests were being performed, the participants were verbally encouraged. On completion of the tests, all the parameters were printed by the analyzer. Pre- and post-training assessments were scheduled at the same time of the day in order to limit confounding variables. The analyzer was calibrated using Beck's (2007) guidelines and all subjects were assessed in compliance with the guidelines proposed by American College of Sports Medicine (Dwyer & Davis, 2008).

Maximal Muscular Strength Measurement

The one-repetition maximum (1-RM) was used for the assessment of the muscular strength. Maximal muscular strength was evaluated using the overhead press machine. The relative value of muscular strength (kg) was used in all analyses. The pre- and post-training assessments were scheduled at least 48 hours before the first training session and after the final training sessions, respectively. After a light 5-minute warm-up, the 1RM test commenced. The initial pre maximum set was carried out with the subject executing 8-10 repetitions at 40-60% of estimated 1RM. Following a short rest, the subjects carried out a set of 3-5 repetitions (75% of estimated 1 RM). Then, after another 2 minutes' rest, the subjects went through a set of 1-3 repetitions (80-90% of estimated 1RM). Upon completion of these sets, the participants were rested for four minutes and then proceeded with the first attempt at the 1RM. Should the lift be successfully executed, there was another rest period of four minutes and the weight was increased and another 1RM was attempted. Should this next attempt be unsuccessful, a second attempt at a 1RM with a lowered weight was made after a four minutes rest period. Only successful attempts within the approved range of motion were considered. This procedure continued until the participants failed to complete a lift. and the final weight that the participants were able to lift successfully was noted as the maximal muscle strength score. Pre- and post-assessments were scheduled at the same time of the day in order to limit confounding variables. Verbal encouragement was given on all tests and participants were finished with the light general active cool-down involving stretching for upper and lower body muscle groups and pedaling on a cycle ergometer at a light resistance for five-minute. All test procedures were based on American College of Sports Medicine (Thompson, Gordon, and Pescatello, 2010), Shiau, Tsao, and Yang (2018), White (2011), Heyward (2014), and Shibata, Takizawa, and Mizuno (2015).

Maximal Muscular Functional Capacity Measurement

The maximum repetitions test (MR) was used for estimating of the dynamic muscular functional capacity by performing repetitions to muscular fatigue using weight machines. Maximal muscular functional capacity was evaluated using the overhead press machine. The relative value of muscular functional capacity (number of repetitions) was used in all analyses. The pre- and post-training assessments were scheduled at least 24 hours before the first training session and after the final training sessions, respectively. After a light 5-minute warm-up, the MR test commenced. For measurement of muscular functional capacity in untrained participants, previous studies were utilized at 60% load of 1RM (Adnan, Kadir, Yusof, Mazaulan, & Mohamed, 2014). The MR test processed with performed maximum repetitions at 60% of estimated 1RM in this study. Only repetitions completed within the approved range of motion were considered. Pre- and post-assessments were scheduled at the same time of the day in order to limit confounding variables. Verbal encouragement was giving on all tests and participants were finished with the light general active cool-down involving stretching for upper and lower body muscle groups and pedaling on a cycle ergometer at a light resistance for five-minute. All test procedures were based on American College of Sports Medicine procedures (Thompson et al., 2010), Shiau et al. (2018), Adnan, Kadir, and Yusof (2014), and White (2011).

Resistance Training Intervention

The training protocols included combined weight and chain (Figure 1), combined weight and elastic band (Figure 2) (Thera-Band: Resistance Band, Singapore), and free weights (control group). Participants performed their special training program assigned to them for 12 weeks. The WC group performed the training program with free-weight and chain, The WE group performed it with free-weight and elastic band, and the CG group performed it with free-weights alone. For the WE and WC groups, approximately 65% of the whole resistance were provided by free-weights and approximately the other 35% of the resistance were provided by elastic bands and chains, respectively (assessed at the top of the range of motion) (Shoepe, Ramirez, & Almstedt, 2010), and all of the resistance were acquired from free-weights for free-weight group. The training program included the following exercises: chest press, squat, overhead press, barbell dead lift, barbell elbow flexion, and barbell triceps extension. All training programs were based on Naderi et al. (2014), Shoepe, Ramirez, Rovetti, and Kohler (2011), and White (2011). Until the end of week 12, the participants trained at 70%-80% of their estimated 1RM with three sets of each exercise for two-three days per week. Participants had two minutes rest periods between sets. The training routines are presented in Table 1. Prior to and following the training sessions, the participants had a five-minute warm-up and another five minutes to cool down, which involved pedaling on a cycle ergometer and stretching of all the major muscle groups. At the end of weeks 6 and 12, post-test 1 and post-test 2 were processed during a separate session, respectively for the purpose of measuring body composition, muscular strength and functional capacity.

