A Comparison of the Effects of 6 Weeks of Traditional Resistance Training, Plyometric Training, and Complex Training on Measures of Strength and Anthropometrics

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Abstract

MacDonald, CJ, Lamont, HS, and Garner, JC. A comparison of the effects of six weeks of traditional resistance training, plyometric training, and complex training on measures of strength and anthropometrics. *J Strength Cond Res* 26(2): 422–431, 2012—Complex training (CT; alternating between heavy and lighter load resistance exercises with similar movement patterns within an exercise session) is a form of training that may potentially bring about a state of postactivation potentiation, resulting in increased dynamic power (P_{max}) and rate of force development during the lighter load exercise. Such a method may be more effective than either modality, independently for developing strength. The purpose of this research was to compare the effects of resistance training (RT), plyometric training (PT), and CT on lower body strength and anthropometrics. Thirty recreationally trained college-aged men were trained using 1 of 3 methods: resistance, plyometric, or complex twice weekly for 6 weeks. The participants were tested pre, mid, and post to assess back squat strength, Romanian dead lift (RDL) strength, standing calf raise (SCR) strength, quadriceps girth, triceps surae girth, body mass, and body fat percentage. Diet was not controlled during this study. Statistical measures revealed a significant increase for squat strength ($p = 0.000$), RDL strength ($p = 0.000$), and SCR strength ($p = 0.000$) for all groups pre to post, with no differences between groups. There was also a main effect for time for girth measures of the quadriceps muscle group ($p = 0.001$), the triceps surae muscle group ($p = 0.001$), and body mass ($p = 0.001$; post hoc revealed no significant difference). There were main effects for time and group × time interactions for fat-free mass % (RT: $p = 0.031$; PT: $p = 0.000$). The results suggest that CT mirrors benefits seen with traditional RT or PT. Moreover, CT revealed no decrement in strength and anthropometric values and appears to be a viable training modality.

Key Words combination training, postactivation potentiation, strength training

Introduction

Optimal training techniques designed to maximize strength receive considerable interest among strength and conditioning specialists, strength coaches, and researchers. This interest is driven by the desire to maximally enhance clients' and athletes' abilities (10). It is accepted by most industry professionals that athletes should incorporate both resistance training (RT) and plyometric training (PT) into their regimens to increase the probability of developing higher muscular power (13). Complex training (CT), a form of combination training, can best be described as training that alternates between traditional resistance (heavy resistance exercise) and plyometric exercises (light resistance exercise) within a single exercise session (8,12,13,18). With CT, the plyometrics performed will be biomechanically similar to the resistance movements performed immediately before those plyometric exercises. This idea of 2 biomechanically similar exercises performed in a complex can be referred to as a complex pair (13). Complex training may be an optimal training strategy for developing sport-specific athletic strength, if it is indeed true that this form of training is more effective than other training programs at enhancing strength (and possibly strength-power) production because of enhanced neuromuscular activity (2,10,12,17,18).

As an alternative to RT or PT programs, CT can be implemented to complement those protocols. It may also enhance the athletes' abilities more effectively than RT or PT performed individually, and it does so in a time-efficient manner. The complex program design must also take into

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Figure 1. Back squat exercise.

Figure 3. Standing calf raise exercise.

account variables such as exercise selection, load, and time between sets within each training session (14). This is important because the timing of resistance to plyometric exercise and plyometric to resistance exercise affects the resultant neuromuscular response.

Results from various CT-related studies report outcomes that show CT may enhance measures of athletic ability (or at worst show no decrement) when compared with more conventional training protocols. Adams et al. concluded that after a protocol of squat and PT, vertical jump heights improved significantly more than those of a group that trained only with a squat protocol (2). Duthie et al. compared CT with contrast training (an alternative method of combination training) and concluded that neither method was superior (11). Mihalik et al. examined the effects of short-term CT vs. short-term compound training (another form of combination training) and also discerned no differences between the 2 types of training, although both groups showed significant improvements in vertical jump heights (19). Fatouros et al. investigated the differences between PT, RT, and their combination with their results showing the combined group to have significantly better vertical jump heights, jumping mechanical power, and flight time (15).

