EFFECTS OF 12 WEEKS COMBINED WEIGHT AND CHAIN VERSUS COMBINED WEIGHT AND ELASTIC BAND VARIABLE RESISTANCE TRAINING ON UPPER AND LOWER BODY MUSCULAR STRENGTH AND ENDURANCE AMONG UNTRAINED MALES IN IRAN

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Abstract

Several studies have shown a positive association between variable resistance training (VRT) and the improvement of muscular performance. However, the most effective method of VRT to improve muscular performance in untrained individuals remains unclear. The objective of this study was to examine the effects of two methods of VRT on maximal muscular strength and endurance among untrained male adults. Fifty apparently 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 freeweight (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 and the other 35% of the resistance was provided by chains and elastic bands for WC and WE groups, respectively. Dependent variables including maximal muscular strength and endurance using one-repetition maximum and maximum repetitions to muscular fatigue were measured, respectively, in the pre-test, post-test 1 (week 6) and post-test 2. The significance level was set at $P < 0.05$. No differences existed among all groups at baseline for dependent variables. A mixed model ANOVA with repeated measurements analysis revealed that all groups showed significant improvements in maximal muscular strength and endurance during and after the intervention (P = 0.0001). In WE and WC groups, maximal muscular strength and endurance were significantly greater than CG group during and after the intervention, and there were no significant differences between WE and WC groups in the maximal muscular strength and endurance during and after the intervention. However, the WE group showed an insignificant more improvement in maximal muscular strength and endurance compared with WC group after the intervention (chest press strength: 47.94 ± 4.2 vs. 46.76 ± 4.4 kg, squat strength: 85.29 ± 6.5 vs. 80.73 ± 6.4 kg, chest press endurance: 16.94 ± 1.24 vs. 15.47 ± 1.58 repetitions, and squat endurance: 17.94 ± 0.74 vs. 16.58 ± 1.66 repetitions). The results of this study show that VRT has a significant better effect than freeweight resistance training to improve upper and lower body muscular strength and endurance during and after 12 weeks intervention, in particular, WE training has a slightly better effect than WC training to improve upper and lower body muscular strength and endurance after 12 weeks of VRT among untrained male adults in Iran.

Keywords: 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 become widely recognised and increasingly popular to enhance 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). During 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 can be applied in 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 called variable resistance training (VRT) and have been applied to traditional lifts and evaluated for the bench press and the squat (Bellar, Muller, & Barkley, 2011). In the VRT technique, 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 percentages of its capacity throughout each point in its total movement range (Wilmore, Costill, & Kenney, 2008). While great number of individuals are beginning to do resistance training, most of them stop the training or turn to using illegal ergogenic aids due to a lack of progression in muscular strength (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, which is the most effective remains unclear. It is important to find out which one of VRT methods is the most effective method to improve muscular strength and endurance in untrained individuals. In addition, most of VRT studies focusing 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 have been a few studies focusing on developing and improving muscular endurance rather than strength and power (Ghigiarelli et al., 2009). Few studies have compared WC and WE training (Ebben & Jensen, 2002; Ghigiarelli et al., 2009). Despite WE training, a few researches have used WC training for muscular function results, because the heavy nature of chain influences the majority of research in this area when using WC on athletes, not 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. (2010), the diverse resistance using combined weight and elastic band, combined weight and chain, and free-weights which were investigated over a period of seven weeks showed that there is no difference in using them interchangeably. But in some studies, it has been 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 that there were no distinguishable differences, although at the beginning of the study there were more physiological superiorities like strength.

By determining the most effective method of VRT, if VRT is shown to be an effective programme for improvement of muscular performance, it can be introduced to the Ministry of Health, Ministry of Sport, health centres and fitness institutes and also using in physical education classes of schools and universities for health promotion. However, it is important to determine which VRT method is most effective in improving muscular strength and endurance among untrained subjects.

Methodology

Participants and Experimental Overview

This study is a randomised controlled trial with two-arm (2 interventional groups and 1 control group). The dependent variables were upper and lower body muscular strength and endurance. These 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 the formula to calculate intervention group size 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 they were healthy enough and eligible to perform all exercises in the study and they were excluded if they had metabolic, cardiovascular or musculoskeletal diseases, or ingested any medications, anabolic steroids or nutritional supplements known to affect resistance training performance at least one year prior to the study. The participants were individually assigned randomly to one of the three groups which were: 1) combined freeweight and chain group (WC) (n=18); 2) combined freeweight and elastic band group (WE) (n=18); and 3) freeweight control group (CG) (n=18). Two participants from free weight control group and two participants from WC and WE groups (one participant from WC group and one participant from WE group) were doped out during 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. The subjects were adequately informed about the risks and benefits involved in the study and written informed consent was provided by participants. This study was approved by the research ethics committee, Universiti Putra Malaysia.

