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The Effects of Mesocycle-Length Weight Training Programs Involving Periodization and Partially Equated Volumes on Upper and Lower Body Strength

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ABSTRACT

The present investigation compared the effects of three selected mesocycle-length weight training programs using partially equated volumes on upper and lower body strength. Ninety-two previously weight-trained males were tested at five intervals (T1 through T5) on free-weight bench press and parallel back squat strength before, during, and after 16 weeks of training. Groups 1 and 2 trained with programs consisting of 5×10-RM at 78.9% of 1-RM and 6×8-RM at 83.3% of 1-RM, respectively, while keeping the amount of sets, repetitions, and training resistance (relative intensity) constant. Group 3 trained with a periodization program involving 4 weeks of 5×10-RM at 78.9% of 1-RM, 4 weeks of 6×8-RM with 83.3% of 1-RM, 4 weeks of 3×6-RM with 87.6% of 1-RM, and 4 weeks of 3×4-RM with 92.4% of 1-RM. Group 4 served as a non-weight-training control group. A 4×5 (Group × Test) MANOVA with repeated measures on test revealed that pretest normalized bench press and squat strength values were statistically equal when the study began. For the bench press at T2, results revealed that Groups 1, 2, and 3 were significantly different from Group 4 but not from each other. At T3, T4, and T5, Group 3 demonstrated significantly different strength levels in the bench press from Groups 1, 2, and 4. Groups 1 and 2 were not significantly different from Group 4. For the squat exercise at T2, T3, and T4, Groups 2 and 3 were significantly different from Groups 1 and 2 but not from each other. At T5, Group 3 was significantly different from Groups 1, 2, and 4. Group 2 was significantly different from Groups 1 and 4, and Group 1 was only significantly different from Group 4. It was concluded that a mesocycle-length weight training program incorporating periodization is superior in eliciting upper and lower body strength gains when compared to programs with partially equated volumes.

Key Words: mesocycle, variation, volume, periodization, bench press, parallel back squat

Introduction

Most strength training programs involve variation, or changes in the exercise program, for optimal gains in strength (9). Variation has been accomplished by changing intensity (resistance) and training volume (estimated by the Sets × Repetitions × Resistance) of exercise over time (18, 19). The volume of weight training is equal to the total workload (17). Strength training that employs the concept of periodization involves variation in the exercise program. Typically, one periodization cycle, a macrocycle, is performed over the training year, and the macrocycle can be divided into training periods of 2 or 3 months, called mesocycles (9). Many empirical models for periodization have been proposed (4, 13, 19, 23). Some studies have demonstrated that, because periodized training involves appropriate variation, it is superior to programs that use constant volume and intensity (19, 20).

One primary underlying concept of variation in periodized training involves starting with high volume and low intensity exercises; over the course of the training period, volume is reduced as the intensity is increased in an attempt to maximize strength development and avoid overtraining (8, 14, 19). Overtraining can be defined as any biochemical, physiological, or psychological factor that leads to a decrement in performance, or fails to improve it, even through an adequate training stimulus is being provided (7).

Periodization has been compared to various methods of strength training: those that include low and high numbers of repetitions per set, pyramiding (sets in which resistance is increased and

then decreased), the principles of overload and progressive resistance exercise, and various sets to exhaustion. These studies and reviews of literature suggest that periodization produces superior strength gains when compared to these methods (4, 5, 13, 14, 18, 19, 20, 21, 22, 24).

However, a potential problem arises that exercise scientists have generally failed to consider when comparing types of strength training protocols. This problem lies in equalizing the amount of work done by equating training volume. When trying to compare protocols that differ in sets, repetitions, resistance, frequency, and duration, it is extremely difficult to accurately equate training volume (26). Regardless of this problem, many studies have shown that, typically, the most effective protocol in developing strength was one involving less volume and heavier training resistance when compared to those involving more volume and lighter training resistance (1, 3, 6, 10, 15, 18, 20, 24).