Figure 1: Combined weight and chain system

Figure 2: Combined weight and elastic band system

Table 1: The training routines

Weeks 1-7	WC group	WE group	CG group
Weeks 1-2 Repetitions	8	8	8
Weeks 3-4 Repetitions	10	10	10
Weeks 5-6 Repetitions	12	12	12
Week 7 Repetitions	8	8	8
Frequency	2 Days/Week	2 Days/Week	2 Days/Week
Weeks 1-2 Intensity	70% of 1RM	70% of 1RM	70% of 1RM
Weeks 3-4 Intensity	70% of 1RM	70% of 1RM	70% of 1RM
Weeks 5-6 Intensity	70% of 1RM	70% of 1RM	70% of 1RM
Week 7 Intensity	80% of 1RM	80% of 1RM	80% of 1RM
Sets	3	3	3
Weeks 8-12	WC group	WE group	CG group
Week 8 Repetitions	8	8	8
Weeks 9-10 Repetitions	10	10	10

Weeks 11-12 Repetitions	12	12	12
Frequency	2 Days/Week	2 Days/Week	2 Days/Week
Week 8 Intensity	80% of 1RM	80% of 1RM	80% of 1RM
Weeks 9-10 Intensity	80% of 1RM	80% of 1RM	80% of 1RM
Weeks 11-12 Intensity	80% of 1RM	80% of 1RM	80% of 1RM
Sets	3	3	3

Elastic Band Resistance Calibration

Most elastic bands are typically 41 inches (1 meter) long and researchers need to know how much resistance the elastic band is imparted onto the barbell during full extension of movements. The exact resistance the elastic bands exert is determined by hanging weights from the elastic band to stretch it to the same length that it will be during the specific exercise (The linear encoder) (Shoepe et al., 2010). The linear encoder has previously been validated as a reliable method of recording and registering power output (Hansen, Cronin, & Newton, 2011; Ravier, 2011). It has been used in previous research on the bench press (Tillaar, Saeterbakken, & Ettema, 2012). The linear encoder is attached to the barbell and place on the floor directly underneath it, in order to establish a vertical line so that distance and power output can be accurately recorded.

The elastic bands are anchored at the bottom of the barbell to provide greatest possible tension at the peak of the lift while the least tension is at the lowest point of the lift. The attachment of elastic bands to the barbell and anchoring the elastic bands to the floor gives highest possible tension because the elastic bands are pulled tight at the peak of the lift. For example, as the lifter commences the descent to the floor in performing a squat exercise, the tension of the elastic bands will decrease the total barbell load. Elastic bands progressively add overall resistance during the concentric part of each repetition. On the other hand, during the eccentric part of each repetition, resistance gradually decreases in line with the descent.

In this research, the Thera-Band was used. Several studies have reported that the Thera-Band is safe and appropriate for training participants (Colado et al., 2012; Colado & Triplett, 2008; Ebben & Jensen, 2002; Wallace, Winchester, & McGuigan, 2006). Elastic bands resistance at various lengths were assessed following the protocol presented by Shoepe, Ramirez, and Almstedt (2010), each of the elastic bands were individually attached to the top of a squat rack. Resting length was measured as shown in Figure 3. Different weights were attached to the free end and the deformation measures in centimeters were recorded. This was repeated with all elastic bands in order to compile a chart of tension (in kg) for several relevant band lengths (41 - 225 cm). Since the elastic bands were looped under the specific exercise equipment and attached to the barbell, the elastic bands were long enough to provide adequate tension throughout the lift (Shoepe et al., 2010).

Figure 3: Calibration of elastic bands using protocol by Shoepe et al. (2010)

Chains Resistance Calibration

Chains produce resistance through the weight of each link. As they hang from the bar and pool on the floor, the only extra weight they produce is from the links between the bar and the floor. With continued lifting of the bar, more links are raised from the floor and add weight to the bar. "Elastic bands" are viscoelastic and supply a curvilinear increase in resistance to the lifter-bar when stretched. In contrast, chain resistance goes up linearly as the links are lifted vertically (Berning & Coker, 2004; Simmons, 1999).