Methods

Experimental Approach to the Problem

Since the inception of research on combination training, a number of studies have recommended the approach to athletes (2,4,12,19). Further research has been conducted examining the effect of CT on specific muscles or muscle groups (2,11,19). However, to date, there is only 1 study (15) that has examined the effectiveness of the entire limb

Figure 2. Romanian dead lift exercise.

Figure 4. Lateral jump exercise.

Figure 5. Depth jump exercise.

Figure 6. Box jump exercise.

segment CT on strength measures. To date, there have been no studies examining the changes in rest periods between complex pairs that coincide with the periodized increases in training volume during the protocols. Therefore, the purpose of this study was to determine if CT was more effective than RT or PT at acutely and chronically improving measures of strength and certain anthropometrics in the lower limbs of college-aged men. Manipulation of the timing within the protocol was also carried out to elucidate the possibility of any potentiating effects of the training.

Subjects

Thirty recreationally trained college-aged men (21.73 ± 3.40 years) volunteered for participation and were trained using 1 of 3 methods (via random assignment); RT ($n = 11$; height: 181.52 ± 3.64 cm; mass: 85.34 ± 22.14 kg), PT ($n = 9$; height: 182.67 ± 8.29 cm; mass: 82.63 ± 10.80 kg), or CT ($n = 10$; height: 185.17 ± 5.56 cm; mass: 87.54 ± 9.04 kg). All the participants regularly performed RT for at least the 6 months leading up to participation in this project (3,11–14). Any participant with a history of cardiac or respiratory disease or with a major traumatic event or surgery to the lower extremities with the last 2 years was excluded from the study. All the participants were asked to cease any additional lower limb RT for the entirety of this study. All the participants gave written consent on University approved consent documents, and this research was approved by the University Institutional Review Board.

Protocols

The training protocols required the participants to train in the laboratory 2 d·wk^{-1} during 6 weeks of training and additional testing sessions, twice weekly pre (W1), mid (W5), and post (W9). It is understood that the overall time course of the training is relatively short, with respect to inducing changes to muscle-to-muscle architecture; however, the 6 weeks of training (9 total consecutive weeks when the testing is included) is the duration in which there was uninterrupted access to the subjects. Additionally, 6–9 weeks could mimic the duration of a preseason training time course for a collegiate athletic program. The recommended recovery for CT sessions is at least 48 hours (13); therefore, the rest periods for all the participants in all training

Table 1. Resistance training protocol.*

		Training day 1		Training day 2	
Week		% 1RM	Repetitions	% 1RM	Repetitions
1	Pretest				
2	1	75	3 × 6	60	3 × 6
3	2	80	3 × 5	65	3 × 5
4	3	82	3 × 5	67	3 × 5
5	Posttest				
6	1	85	3 × 4	55	3 × 4†
7	2	88	3 × 3	50	3 × 3†
8	3	90	3 × 3	45	3 × 3†
9	Posttest				

*1RM = 1 repetition maximum
†Speed squats.

TABLE 2. Plyometric training protocol.

Week		Repetitions Training day 2	Training day 2
1	Pretest		
2	1	3 × 7	3 × 6
3	2	3 × 6	3 × 5
4	3	3 × 5	3 × 4
5	Posttest		
6	1	3 × 5	3 × 4
7	2	3 × 4	3 × 3
8	3	3 × 3	3 × 3
9	Posttest		

groups was at least 2 (but not >3) days between subsequent sessions, to normalize timing for the participants. Consideration of rest intervals between sets, within each exercise session, was also pertinent, and it was necessary that this time course be enough to allow for replenishment of the anaerobic energy stores that are required for these exercises; therefore, the rest periods used were 3 minutes in length for the RT, PT, and CT groups (13). The rests between complex pairs during the first mesocycle (W2–W4) was up to 30 seconds, and the rest period between complex pairs during the second mesocycle (W6–W8) was 3 minutes (12). With respect to the heavier lifts (during the second mesocycle), the time course between complex pairs extended to 3 minutes to use any potentiation without causing residual fatigue (9).

A specific warm-up protocol was followed by all the participants before the training days and the testing days that included pedaling at 50–60 rpm, with 0.5 kilopond of resistance, on a cycle ergometer (Monark 828 E Pendulum Ergometer; Monark Sports and Medical, Varberg, Sweden), for 5 minutes. This took place before the additional warm-up process for the training groups. The RT and CT groups would, in addition to the cycle ergometer warm-up, perform their body weight, then 50% of 1 repetition maximum (1RM) back squat exercises for 6 repetitions.