Therefore the purpose of this study was to compare the effects of three mesocycle-length weight training protocols using partially equated training volumes through the first 8 weeks of training, followed by 8 weeks in which the periodization group's training volume was decreased. Based on this purpose, the specific objectives were twofold: (a) to determine the effects of partially equated training volumes among the groups after 4 and 8 weeks of training, and (b) to determine the effects of decreasing the amount of volume during the remainder of the training period for the periodization group while the volume amounts for the other two training groups remained partially equated and constant.

Methods

Subjects

Ninety-two able-bodied, previously weight-trained male college students who were enrolled in four physical education classes (three weight training, one badminton) volunteered as subjects for the study. Average age was 20.30 (±1.87) years and average body mass was 80.00 (±16.65) kg.

The criteria for selecting previously weight-trained subjects were based on established guidelines (1, 10, 25). Subjects were considered eligible (previously weight-trained) for the study if their 1-RM was more than 120% and 150% of their body mass on the bench press and parallel back squat (bar resting across trapezius muscle) exercises, respectively. Eligible subjects who were willing to participate in the study agreed to sign an informed consent form, limit their weight training activities to the designated training sessions, and make up any missed training sessions. Subjects were informed that four missed training sessions resulted in disqualification from the study.

Further ensuring the previously weight-trained eligibility status required for all subjects was a minimum of 3 years of weight training experience using free weights. Also, all subjects had to have abstained from weight training at least 6 months immediately preceding the study. This abstinence served two purposes: (a) subjects' strength levels could have been nonhomogeneous if they had been actively engaged in their own weight training programs; and (b) there was a need to prevent the strength effects of their own weight training programs from confounding any strength effects obtained from the training protocols in the study.

Previously weight-trained subjects were chosen over untrained subjects because when an untrained person begins to train for maximal strength, the initial improvements in strength are great and increases of 10% or more can be obtained after only 2 weeks of intense training (11). This may be why it is difficult to evaluate the effects of different training regimens if subjects who are untrained or who have varying pretraining statuses are compared. Therefore the trained individual may not respond to a training program in the same manner as the untrained individual. However, it is important to note that the 6-month abstinence involved in this study could have constituted a state of detraining in which subjects could have responded differently in strength.

Procedures

The study lasted 16 weeks, with three 50-minute training sessions occurring weekly on Monday, Wednesday, and Friday for the three training groups and control group.

Screening of Subjects. All 167 males who were enrolled in the four respective physical education classes were screened on the one-repetition maximum (maximum resistance that can be lifted once, hereafter referred to as 1-RM) free-weight bench press and parallel back squat (top of thighs parallel to floor) to ascertain eligibility for the study. After the screening session, 98 males were deemed eligible for the study but only 92 consented to participate. The two exercises were chosen because they have been shown to be valid indicators of upper and lower body strength (12). They were also chosen, based on previously established guidelines (3), because they were familiar to the subjects, are easily administered, and have been shown to be valid indicators of muscular function. Body mass was obtained on a standard balance scale; measurement was to the nearest kilogram. The percentage of body mass and the 1-RM were used to determine eligibility for the study.

Assignment of Treatment to Groups. Three separate treatments were randomly assigned to the three weight training classes to construct treatment groups. After screening, each group consisted of

23 subjects. Group 2 trained at 10 a.m., Group 1 at 11 a.m., and Group 3 at noon. Group 4, the control group, contained 23 previously weight-trained subjects and was involved in no weight training activities during the course of the study. The 1-RM strength scores obtained from the bench press and squat exercises during the screening session for eligible subjects in each group were also used for the pretest strength scores.

1-RM Testing Sessions. One-repetition maximum testing sessions were conducted every 4th week of the study. Thus a 1-RM testing session was conducted in which a 1-RM for both the bench press and squat exercises and body mass were obtained at Week 0 (pretest, T1), Week 4 (T2), Week 8 (T3), Week 12 (T4), and Week 16 (posttest, T5). The 1-RM obtained on the bench press and squat exercises served two purposes: (a) to determine relative training resistances for each group, and (b) to determine the relative upper and lower body strength effects elicited by the training programs at each testing session. Due to the partial equating of training volumes, further experimental control was established by measuring relative strength, which accommodates for strength discrepancies between subjects due to body mass differences.