A bunch of chains linked to each side of a barbell. In this study, six chains consisting of "training chains" (two on each side), two are considered as "support chains" (one on each side) and two quick links were used. The support chain goes thru any link in the training chain and connects to form a complete loop that slips over the ends of the bar (Figure 4) (Ebben & Jensen, 2002). As the bar is lifted, the chain weight continues to increase, with more and more chain lifted off the floor. The weight that is lifted therefore increases. Furthermore, when a lifter commences the descent to the floor in the process of performing WC training, the barbell is lowered and additional chain links accumulate on to the floor, reducing the overall weight of the load. The extra length of training chains allow adjustment up to a full standing length of 8 feet or adjust as short as researcher prefers.

In this study, approximately 65% of total resistance was provided by free-weights and the other 35% of the resistance was provided by chains (assessed at the top of the range of motion) for combined weight and chain group. The height of each lift in concentric phase was measured at the top of the range of motion in chain group for each participant, and the average of the height of each lift was calculated. Then, as initial intensity for starting the intervention, the 70% of 1RM for all exercises calculated based on 1RM average of all training exercises in baseline. Therefore, the appropriate bunch of chains were calibrated based on the height of each lift and initial training intensity to exert approximately 35% resistance on the barbell for each exercise at the top of the range of motion. Different chains with different sizes and links weight were used for all exercises in this study. Chains were managed, lengthen and shorten such that they exerted approximately 35% resistance on the barbell for each exercise at the top of the range of motion.

Figure 4: The support chain goes thru any link in the training chain and connects to form a complete loop that slips over the ends of the bar

Research Finding

All data have been expressed in terms of means ± standard deviation (SD). Data were tested for normal distribution with Skewness and Kurtosis and for homogeneity of variances with Levene's test (Byrne, 2016; Garson, 2012; Meyers, Gamst, & Guarino, 2016). The variables were analyzed using a mixed model analysis of variance (ANOVA) (3 times x 3 groups) with repeated measurements followed by Bonferroni analysis as post hoc comparisons. The statistical significance was set at $P < 0.05$. The statistical procedures were conducted using Statistical Package for Social Sciences software (SPSS) Version 24 (IBM Company, United States).

Fat mass, fat free mass, muscular strength and functional capacity of the three groups in the baseline are presented in Table 2. No significant differences were evident between the three groups in terms of the fat mass, fat free mass, muscular strength and functional capacity before the training program began ($P > 0.05$). In Table 3, the data shows the means and standard deviation of baseline and post tests for fat mass, fat free mass, muscular strength and functional capacity in all groups.

Table 2: Baseline values of Dependent variables for separate groups

Variables	WC group	WE group	CG group	P value
Fat mass (kg)	15.86 ± 1.6	15.94 ± 2	16.58 ± 0.8	0.37
Fat free mass (kg)	52.28 ± 4	54.23 ± 3.9	54.35 ± 3.8	0.24
Overhead press Strength (kg)	25.14 ± 2.5	23.67 ± 2.5	24.06 ± 2.3	0.21
Overhead press Functional capacity (repetitions)	10.05 ± 0.8	9.47 ± .7	9.31 ± 1.7	0.17

*indicates significance at $P < 0.05$

Table 3: Means and standard deviations of Dependent variables for separate groups

Variables		WC group		WE group		CG group	
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Fat mass (kg)	Baseline	15.86	1.64	15.94	2.05	16.58	0.82
	Posttest1	15.38	1.62	15.51	2.03	16.22	0.78
	Posttest2	15.10	1.59	15.24	2.01	16.01	0.80
Fat free mass (kg)	Baseline	52.28	4.05	54.23	3.92	54.35	3.86
	Posttest1	52.82	4.05	54.79	3.90	55.15	3.99
	Posttest2	53.66	5.46	55.65	5.13	55.35	4
Overhead press strength (kg)	Baseline	25.14	2.5	23.67	2.5	24.06	2.3
	Posttest1	29.41	2.4	29.11	3.1	28.28	2.9
	Posttest2	34.85	2.7	35.73	4	32.03	4
Overhead press functional capacity (repetitions)	Baseline	10.05	0.89	9.47	0.79	9.31	1.70
	Posttest1	12.11	0.92	11.94	0.96	11.37	1.62
	Posttest2	13.41	0.91	14	1	12.50	1.75

Body Composition Measurement

The results of FM and FFM are displayed in Table 4. The analysis of data demonstrated that in body composition, there were significant decreases in FM among post-tests 1 and 2 in all groups ($P = 0.0001$). But, there was not a significant difference in FM among all three groups in post-tests 1 and 2 ($P > 0.05$). However, FM decreased insignificantly more in WE and WC groups compared with CG group among post-test 1 and 2.