As mentioned, the actual training protocols for the 3 training groups (CT, RT, and PT) were not equal in volume and intensity; however, the RT and PT protocols were kept as similar as possible, to one another, with respect to volume and intensity. The CT group performed a combination of the RT and PT protocols, thereby making this protocol greater in total volume. Total volume was defined as load multiplied by sets multiplied by repetitions (load × sets × reps). Variation in total volume was incorporated in this fashion because it more closely mimics what is done with a practical CT protocol; the RT and PT groups were treated as active control groups because they each did part of the entire CT protocol; this increase in training volume may result in a greater increase in performance measures, and this was done in previous research (15).

The RT group performed the following exercises (in the listed order): Jones Machine (The Jones Max Rack 3D, Body Craft; Sunbury, OH, USA) high bar back squat ("Smith Machine" that allowed for anterior and posterior freedom),

TABLE 3. Complex training protocol.*

		Training day 1			Training day 2		
		Resistance exercises			Resistance exercises		
Week		% 1RM	Repetitions	Plyo exercises Repetitions	% 1RM	Repetitions	Plyo exercises Repetitions
1	Pretest						
2	1	75	3 × 6	3 × 7	60	3 × 6	3 × 6
3	2	80	3 × 5	3 × 6	65	3 × 5	3 × 5
4	3	82	3 × 5	3 × 5	67	3 × 5	3 × 4
5	Posttest						
6	1	85	3 × 4	3 × 5	55	3 × 4†	3 × 4
7	2	88	3 × 3	3 × 4	50	3 × 3‡	3 × 3
8	3	90	3 × 3	3 × 3	45	3 × 3‡	3 × 3
9	Posttest						

*1RM = 1 repetition maximum.
†3-minute rest between complex pairs.
‡Speed squats.

TABLE 4. Timing for training protocols.*

	Timing between				
Training protocol	Sessions (h)	Exercises (min)	Sets (min)	Repetitions	Complex pair
RT	≥48	4	3	N/A	N/A
PT	≥48	4	3	N/A	N/A
CT	≥48	4	3	N/A	Up to 30 s or 3 min†

*RT = resistance training; PT = plyometric training; CT = complex training.
†30 s for the first microcycle and 3 min for the second microcycle.

Romanian Dead Lift (RDL) (20-kg Power Lifting Bar, Power Systems; Knoxville, TN, USA), and standing calf raise (SCR) (Calf Raise, Power Systems) (Figures 1–3).

The participants in both the RT and CT groups performed these same exercises over the 2, 3-week mesocycles (i.e., during the entire 6-week training period); however, there was a steady increase in the percentage of the participants' 1RM weight lifted, following a periodized model (6,21). There was also a fluctuation in the load lifted between training days every week and a fluctuation in the amount of repetitions performed per set, allowing for recovery of the participant.

The PT group performed the following exercises for their training sessions (in the listed order): the lateral jumps (LJs), the depth jumps (DJs), and box jumps (BXJs) (Figures 4–6).

The LJ, or lateral double leg hops, are useful for developing the abilities to move and change direction laterally (7). The participant hopped laterally, across a distance of 35 cm, while minimizing ground contact time. The DJ uses body mass of the participant and gravity to exert a force against the ground (7). The participants began with a double leg stance from a specific 12-in. height, stepped off the box (Power Systems), with 1 foot leading, and both feet contacting the ground at the same time. The landing movement was understood as an "active-reactive" movement, as the participant immediately and rapidly exploded from the ground, (7). For the purpose of this study, the participants jumped vertically, as high as possible, upon the reactive movement. Repetitions were performed in 5-second intervals from foot contact upon landing. The BXJ required the participant to start in a standing position, with both legs on the top of a box (height of 12 in.) and drop off the back of the box. The participant then rebounded as quickly as possible, minimizing ground contact time, off both legs, returning to the top of the box, and then repeating the exercise.