Partially Equating Volume

Volume, in the context of this study, was based on the guidelines suggested previously (9, 18, 19). After each 1-RM testing session, and prior to each of the four training intervals (i.e., Weeks 0–4, 4–8, 8–12, and 12–16) of the study, training volumes were calculated and monitored. Training volume was expressed as total mass lifted per week and was calculated as load = number of repetitions per set × number of sets per training session × mass lifted per set × number of training sessions per week. At the beginning of the first training interval, determination of the initial training resistance for each subject was based on the procedures outlined previously (2) in which the desired training repetitions were set using a percentage of the 1-RM from T1.

Training resistances for both exercises during the course of the study were further controlled by recalculating the training resistance (2) and volume after each 1-RM testing session. This was done to accommodate for any changes in 1-RM strength scores from the previous 1-RM testing session. One-repetition maximums obtained from each subject on the bench press and squat exercises were again set at the percentage that allowed for successful completion of the desired repetitions (2). The amount of sets within each training protocol were established so that, based on the amount of repetitions and training resistance percentages, training volume would be essentially equal during each training session.

Treatments and Training Sessions

Group 1 trained with five sets of a 10-repetition maximum (5×10-RM) involving 78.9% of the 1-RM derived from the 1-RM testing sessions. This relative intensity was kept constant throughout the study. At no time was the training resistance increased during the time between 1-RM testing sessions. The only time the training resistance was modified was after a 1-RM testing session, due to a change (increase or decrease) in the 1-RM strength score. However, at no time was the training resistance modified so that each subject could not achieve the 10-RM.

Group 2 trained with 6×8-RM involving training resistances of 83.3% of the 1-RM. As with Group 1, this relative intensity was kept constant and training resistance modifications were made only after each 1-RM testing session.

Group 3 utilized a periodization program that involved 4 weeks 5×10-RM with 78.9% of 1-RM, 4 weeks 4×8-RM with 83.3% of 1-RM, 4 weeks 3×6-RM with 87.6% of 1-RM, and 4 weeks 3×4-RM with 92.4% of 1-RM. This protocol involved an obvious decrease in training volume and an increase in relative intensity throughout the course of the study. Consequently, it can be seen that the training protocol in Group 3 mimicked Group 1 until Week 4 and mimicked Group 2 until Week 8. Nevertheless, the volume among the three training groups was partially equated during this time, after which Group 3 decreased below both groups through the remainder of the study.

Group 4 was a physical education badminton class and represented a non-weight-training control group. However, the subjects from this group complied with the previously weight-trained eligibility status for the study. They were also tested on the 1-RM every 4th week just as the training groups were; however, they did not engage in any weight training activities between 1-RM testing sessions.

Throughout the study, all three training groups trained with only the free-weight bench press (performed first each training session) and parallel back squat exercises. A 3-minute recovery period between each set was mandatory for each subject to counteract possible fatigue (10, 18, 25). In the event that fatigue might have prohibited the subject from completing the designated amount of repetitions, a spotter was ready to assist him in completing the remaining repetitions in each set. However, all subjects in each group were able to complete the designated amount of repetitions with the respective training resistance without assistance from spotters.

Treatment of Data

Statistical analysis of the training volume each training group employed during each of the four

training intervals was done by a 4×4 (Group × Test) multivariate analysis of variance (MANOVA) with repeated measures on test based on Wilks' lambda criteria. Means and standard deviations were calculated for relative strength variables of upper and lower body strength as indicated by the strength/kg of body mass ratios. Relative strength variables for upper and lower body strength at each 1-RM testing session (e.g., T1, T2, T3, T4, T5) were analyzed with a 4×5 (Group × Test) MANOVA with repeated measures on test based on Wilks' lambda criteria. After the MANOVA results, significant differences between groups were analyzed with separate univariate analysis of variance (ANOVA) procedures in order to locate between-group differences. Significant differences among groups were then analyzed with the Bonferroni post hoc test.