Likewise, there was a significant increase in FFM among post-tests 1 and 2 in all groups ($P = 0.0001$). But, there was not a significant difference in FFM among all three groups in post-tests 1 and 2 ($P > 0.05$). However, FFM increased insignificantly more in WE and WC groups compared with CG group only in post-test 2. In this study the results showed that FM decreased and FFM increased insignificantly more in WE and WC groups compared with CG group during and after 12 weeks of variable resistance training.

Table 4: The results of Mixed Model Analysis of Variance (ANOVA) with Repeated Measurements within and between groups for body composition

Variable	Time		Group		Time * Group	
	F	P value	F	P value	F	P value
Fat mass	607.63	0.0001 *	1.31	0.27	4.32	0.01 *
Fat free mass	12.35	0.0001 *	1.27	0.28	0.35	0.79

*indicates significance at $P < 0.05$

Maximal Muscular Strength Measurement

The results of muscular strength are displayed in Table 5. The analysis of data demonstrated that in muscular strength, there were significant increases in overhead press strength among post-tests 1 and 2 in all groups (P = 0.0001). The result showed that although there was a significant improvement in overhead press strength only for WE group compared with CG group in post-test 2, WC group also showed an insignificant improvement in overhead press strength compared with CG group in post-test 2. On completion of the training program, although there was a more improvement in overhead press strength for WE group compared with WC group in post-test 2, no significant differences were observed between WE and WC groups (P > 0.05). In this study the results showed that muscular strength increased insignificantly more in WE group compared with WC group after 12 weeks of variable resistance training.

Table 5: The results of Mixed Model Analysis of Variance (ANOVA) with Repeated Measurements within and between groups for muscular strength

Variable	Time		Group		Time * Group	
Overhead press strength	F	P value	F	P value	F	P value
	551.75	0.0001*	1.69	0.19	8.37	0.0001*

*indicates significance at $P < 0.05$

Maximal Muscular Functional Capacity Measurement

The results of the muscular functional capacity are displayed in Table 6. The analysis of data demonstrated that in muscular functional capacity, there was a significant increase in overhead press functional capacity among post-tests 1 and 2 in all groups (P = 0.0001). The result showed that although there was a significant improvement in overhead press functional capacity only for WE group compared with CG group in post-test 2, WC group also showed an insignificant improvement in overhead press functional capacity compared with CG group in post-test 2. On completion of the training program, although there was a more improvement in overhead press functional capacity for WE group compared with WC group in post-test 2, no significant differences were observed between WE and WC groups (P > 0.05). In this study the results showed that muscular functional capacity increased insignificantly more in WE group compared with WC group after 12 weeks of variable resistance training.

Table 6: The results of Mixed Model Analysis of Variance (ANOVA) with Repeated Measurements within and between groups for muscular functional capacity

Variable	Time		Group		Time * Group	
Overhead press functional	F	P value	F	P value	F	P value
capacity	401.51	0.0001*	2.67	0.07	5.46	0.001*

*indicates significance at $P < 0.05$

Discussion

This segment examines the essential finding from the present study with those cited in the literature, as well the limitations of the present study and conclusion.

Variable Resistance Training on Body Composition

The findings of this research support the findings by Colado and Triplett (2008), Martins et al. (2015) and Colado et al. (2012). For example, Colado and Triplett (2008), reported that FM decreased and FFM increased significantly after 10-week of VRT for twice a week among sedentary women. In other study by Martins et al. (2015), who indicated that FM decreased and FFM increased insignificantly after 8-week of VRT among untrained males and maybe the short duration of training period was the reason of observing the changes in FM and FFM insignificantly. Whereas elastic band produces isokinetic contraction, in other study by Colado et al. (2012), findings indicated that greater decreases in FM and greater increases in FFM were observed significantly after 10-week of isokinetic VRT.

Variable resistance training provide ideal resistance for the whole range of motion by accommodating the changing length tension relationship of the musculoskeletal system (Baker & Newton, 2005; Zatsiorsky & Kraemer, 2006), and by combining elastic band and chain with free weights; such advantages will be more effective. Variable resistance training produce more pressure in eccentric phase of exercise than free weights, thus, eccentric contraction due to weight and chain, and weight and elastic band is considered an appropriate stimulus as it has greater metabolic efficiency in comparison with concentric contraction, as well as being able to generate higher forces (White, 2011). There are also reports indicating that eccentric exercise in comparison with concentric exercise tends to produce higher and faster increases in muscle strength and functional capacity, eventually improving body composition (Hortobagyi et al., 2000).