These exercises remained the same over the first mesocycle of training and then progressed to more advanced plyometrics in the second mesocycle of training for both the PT and CT groups, with the intent of creating an environment theoretically more conducive to the stimulation of maximal adaptations. The LJ progressed to lateral jumps over a 12-in. barrier (Gorilla Speed Hurdles, Ann Arbor, MI, USA), across the same 35-cm distance. This was performed in the same

TABLE 5. Participant anthropometrics: participants' anthropometric information including changes in body mass after 6 weeks of training.*

				Mass (kg)		
Group	*N*	Age	Height (cm)	Pre	Mid	Post
RT	11	22 (±3.66)	181.52 (±3.64)	85.34 (±22.14)	86.77 (±21.84)†	85.79 (±21.87)
PT	9	20.56 (±3.32)	182.67 (±8.29)	82.63 (±10.80)	83.14 (±10.93)	83.72 (±10.70)
CT	10	22.50 (±3.24)	185.17 (±5.56)	87.54 (±9.04)	87.58 (±9.09)	86.85 (±8.62)

*RT = resistance training; PT = plyometric training; CT = complex training.
†Significantly greater than pre ($p = 0.001$, $1 - \beta = 0.959$, effect size = 0.487).

Table 6. Quadriceps girth: change in quadriceps girth after 6 weeks of training.*

Group	*N*	Girth quadriceps (cm)		
		Pre	Mid	Post
RT	11	57.77 (±9.74)	58.5 (±9.50)†	59.55 (±9.49)†
PT	9	58.22 (±4.79)	58.56 (±4.63)†	58.5 (±3.88)†
CT	10	58.1 (±3.58)	59.6 (±4.28)†	59.35 (±4.57)†

*RT = resistance training; PT = plyometric training; CT = complex training.
†Significantly greater than pre ($p = 0.001$, $1 - \beta = 0.957$, effect size = 0.239).

manner as the LJ, with the addition of height that must be cleared. The DJ height increased from 12 to 18 in., and the BXJs progressed from a double leg exercise on a 12-in. box to a single leg exercise on a 6-in. box.

The CT group performed a combination of the exercises in the RT group and the PT group, in specific time intervals. The CT group executed their exercises in the following order: the back squat and LJ were performed in the same set; the RDL and DJ were performed in the same set; and the SCR and BXJ were performed in the same set. These complex pairs were chosen because the exercises are biomechanically similar (Tables 1–3).

Along with the 3-minute rest period between sets, there was a 4-minute rest period between exercises. The number of repetitions and sets within the CT was a combination of the entire RT and entire PT protocols as was done in the research of Fatouros et al. (15). The rest period was sufficient to prevent any substantial muscle fatigue and to potentially exploit any acute increase in hormone production. Also, the fluctuation of training volume between training day 1 and training day 2, during the week, was like that in a similar study, giving the proper time course for the participants to recover (15). The participants were instructed to move the loads with maximum movement intent during resistance exercises and to minimize ground contact time during the plyometric exercises (13) (Table 4).

Testing

After W2–W4 (first mesocycle) and W6–W8 (second mesocycle) of training were finished, all the participants performed midtesting (W5) and posttesting (W9), respectively.

The participants were asked to engage in no strenuous physical activity (aerobic or anaerobic) 24 hours before the pretraining measures. This allowed for the prevention of any residual fatigue from any strenuous physical activity that would affect testing measures. The participants were also asked to consume no caffeine in the 4 hours before the pretraining (16).

The test measures were as follows: 1RM assessment of the back squat (kilograms), RDL (kilograms), and SCR (kilograms). National Strength and Conditioning Association guidelines (3) were followed for the protocol of the lifts (both during the testing and training). The intraclass correlation coefficient (ICC)α for strength measures in our laboratory ranged from 0.890 to 0.935. If the weights lifted were too heavy to be safely attempted, the participants were allowed to attempt a multiple RM, and it was then put into a prediction equation from Brzycki (5).

Measures of anthropometrics included height (centimeters), body mass (kilograms) (Seca digital scale, Lafayette Instrument Co., Lafayette, IN, USA), body fat percentage (Lange skinfold caliper, Beta Technology Incorporated; Cambridge, MD, USA), and girth (centimeters; midquadriceps muscle group; ICCα = 0.990 and midtriceps surae muscle group; ICCα = 0.987) (Gulick II Measuring Tape, Country Technology Inc., Gays Mills, WI, USA) were also taken. Body fat percentage was derived with skinfolds being measured with Lange® skinfold calipers, using the Jackson and Pollock 3 site test (ICCα = 0.981). Again, all the tests were repeated during W5 and W9.