Mean overall relative strength differences (T1 and T5) of the three training groups due to use with the bench press and parallel back squat exercises were tested with a univariate ANOVA. This was done in order to determine whether the three training protocols elicited different strength effects in upper and lower body strength.

Results

Training Volumes

Figure 1 illustrates volumes among the three training groups during the four training intervals for the bench press and squat exercises. Results from Wilks' lambda revealed a significant multivariate volume difference, $F(4, 128) = 15.65$; $p<.0001$, among the four groups. Separate univariate ANOVA revealed significantly different training volume differences for the bench press and squat exercises, $F(2, 66) = 8.26$; $p<.0001$, respectively. The Bonferroni test showed that significantly less volume was performed by Group 3 during Weeks 8–12 and 12–16. However, there were no significant differences in training volume between Groups 1 and 2 throughout the duration of the study.

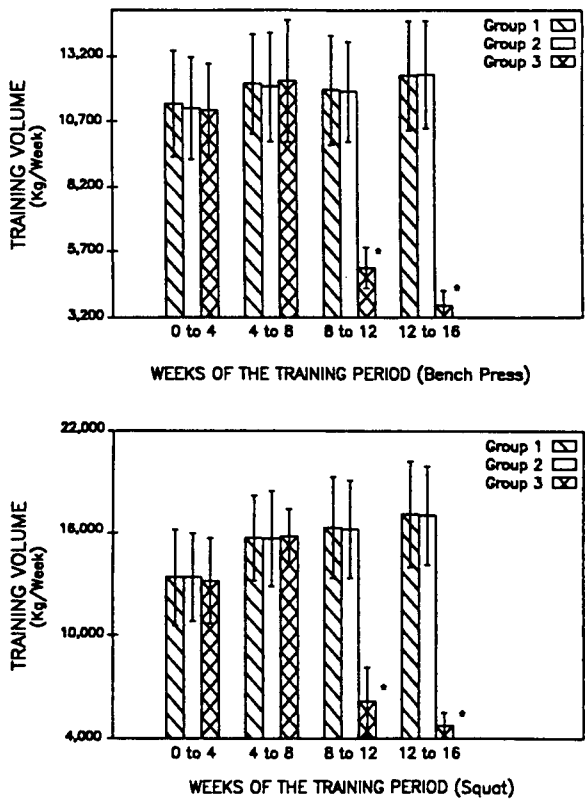

Figure 1. Mean (±*SD*) volumes among the three training groups during the four training intervals for the bench press and parallel back squat exercises. Training intervals were from Weeks 0–4, 4–8, 8–12, and 12–16, respectively. Mean training volume is presented as load expressed as total mass lifted/week and was calculated: load = no. of repetitions per training session × no. of sets per training session × mass lifted per set × no. of training sessions per week. *Significantly different volume differences.

Relative Strength

Wilks' lambda criteria revealed a nonsignificant difference in the multivariate strength score, $F(6, 174) = .610$; $p>.0001$, at T1, suggesting homogeneity among the four groups for both exercises at the onset of training. However, significant differences in multivariate strength effects were elicited at T2 through T5, $F(6, 174) = 4.84, 7.18, 10.52, 14.22$; $p<.0001$, respectively, for both training exercises.

Bench Press (upper body strength). Figure 2 illustrates upper body strength effects elicited by the bench press exercise. Separate univariate ANOVA analyses on the bench press exercise revealed significant differences, $F(3, 88) = 4.62, 4.74, 9.20, 14.70$; $p<.0001$, among the four groups for T2, T3, T4, and T5, respectively. Results from the Bonferroni test showed that, at T2, Groups 1, 2, and 3 were not significantly different but all three differed significantly from Group 4. At T3, Group 3 was significantly different from Groups 1, 2, and 4. Groups 1 and 2 were not significantly different from each other but were both significantly different from Group 4. At T4, results mimicked those from T3 and showed that Group 3 was significantly different from Groups 1, 2, and 4. Groups 1 and 2 were not significantly different in comparison but were significantly different from Group 4. For overall relative upper body strength gains from the beginning to the end of the study (T5), Group 3 proved to be significantly different from Groups 1, 2, and 4. Also at T5, Groups 1 and 2 were statistically equal in their strength gains but were both significantly different from Group 4.