Anthropometry

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/m2).

Maximal Muscular Strength Measurement

The one-repetition maximum (1-RM) was used for the assessment of the upper and lower body muscular strength. Maximal muscular strength of upper and lower body was evaluated using the chest press machine and squat machine, respectively. 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 minutes 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). On 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. 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 for all tests and participants were finished with light general active cool-down involving stretching for upper and lower body muscle groups and pedalling on a cycle ergometer at a light resistance for five minutes. 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 Endurance Measurement

The maximum repetitions (MR) was used for estimating of the upper and lower body dynamic muscular endurance by performed repetitions to muscular fatigue using weight machines. Maximal muscular endurance of upper and lower body was evaluated using the chest press machine and squat machine, respectively. The relative value of muscular endurance (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 min warm-up, the MR test commenced. For measurement of muscular endurance 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 the 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 pedalling on a cycle ergometer at a light resistance for five minutes. All test procedures were based on American College of Sports Medicine (Thompson et al., 2010), Shiau et al. (2018), Adnan, Kadir, and Yusof (2014), and White (2011).

Resistance Training Intervention

Training protocols included combined weight and chain (Figure 1), combined weight and elastic band (Figure 2) (Thera-Band: Resistance Band, Singapore), and free weight (control group). Participants performed their special training program assigned to them for 12 weeks. The WC group performed the training program with freeweight and chain, The WE group performed it with freeweight and elastic band, and the CG group performed it with free-weights alone. For 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 freeweight group. Training programs were 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 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 pedalling 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 upper and lower body muscular strength and endurance.

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. Researchers need to determine how much resistance the elastic band is imparting 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 will attach 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 Thera-Band elastic bands were used. Several studies have reported that Thera-Bands are safe and appropriate for training (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 seen in Figure 3. Different weights were attached to the free end and the deformation measures in centimetres 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 provided adequate tension throughout the lift (Shoepe et al., 2010).

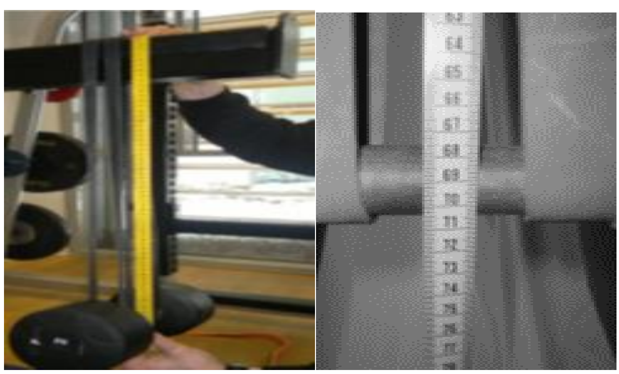

Figure 3: Calibration of elastic bands using protocol by Shoepe et al. (2010)

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 increases linearly as links are lifted vertically (Berning & Coker, 2004; Simmons, 1999).

Chains were linked to each side of a barbell. In this study, six chains consisting of “training chains” (two on each side), two “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 being 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. An extra length of training chains allow adjustment up to a full standing length of 8 feet, which may be adjusted as short as researcher prefers.

In this study, approximately 65% of the whole 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 an initial intensity level for starting the intervention, the 70% of 1RM for all exercises was 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 weights were used for all exercises in this study. Chains were managed, lengthen and shorten in a way that exerted approximately 35% resistance on the barbell for each exercise at the top of the range of motion.

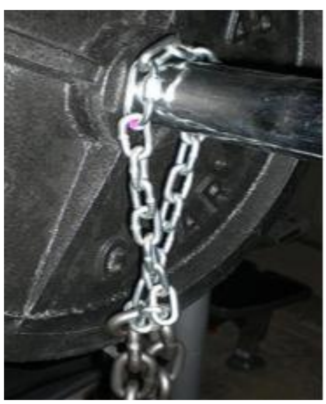

Figure 4: The support chain goes thru any link in the training chain and connects to form a complete loop that slips over the ends of the bar

Research Finding

All data have been expressed as 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 analysed using a mixed model analysis of variance (ANOVA) (3 times x 3 groups) with repeated measurements followed by Bonferroni analysis as post hoc comparisons. 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).