Testing order was as follows (W1, W5, and W9); day 1

Table 7. Triceps surae girth: change in triceps surae girth after 6 weeks of training.*

Group	*N*	Girth triceps surae (cm)		
		Pre	Mid	Post
RT	11	38.55 (±4.54)	39.36 (±4.70)†	39.05 (±4.54)†
PT	9	37.72 (±2.14)	38.5 (±1.82)†	38.58 (±2.02)†
CT	10	38.4 (±2.39)	38.7 (±2.55)†	38.5 (±2.51)†

*RT = resistance training; PT = plyometric training; CT = complex training.
†Significantly greater than pre ($p = 0.001$, $1 - \beta = 0.954$,effect size = 0.236).

TABLE 8. Body fat percentage: changes in body fat percentage after 6 weeks of training*

		Body fat (%)		
Group	N	Pre	Mid	Post
RT	11	19 (±9)	19 (±8)	20 (±8)†‡
PT	9	19 (±5)	18 (±5)	22 (±5)†‡
CT	10	20 (±6)	20 (±6)	21 (±6)

*RT = resistance training; PT = plyometric training; CT = complex training.
†Significantly greater than pre.
‡Significantly greater than mid (RT: $p = 0.031$, $1 - \beta = 0.665$, effect size = 0.294; PT: $p = 0.000$, $1 - \beta = 0.995$, effect size = 0.647).

included all anthropometric measurements (height, body mass, body fat percentage, and girth) and day 2 of testing included the strength measurements (back squat, RDL, and SCR).

Statistical Analyses

A series of 1-way analyses of variance (ANOVAs) were run for all baseline data trials between groups to identify any significant differences. Because no differences were seen between groups, repeated-measures ANOVA were used in data analysis (specifically a 2-way 3 (group) × 3 (time) repeated measures ANOVA). Group by time-point interactions and main effects for group and time point were assessed using a Bonferroni correction for multiple comparisons. A Bonferroni post hoc test was used to highlight the nature of any within and between group differences. A pairwise comparison error rate (α) was set a Bonferroni corrected 0.05. All analyses were run with SPSS 16.0.

RESULTS

Participant Characteristics

Listed below are the results from the participants' anthropometric data, girth measurements, and body fat percentage data. There was a significant increase, from W1 to W5, in the body mass of the RT group. This, however, was not a large practical increase (~1.4 kg), and the significance was lost from W5 to W9 as the group's body mass decreased closer to its initial level. There was a significant increase in girth measurements of the quadriceps and triceps surae muscle groups, from W1 to W5 and subsequently from W1 to W9, for all the groups. Again, though statistical significance resulted, these results do not relay a great amount of practical significance (increases range from 0.1 to 1.78 cm). With respect to the changes in body fat percentage, the RT and PT showed a significant increase from W1 to W9 and from W5 to W9. Here again, the results show that though statistical significance was found, these results may not be practically significant because an increase of 1% for the RT group (n = 11) is significant; however, an increase of 1% for the CT group (n = 10) is not statistically significant. Further possible explanation for the fluctuation in body mass and body fat percentages is described in the Discussion (Table 5–8).