Squat (lower body strength). Figure 3 illustrates lower body strength effects elicited by the

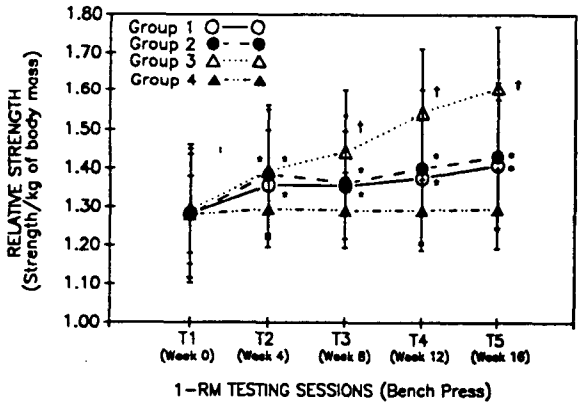

Figure 2. Mean (±*SD*) relative strength variables for the bench press exercise from T1 through T5. T5 represents overall strength gains from beginning to end of study. *Denotes significant strength differences, $p<.0001$. However, means with the same symbol are not significantly different from each other but are significantly different from those without*. †Denotes significant difference over means with and without*.

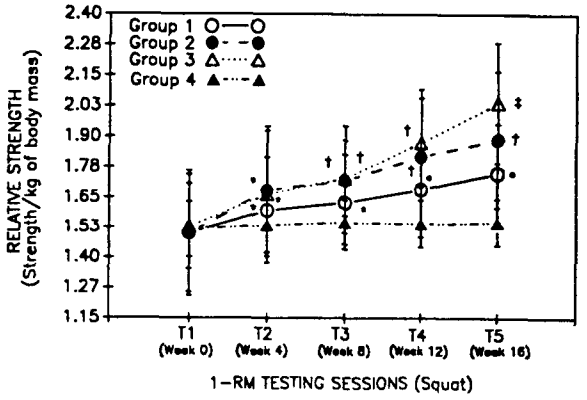

Figure 3. Mean (±*SD*) relative strength variables for the parallel back squat exercise. T5 represents overall strength gains from beginning to end of study. *Denotes significantly different strength differences, $p<.0001$. However, means with the same symbol are not significantly different from each other but are significantly different from those without*. †Denotes a significant difference over means with and without*. ‡Denotes a significant difference over means with and without* and †.

squat exercise. Separate univariate ANOVA analyses on the squat exercise revealed significant differences, $F(3, 88) = 5.43, 12.77, 20.22, 29.85$; $p<.0001$, among the four groups for T2, T3, T4, and T5, respectively. Results from the Bonferroni test revealed that, at T2, Groups 2 and 3 were not significantly different but they differed significantly from Groups 1 and 4, while Group 1 was only significantly different from Group 4. At T3, Groups 2 and 3 were not significantly different from each other but both differed significantly from Groups 1 and 4, and Group 1 was only significantly different from Group 4. At T4, results remained the same as in T2 and T3. Groups 2 and 3 were not significantly different in comparison but both differed significantly from Groups 1 and 4, while Group 1 was only significantly different from Group 4. At T5, Group 3 showed significantly different lower body strength gains from Groups 1, 2, and 4. Also at T5, Group 2 was significantly different from Groups 1 and 4, while Group 1 was only significantly different from Group 4.

Overall Strength Differences. For the bench press and parallel back squat exercises, the mean (±*SD*) relative strength values for the three groups were 1.28 (±.002) and 1.48 (±.105) kg/body mass for T1, and 1.51 (±.014) and 1.89 (±.144) kg/body mass for T5, respectively. These values revealed an overall increase in relative strength of 0.20 and 0.38 kg/body mass for the bench press and squat exercises, respectively. However, the overall relative strength differences were not statistically different, $F(1, 5) = 3.44$; $p>0.1374$, for the two training exercises.