Variable Resistance Training on Muscular Strength

A study by Ghigiarelli et al. (2009) compared the effects of WC versus WE training on muscular strength for only 7 weeks among football players. Although both groups showed significant improvements in muscular strength, the differences were not significant between groups. Maybe because the study duration was too short it caused to observe no significant difference between groups in muscular strength. Specially, a study by Mccurdy, Langford, Ernest, Jenkerson, and Doscher (2009), is a study that used only chain resistance to investigate muscular strength changes. They compared effects of training with chains versus free weight on chest press strength. The results showed that there was no significant difference between both groups in chest press strength and the reason of achieved this result may be using chains alone and less resistance that acquired from chain resistance in training protocol (5 - 20 percentage of resistance acquired from chain resistance). Colado et al. (2010), investigated the effects of training with elastic bands versus free weights on muscular strength among untrained individuals. Subjects trained for 8 weeks and the results showed that there was no significant differences between elastic band alone and free weight in muscular strength; both training methods had an equivalent effect on muscular strength. Maybe using elastic band alone in their study caused that Colado et al. (2010), could not find out a significant difference in muscular strength between groups and they should have used combined weight and elastic band training instead of using elastic band alone, because the results of the studies by Cronin, Mcnair, and Marshall (2003), Anderson (2005), Ghigiarelli et al. (2009), Anderson, Sforzo, and Sigg (2008), and Bellar, Muller, and Barkley (2011), indicated if elastic band combined with free weights, it improves muscular strength better than free weights alone.

In a 10-week study by Cronin et al. (2003), subjects trained twice a week using WE training and the results reported that muscular strength increased more in WE group compared with free weight group. Also Anderson (2005), examined the effect of WE training on upper and lower body strength in comparison with traditional weight training among men and women for seven weeks. The results indicated that the WE group showed significant improvements in upper and lower body muscular strength more than free weight group. In other study by Bellar et al. (2011), untrained male subjects trained for 10 weeks with WE training with 15% of resistance acquired from elastic band. The results indicated that WE group gained more strength in chest press exercise compared with free weight group.

This study is one of few long-term studies comparing combined weight and chain versus combined weight and elastic band variable resistance training on muscular strength among untrained males. This study results showed that WE training is more effective insignificantly compared with WC training in improving muscular strength after 12 weeks of VRT, but Ebben and Jensen (2002) and Ghigiarelli et al. (2009) studies, indicated there were no significant differences between WE and WC training on muscular strength. Maybe using a shorter duration and less frequency of training in their studies was the reason that they could not find significant differences between WE and WC training in terms of muscular strength. Several researches have recommended that resistance training duration should be as long as 10 weeks with training frequency of twice weekly.

Elastic band produces isokinetic contraction and isokinetic system controls constant speed throughout the range of motion. As different levels of force are generated by skeletal muscles at various joint angles, isokinetic system matches the force produced by the muscles at each joint angle by controlling speed and causes better improvement in strength (White, 2011). Maybe this is the only advantage of elastic band as compared with chains. In particular, elastic bands are known to generate higher peak force output because of the higher velocity of eccentric muscle contraction due to the elastic bands pulling the barbell downwards at the beginning of the eccentric phase (Anderson, 2005; Cronin, Mcnair, & Marshall, 2003; Wallace et al., 2006). This kind of contraction has a better neuron and muscle adaptability which causes more strength also. On the other hand, it is assumed that combined weight and chain may be a useful method for gaining strength on the basis of the theoretical concept of the muscle-joint relationship. For example, a weight and chain system accommodates a load at weaker joint angles. Researchers have also indicated more benefits from weight and chains turning and swinging during the full range of motion that involves the greater use of stabilization muscles, which is an advantage in comparison with free weights (Berning & Coker, 2004; Simmons, 1999). Variable resistance training enable strength curves of a particular movement to exert maximum force during the whole range of motion (Zatsiorsky & Kraemer, 2006). This may be achieved by altering the resistance training method in an effort to particularly match the strength curve of the exercise movement (Ghigiarelli et al., 2009).