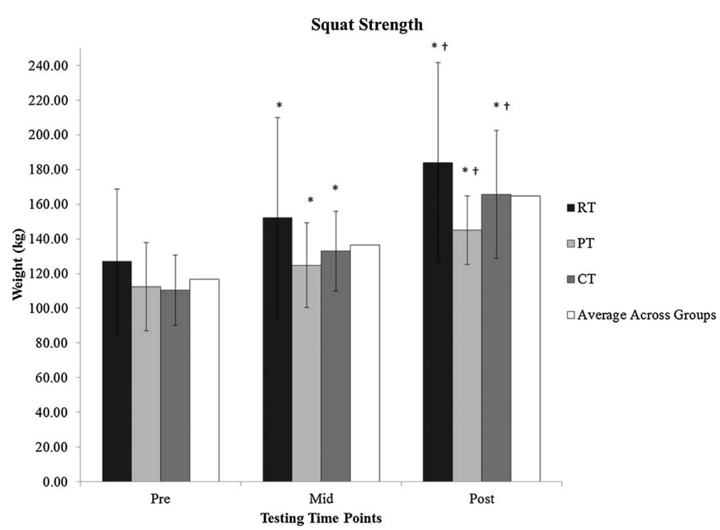

Figure 7. Back squat strength (1 repetition maximum); changes in back squat strength for all the groups after 6 weeks of training; *significantly greater than pre; †significantly greater than mid ($p = 0.000$, $1 - \beta = 1.0$, effect size = 0.725).

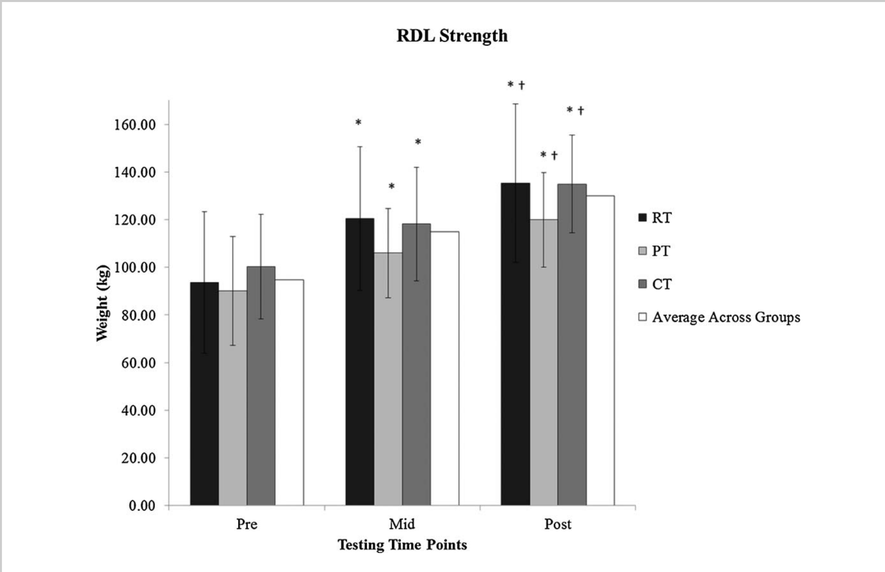

Figure 8. Romanian dead lift (RDL) strength (1 repetition maximum); changes in RDL strength for all the groups after 6 weeks of training; *significantly greater than pre; †significantly greater than mid ($p = 0.000$, $1 - \beta = 1.0$, effect size = 0.760).

Strength Measures

The following figures depict the results from the back squat, RDL, and SCR exercises. There is a significant increase in 1RM for all exercises and across all groups, with no difference between groups.

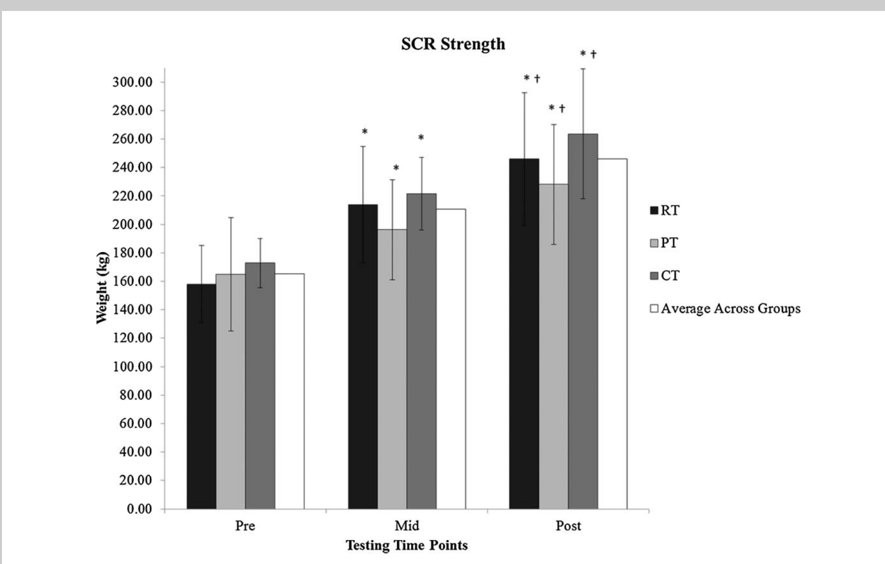

Figure 9. Standing calf raise (SCR) strength (1 repetition maximum); changes in SCR strength for all the groups after 6 weeks of training; *significantly greater than pre; †significantly greater than mid ($p = 0.000$, $1 - \beta = 1.0$, effect size = 0.837).