The upper and lower body muscular strength and endurance 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 upper and lower body muscular strength and endurance before the training program began ($P > 0.05$). Table 3 shows the means and standard deviation of baseline and post tests for upper and lower body muscular strength and endurance in all groups.

Table 2: Baseline values of dependent variables for separate groups

Variables	WC group	WE group	CG group	P value
Chest press Strength (kg)	36.47 ± 4.3	34.41 ± 3.1	34.37 ± 3.9	0.26
Squat Strength (kg)	58.82 ± 5.8	57.79 ± 5.1	55.62 ± 5.5	0.24
Chest press Endurance (repetitions)	11.23 ± 0.7	11.23 ± 1	11.56 ± 1.9	0.72
Squat Endurance (repetitions)	12.11 ± 1.3	12.23 ± 0.9	12.25 ± 1.4	0.94

*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
Chest press strength (kg)	Baseline	36.47	4.3	34.41	3.1	34.37	3.9
	Posttest1	41.17	4.3	40.29	3.4	38.12	3.5
	Posttest2	46.76	4.4	47.94	4.2	42.65	4.1
Squat strength (kg)	Baseline	58.82	5.8	57.79	5.1	55.62	5.5
	Posttest1	69.55	5.3	71.47	5.1	64.53	5.7
	Posttest2	80.73	6.4	85.29	6.5	73.75	5.8
Chest press endurance (repetitions)	Baseline	11.23	0.75	11.23	1.03	11.56	1.99
	Posttest1	14	1.41	14.64	0.93	14.31	1.74
	Posttest2	15.47	1.58	16.94	1.24	15.75	2.40
Squat endurance (repetitions)	Baseline	12.11	1.36	12.23	0.97	12.25	1.43
	Posttest1	14.94	1.59	15.82	0.72	14.43	1.71
	Posttest2	16.58	1.66	17.94	0.74	15.93	1.84

Maximal Muscular Strength Measurement

The results of the upper and lower body muscular strength are shown in Table 4. The analysis of data demonstrated that in upper body muscular strength, there were significant increases in chest press strength among post-tests 1 and 2 in all groups (P = 0.0001). The result showed significant improvements in chest press strength among the WC and WE groups compared with the CG group in post-tests 1 and 2 (P < 0.05). On completion of the training program, although there was a more improvement in chest 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).

Likewise, for lower body muscular strength, there was a significant increase in squat strength among post-tests 1 and 2 in all groups (P = 0.0001). The result indicated there was a significant increase in squat strength for WC and WE groups compared with CG group in post-tests 1 and 2 (P < 0.05). On completion of the training program, although there was a more improvement in squat strength for WE group compared with WC group in post-tests 1 and 2, no significant differences were observed between WE and WC groups (P > 0.05). In this study the results showed that upper and lower body muscular strength increased insignificantly more in WE group compared with WC group 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 upper and lower body muscular strength

Variable	Time		Group		Time * Group	
	F	P value	F	P value	F	P value
Chest press strength	665.10	0.0001*	3.03	0.04*	13.64	0.0001*
Squat strength	1172.16	0.0001*	7.05	0.0001*	17.05	0.0001*

*indicates significance at $P < 0.05$

Maximal Muscular Endurance Measurement

The results of the upper and lower body muscular endurance are shown in Table 5. The analysis of data demonstrated that in upper body muscular endurance, there was a significant increase in chest press endurance among post-tests 1 and 2 in all groups (P = 0.02). The results indicate that although there was a more improvement in chest press endurance only for WE group compared with WC and CG groups in post-test 2, no significant differences were observed between the three groups (P > 0.05).