Discussion

Results from this study (Figures 2 and 3) seem to suggest that variation is an important component of a strength training program whenever optimal gains in strength are desired. For both training exercises, it can be seen that all groups were essentially equal in muscular strength at the beginning of the study (T1). For the bench press at Week 4 (T2), when volume was partially equated, all three training groups showed statistically equal increases in strength. However, at Weeks 8, 12, and 16 (T3, T4, and T5), the decreased training volume and increased intensity of Group 3 seemed to result in significantly greater strength gains over Groups 1, 2, and 4. Even though Groups 1 and 2 achieved gains in strength, they were statistically equal when compared to each other.

However, for the squat exercise, at Weeks 4, 8, and 12 (T2, T3, and T4), the decreased training volume and increased intensity for Group 3 did not produce significantly different strength effects over Group 2, although both groups were significantly different from Groups 1 and 4. These strength effects remained unchanged until Week 16 (T5), at which point those for Group 3 were significantly greater than for Group 2.

From these results it can be seen that the strength effects elicited by the bench press exercise yielded less overall relative strength increases when compared to the squat exercise. Consequently these differences between upper and lower body strength could have occurred because the bench press involves a relatively smaller muscle

mass than the squat exercise. The smaller muscle mass could produce smaller gains, especially over a short term, and the smaller gains could make significant differences harder to achieve (20). It can also be seen that Groups 1 and 2 did not increase significantly in strength at Week 8 for the bench press and Week 12 for the squat, while Group 3 continued to increase significantly. It is likely that the potential for overtraining is reduced by changes in volume, intensity, and technique or amount of other specialized work performed (19). Therefore the failure of Groups 1 and 2 to continue producing meaningful gains over time could be indicative of the program's employment of little variation in volume and/or intensity. Thus these two groups may have been reaching the early stages of overtraining during the last few weeks of the training period (18, 19, 22, 23).

Comparative studies and reviews suggest that strength gains resulting from short-term training with traditional methods versus periodization found that the latter produced significantly greater gains in strength than did the former (5, 14, 18, 19, 20, 21, 24). It does not seem that equating training volumes was a primary component in these studies. In this study, however, partially equating training volume was attempted and results seem to follow the assumptions set forth previously.

These previous results may have occurred because of increases in maximal strength based on training with heavy resistances (11). They could also be due to a decrease in volume with a concomitant increase in intensity throughout the course of the training period, both of which have been observed to produce significant strength increases in trained athletes (19).

Practical Implications

Coaches and athletes usually agree that an individual's or team's physical strength is a significant factor in determining success. Granted, ability and strategy are necessary in athletics, but when these factors are combined with stronger athletes, the result is usually improved performance. There are many theories in the area of strength development, some based on factual research while others are fallacies passed down over the years. Two thoughts that most practitioners and exercise scientists agree upon are (a) in resistance training, one should recruit as many muscle fibers as possible, and (b) one should overload those fibers to cause possible hypertrophy and increases in strength (16).

In applying periodization to a mesocycle-length weight training program, most individuals seem to benefit from using some method of training variation (20). Some simply alternate days on which they perform heavy (3–5-RM), moderate (8–10-RM), and light (12–15-RM) exercise. Others perform light sets, moderate sets, and heavy sets for 2 to 3 weeks each (9). Thus, variation can be achieved in many ways over the course of a training period (20).

Research needs to further clarify the efficacy of periodization (particularly mesocycle-length programs) and the best methods for varying the exercise stimulus—not only for strength development but for other physiological variables such as muscular power and endurance as well. Furthermore, periodization of other acute variables (e.g., rest periods) also should be studied (9).

Based on the results of this study as well as other studies that have yielded similar results, in order for athletes to obtain greater strength gains, a weight training program based on the tenets of periodization is recommended. However, in order to continue progressing, advanced athletes may require greater planned variation in volume and intensity than presented in this study (19).

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