Discussion

There were significant changes in some participants' anthropometrics (body mass, body fat percentage, girth of the quadriceps, and girth of the triceps surae). The RT group's results showed a significant increase in body mass from W1 to W5; however, there was no other significant change in body mass for any other testing time point in any other training group. With respect to body fat percentage, there was a significant increase in the RT and PT groups from W5 to W9 and, subsequently, from W1 to W9. The changes in body mass and body fat percentage could be because of changes in the participants' diet (which is theorized to have increased, with respect to caloric intake, because of the implementation of training protocols). Diet was not controlled during this study, making this conclusion speculative, but these researchers discern that these changes are not attributed to the training.

The girth measures for both the quadriceps muscle group and the triceps surae muscle group saw significant increases from W1 to W5 and from W1 to W9 for all 3 training groups. Although significant, the increases seen in the girth measures are practically minimal. Seynnes et al. (20) who examined early skeletal muscle hypertrophy and architectural changes in response to high-intensity RT concluded that the changes in muscle size were detectable after only 3 weeks of RT and that the remodeling of muscle architecture precedes gains in muscle cross-sectional area. The authors state that muscle hypertrophy seems to contribute to strength gains earlier than previously reported (20). Although the results from Seynnes et al. (20) may shed light on the results in the present research, our results concerning girth measures more likely may be because of changes in participants' body fat percentages (possibly from diet fluctuations and changes in water retention), not because of training-induced increases in muscle cross-sectional area (1,3).

Figures 7–9 represent the changes in these 3 measures that occurred in the participants after training from W1 to W5 to W9. These results show that there was no significant group × time interaction for any of the 3 training modes for all 3 strength test measures. There was a significant main effect for time for all 3 groups. Test results from W5 were significantly greater than those at W1, and results in W9 were significantly greater than W1 and W5.

It can be conceived that the results from this study, reporting significant increases in strength measures from the back squat, RDL, and the SCR exercises, may be predominantly attributed to neuromuscular adaptations, not to hypertrophic adaptations, in all the participants. The majority of current research (with the exception from that from Seynnes et al.) has determined that 6 weeks may not be enough time to induce hypertrophic effects via a periodized RT protocol (1,3). More specifically, significant changes may have occurred, with respect to strength and anthropometrics, in the CT group (compared with that in the RT and PT groups) if the training protocol was longer than the allotted 6 weeks, possibly allowing for hypertrophic adaptations to this training group that had no prior CT experience.

Practical Applications

The results from this study suggest that CT mirrors the benefits seen with traditional RT or PT. Moreover, CT revealed no decrement in strength and anthropometric values, and it appears to be a viable training modality. Further, CT allows for the incorporation of various modalities into a single work session, offering variability and time-efficient training regimens into a power athlete's periodized protocol. Further research is warranted to determine the optimal and specific set to repetition to timing scheme of CT, in this population, to maximize the benefits of this hybrid training method. At the time during which this research was carried out, this was the only design that attempted to tease out the correct time course for rest periods in an attempt to delineate the optimal window in which to perform the light resistance exercise after a potentiating, heavy resistance exercise, over the duration of a chronic CT protocol. Although this project was not able to ultimately discern that time course, future research considerations may create the proper environment to do so (discussed below). Additionally, these results provide researchers and practitioners with the knowledge that gains in strength may occur in the lower limbs of recreationally trained college-aged men after 6 weeks of training while using any of the 3 modes used in this study, primarily because of short-term neuromuscular adaptations.