Furthermore, in lower body muscular endurance, there was a significant increase in squat endurance among post-tests 1 and 2 in all groups (P = 0.0001). The result indicated there was a significant increase in squat endurance for WE group compared with CG group in post-tests 1 and 2 (P < 0.05). However squat endurance also increased more insignificantly for WC group compared with CG group in post-tests 1 and 2 (P > 0.05). On completion of the training program, although there was a more improvement in squat endurance for WE group compared with WC group in post-tests 1 and 2, no significant differences were observed between the WE and WC groups (P > 0.05). In this study the results showed that upper and lower body muscular endurance 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 upper and lower body muscular endurance

Variable	Time		Group		Time * Group	
	F	P value	F	P value	F	P value
Chest press endurance	304.02	0.0001*	1.24	0.29	3.37	0.02*
Squat endurance	752.60	0.0001*	3.26	0.04*	12.46	0.0001*

*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 Upper and Lower Body Muscular Strength

A study by Ghigiarelli et al. (2009) compared effects of WC versus WE training on muscular strength for only 7 weeks among football players. Although both groups showed a significant improvement in muscular strength, the differences were not significant. Perhaps the short study duration caused no significant differences between groups in terms of muscular strength. Specially, a study by Mccurdy, Langford, Ernest, Jenkerson, and Doscher (2009) 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 were no significant differences between both groups in terms of chest press strength and the reason for these results may be using chains alone, meaning that less resistance was 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. The subjects trained for 8 weeks and the results showed that there were no significant differences between elastic band alone and free weight in muscular strength; both training methods had an equivalent effect on muscular strength. Maybe the sole use of an elastic band in their study meant that Colado et al. (2010) was unable to 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 that if elastic bands are combined with free weights, they improve 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. The results indicated 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. Results indicated WE group showed significant improvements for upper and lower body muscular strength more than free weight group. Another study by Bellar et al. (2011), untrained male subjects trained for 10 weeks with WE training which 15% of the 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 that compared combined weight and chain versus combined weight and elastic band variable resistance training on upper and lower body 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) found that there were no significant differences between WE and WC training in terms of muscular strength. Maybe using shorter duration and less frequency of training in their studies caused that they could not find significant differences between WE and WC training in muscular strength. Several researchers have recommended that resistance training duration should be as long as 10 weeks with training frequency of twice weekly.

Elastic bands produce 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). Perhaps this is the only advantage of elastic band 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 leads to greater strength gains. 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, the weight and chain system accommodates a load at weaker joint angles. Researchers have also found greater benefits from weight and chains turning and swinging during the full range of motion. This involves the greater use of stabilisation 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 Upper and Lower Body Muscular Endurance

Based on previous VRT studies, there has been no direct study of VRT on muscular endurance. There is thus a lack of information pertaining to the effects of VRT on muscular endurance. As elastic bands produce isokinetic contractions, a study by Gehlsen, Grigsby, and Winant (1984), supported the positive effects of isokinetic resistance training on muscular endurance. They trained 40 untrained males for 10 weeks with isokinetic resistance training. The results showed that isokinetic resistance training increased muscular endurance significantly. On the other hand, Svensson, Gerdle, and Elert (1994), observed greater muscular endurance after 6 weeks of isokinetic resistance training compared with free weight. Also, in other study by Selig et al. (2004), the results demonstrated that isokinetic resistance training increased muscular endurance significantly.

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. 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 pressure. They also increase the velocity of performance in the eccentric phase and gradually decrease the pressure in this phase which as a useful stimulus enhances the muscle adaptability leading to concentric contractions, create more energy hence better muscular metabolic function that causing muscle endurance. 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 an eccentrically loaded 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 endurance. After 8 weeks, the results demonstrated eccentric contraction have a better effect on muscular endurance. On the other hand, Yu, Park, and Lee (2013), examined the effects of eccentric and concentric contractions on muscular endurance training 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 endurance.

Eccentric contraction enhances the effects of the stretch-shortening cycle (SSC). The SSC is a part of practically all dynamic movements involving 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 when using an elastic band is the result of combined 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 were 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 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 in the beginning of the study (Otto & Carpinelli, 2006). Muscular soreness occurs when a muscle is stretched and microfilaments of the muscle will be damaged temporarily due to performing resistance training, but muscular soreness usually disappears 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 programme.

Conclusion

In summary, VRT is significantly more effective in improving upper and lower body muscular strength and endurance compared with free-weights and WE training as a method of VRT, is insignificantly superior compared with WC training in improving upper and lower body muscular strength and endurance 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 as increasing maximal muscular strength and endurance for being healthy and to combat muscular weakness. In addition, this information also can increase the choices of available resistance training methods and encourage participation in workouts that are known to have health benefits. Furthermore, VRT also provides greater options in exercise prescription for the strength and conditioning practitioners. VRT could be introduced by the Ministry of Sport and Ministry of Health to health centres and fitness institutes and also used in physical education classes of schools and universities for health promotion.

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