Variable Resistance Training on Muscular Functional Capacity

Based on previous VRT studies, there has been no direct study of VRT on muscular functional capacity, and there is a lack of information pertaining to the effects of VRT on muscular functional capacity. Whereas elastic band produces isokinetic contraction, a study by Gehlsen, Grigsby, and Winant (1984), supported the positive effects of isokinetic resistance training on muscular functional capacity. They trained 40 untrained males for 10 weeks with isokinetic resistance training and results showed that isokinetic resistance training increased muscular functional capacity significantly. On the other hand, Svensson, Gerdle, and Elert (1994), observed greater muscular functional capacity after 6 weeks of isokinetic resistance training compared with free weight. Additionally, another study by Selig et al. (2004) demonstrated isokinetic resistance training increased muscular functional capacity significantly.

Adding elastic band and chain to weights will inflict a great difference in the training patterns. In the concentric phase of the exercise and together with the start of the easier part of the exercise, elastic band and chain amplify the pressure. On the other hand, they increase the velocity of performance in the eccentric phase and gradually decrease the pressure in this phase, which acts as a useful stimulus enhances the muscle adaptability leading to concentric contractions, create more energy hence better muscular metabolic function that causing muscle functional capacity. Studies suggest that there is a positive correlation between the exact speed of eccentrically loaded or lengthened of a muscle, and the greater the resultant concentric force generated (Adnan et al., 2014; Bosco & Komi, 1979). The exact speed of eccentrically loaded of a muscle is an advantage of elastic band compared with chains, because only elastic band produces isokinetic contraction for the muscles and increasing the stretch velocity in the respective movement (Bobbert, Huijing, & Schenau, 1987; Doan, Newton, & Marsit, 2002; White, 2011).

Grimby et al. (1992) examined the effects of eccentric, concentric, and isometric contractions on muscular functional capacity and after 8 weeks the results demonstrated eccentric contraction have a better effect on muscular functional capacity. On the other hand, Yu, Park, and Lee (2013), examined the effects of eccentric and concentric contractions on muscular functional capacity with 32 males who were assigned to either the experimental group that carried out eccentric training, or the control group that executed concentric training for eight weeks, thrice a week. The results indicated that compared to the concentric contraction group, the eccentric contraction group showed significant improvement in muscular functional capacity.

Eccentric contraction enhances the effects of the stretch-shortening cycle (SSC). SSC is a part of practically all dynamic movements that involves a lengthening (eccentric) and shortening (concentric) of the muscle tendon unit during the reversal phase of the movement. It can briefly be said that the higher concentric force generated by the SSC phenomenon in using elastic band, is the result of combining neural reflexes and the ability to use stored elastic band energy in the muscle tendon unit (Stevenson, Warpeha, & Dietz, 2010).

Limitations

Certain variables outside of the gym control exist which could affect the results (i.e. genetics, motivation levels, and muscular soreness and overall fatigue). Genetic factors apparently have a strong influence on how people respond to the exact resistance training protocol. Also some of untrained individuals may perceive a sub-maximal effort instead of perceiving a maximal effort during training because of different motivation levels and/or muscular soreness and overall fatigue with resistance training (Naimo, 2011; Otto & Carpinelli, 2006). But motivation levels of untrained individuals will be increased with exact and complete explanations about advantageous effects of particular physical activity at the beginning of a study (Otto & Carpinelli, 2006). Muscular soreness occurs when a muscle is stretched and microfilaments of the muscle will damaged temporarily due to performing resistance training, but muscular soreness usually disappear within a few sessions of resistance training (Wilmore et al., 2008). In order to control the effects of limitations in this study, before starting the intervention, the participants were given a briefing that explained the advantages of exercise training program.

Conclusion

In summary, VRT is insignificantly more effective in improving body composition compared with free-weights. Also, VRT is significantly more effective in improving muscular strength and functional capacity compared with free-weights, furthermore WE training as a method of VRT, is insignificantly superior compared with WC training in improving muscular strength and functional capacity after 12 weeks of VRT.

The results of this study may be beneficial for untrained individuals who are willing to find a better method of resistance training to reach their primary goals of improving body composition and increasing maximal muscular strength and functional capacity for being healthy and to combat muscular weakness. In addition, this information can also increase the choices of available resistance training methods and encourage participation in workouts that are known to have health benefits. Furthermore, VRT provides more options in exercise prescription for the strength and conditioning practitioners. Also, VRT can be introduced to the Ministry of Sport and Ministry of Health, health centers and fitness institutes and used in physical education classes of schools and universities for health promotion as well.

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