This preliminary research using CT on a recreationally trained population provides ground work for future studies to implement this type of training with an athletic population, a population in which CT may have the greatest positive net affect. Additionally, future research in this area may need to include a longer overall duration of training and additional posttesting trials several weeks after the cessation of training. Consideration should also be given with respect to the populations that are examined. Specifically, future work should incorporate an athletic population (possibly even an elite athletic population) as the participant pool because their adaptations to chronic CT may differ significantly from that of recreationally trained individuals.

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References

1. Aagaard, P. Training-induced changes in neural function. *Exerc Sport Sci Rev* 31: 61–67, 2003.
2. Adams, K, O'Shea, JP, O'Shea, KL, and Climstein, M. The effects of six weeks of squat, plyometric and squat-plyometric training on power production. *J Appl Sport Sci Res* 6: 36–41, 1992.
3. Baechle, TR. and Earle, RW. *Essentials of Strength Training and Conditioning*. Champaign, IL: Human Kinetics, 2000.
4. Blakey, JB and Southard, D. The combined effects of weight training and plyometrics on dynamic leg strength and leg power. *J Appl Sport Sci Res* 1: 14–16, 1987.
5. Brzycki, M. Strength testing: Predicting a one-rep max from reps-to-fatigue. *J Health Phys Educ Recr Dance* 64: 88–90, 1993.
6. Buford, TW, Rossi, SJ, Smith, DB, and Warren, AJ. A Comparison of periodization models during nine weeks with equated volume and intensity for strength. *J Strength Cond Res* 21: 1245–1250, 2007.
7. Chu, DA. Plyometric exercise. *NSCA J* 5: 56–63, 1984.
8. Chu, DA. *Explosive Power and Strength: Complex Training for Maximal Results*. Champaign, IL: Human Kinetics, 1996.
9. Comyns, TM, Harrison, AJ, Hennessy, LK, and Jensen, RL. The optimal complex training rest interval for athletes from anaerobic sports. *J Strength Cond Res* 20: 471–476, 2006.
10. Docherty, D, Robbins, D, and Hodgson, M. Complex training revisited: A review of its current status as a viable training approach. *Strength Cond J* 26: 52–57, 2004.
11. Duthie, GM, Young, WB, and Aitken, DA. The acute effects of heavy loads on jump squat performance: An evaluation of the complex and contrast methods of power development. *J Strength Cond Res* 16: 530–538, 2002.
12. Ebben, WP. Complex training: A brief review. *J Sports Sci Med* 1: 42–46, 2002.
13. Ebben, WP and Blackard, DO. Complex training with combined explosive weight training and plyometric exercises. *Olympic Coach* 7: 11–12, 1997.
14. Ebben, WP and Watts, PB. A review of combined weight training and plyometric training modes: Complex training. *Strength Cond* 20: 18–27, 1998.
15. Fatouros, IG, Jamurtas, AZ, Leontsini, D, Taxildaris, K, Aggelousis, N, Kostopoulos, N, and Buckenmeyer, P. Evaluation of plyometric exercise training, weight training, and their combination on vertical jumping performance and leg strength. *J Strength Cond Res* 14: 470–476, 2000.

16. Lamont, HS. The effect of whole body vibration induced post activation potentiation upon indices of isometric and dynamic force/power production during, and following a six week periodized Smith machine back squat protocol. Thesis,University of Oklahoma, Norman, OK, 2006.
17. Luebbers, PE, Potteiger, JA, Hulver, MW, Thyfault, JP, Carper, MJ, and Lockwood, RH. Effects of plyometric training and recovery on vertical jump performance and anaerobic power. *J Strength Cond Res* 17: 704–709, 2003.
18. Masamoto, N, Larson, R, Gates, T, and Faigenbaum, A. Acute effects of plyometric exercise on maximum squat performance in male athletes. *J Strength Cond Res* 17: 68–71, 2003.
19. Mihalik, JP, Libby, JJ, Battaglini, CL, and McMurray, RG. Comparing short-term complex and compound training programs on vertical jump height and power output. *J Strength Cond Res* 22: 47–53, 2008.
20. Seynnes, OR, de Boer, M, and Narici, MV. Early Skeletal muscle hypertrophy and architectural changes in response to high-intensity resistance training. *J Appl Physiol* 102: 368–373, 2007.
21. Stone, MH, O'Bryant, H, and Garhammer, J. A hypothetical model for strength training. *J Sports Med Physl Fitness* 21: 342–351, 1981.