Resistance Circuit Training: Its Application for the Adult Population

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SUMMARY

THE PURPOSE OF THE ARTICLE IS TO FOCUS ON RESISTANCE CIRCUIT TRAINING (RCT) AS A METHOD OF STRENGTH TRAINING FOR THE ADULT POPULATION. HEALTH-FITNESS ADAPTATIONS GAINED FROM RCT INCLUDE IMPROVED $\dot{V}O_2$max (MAXIMAL AMOUNT OF OXYGEN CONSUMPTION OF THE BODY DURING EXERCISE) IN CERTAIN CASES, AN INCREASE IN TIME TO EXHAUSTION, A DECREASE IN RESTING BLOOD PRESSURE, INCREASED MUSCULAR STRENGTH, AND CHANGES IN CIRCULATING CHOLESTEROL AND HORMONE CONCENTRATIONS. RCT MAY USE A PERIODIZED OR PROGRESSIVE PROGRAM MODEL IN A CONDENSED FORM TO ACHIEVE HEALTH-FITNESS RESULTS BY THE CERTIFIED PERSONAL TRAINER DETAILING LONG-TERM AND SHORT-TERM PROGRAM PLANS.

INTRODUCTION

Although many variations or descriptions for circuit training exist, this article will focus on resistance circuit training (RCT) as a method of resistance training that uses stations or various exercises performed with weight training equipment separated by predetermined rest intervals. The exact number of exercises, volume, load, rest-interval length, session duration, and length of training phase will vary depending on the training objective. Circuits can be used for health or performance gains with each one dictating the aforementioned components (6,19).

Health-fitness adaptations gained from RCT include improved time to lactate threshold, increased strength endurance, and changes in circulating cholesterol and hormone concentrations (18,31). The current article will not focus on all of the health-fitness adaptations because of the length of the article. However, the initial training status, health, and previous exercise experience of an individual will impact the degree to which these changes occur. Improving health and fitness through RCT may use a periodized or progressive program model with the inclusion of plyometrics, explosive lifts, or high relative intensities in a condensed form to achieve these results. Regardless of the training objective for RCT, the details of the long-term and short-term program plans by a certified personal trainer (CPT) are critical.

PHYSIOLOGICAL RESPONSES TO CIRCUIT TRAINING

The desired physiological responses that occur as a result of RCT should influence the CPT's decision on the structure of the program. There are 4 main physiological areas that have been the primary focus of research conducted on circuit training: (a) oxygen consumption ($\dot{V}O_2$), (b) body composition, (c) changes to the physiological markers of health, and (d) strength and flexibility (5,9,10,18,20,21,25,31).

MAXIMUM OXYGEN CONSUMPTION

A positive physiological adaptation associated with RCT involves changes to $\dot{V}O_2$max. Oxygen consumption is an important cardiovascular health parameter and one measurement of endurance training status. Furthermore, the effectiveness of a training program to improve cardiovascular health and the efficiency (production of adenosine triphosphate with minimal work) of the aerobic energy system can be quantified by increases in $\dot{V}O_2$max (22).

The effects of RCT on $\dot{V}O_2$max are best achieved when using a program of 8–10 stations implemented 3 days per week. This exercise prescription has produced moderate but significant improvements in $\dot{V}O_2$max in untrained postmenopausal women (18.6%), college-aged women (10%) and college-aged men (11–12%) (5,31). The rest-interval length in those studies that measured $\dot{V}O_2$max before and after training varied between no rest to 15 seconds with work intervals of 30 seconds and intensities of 40–60% of 1 repetition maximum (1RM). These intervals can be used as guidelines to

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progress a program for improving $\dot{V}O_2$max.

The work to rest ratio is also a critical factor in prescribing a bout of circuit training for the improvement of aerobic fitness. For example, an RCT (3 sets × 8RM × 3 days) using a rest ratio of 1:2 (30:60 seconds) did not produce improvements in cardiovascular variables (2). However, a multiple set, 8- to 10-station RCT using a work to rest ratio of 1:1 was more effective than traditional strength training in increasing $\dot{V}O_2$max and may result in increases of $\dot{V}O_2$max upward of 18% ($P < 0.01$) in untrained populations (5). Therefore, a shorter rest period during RCT does appear to augment improvements in $\dot{V}O_2$max. However, even with shorter rest intervals and lower work to rest ratios, there are limitations in the effectiveness of an RCT to increase $\dot{V}O_2$max. A resistance training only circuit cannot match the consistent aerobic intensity that is accomplished through continuous aerobic exercise, such as running or cycling. Therefore, improvements in aerobic capacity as a result of RCT will be limited to individuals who have lower pretraining $\dot{V}O_2$max values.

LACTATE

Aerobic exercise can be identified by repetitive and cyclic actions, but if these actions are performed at a higher intensity (>75% $\dot{V}O_2$max), an accumulation of lactate in blood and muscles may result. The point at which this lactate accumulation outpaces disposal is known as lactate threshold, which can eventually lead to temporary cessation of muscular contraction. Ability to change the point of threshold can influence performance by improving the time to volition of an activity.

Lactate threshold can be a marker of physical performance, although the effects of RCT on the time to lactate threshold remain unclear. Indications that lactate levels can be acutely elevated during an RCT session to concentrations similar to traditional strength training have been seen after a circuit training protocol that resulted in blood lactate concentrations greater than 15 mmol (17). Performing RCT with short rest intervals may produce similar affects on lactate threshold as traditional strength training. However, the magnitude or significance of the change in lactate threshold will need to be quantified in all populations of varying training status. Increases in lactate threshold may also be possible with RCT as a result of the intense resistance training and short rest periods. Through RCT, there may be an improvement of lactate clearance by an increase of mitochondrial density; though, future research will need to investigate the validity of this physiological adaptation and other possible responses.

BODY COMPOSITION

An RCT program can affect body composition in regards to total body mass (BM), lean BM (LBM), and body fat (BF) percentage. Body composition changes will most likely depend on the circuit type, with hypertrophy promoting circuits producing greater improvements in LBM (15). Studies with rest intervals ≤1 minute have all seen significant improvements in body composition whether using moderate loads around 70–75% (15,17) or lighter loads as low as 40–55% (31). The physiological responses leading to muscle hypertrophy and increases in LBM could be a product of higher training volumes (21). Additionally, in women, as in traditional strength training, high-volume multiple set circuits can elicit greater muscle strength when compared with a single-set lower volume circuit (21).

BF is also positively altered by RCT with Marx et al. (21) showing a BF reduction in untrained women with only 1 circuit session performed 3 times per week. The traditional 3 days per week, three 10-station circuits per day using intensities of 40–55% of 1RM, and a work to rest ratio of 30:15 seconds also produced significant reductions in BF in women (31). Furthermore, combined aerobic and strength exercises in a circuit program has also shown a reduction in skinfold measurements, waist circumference, and waist to hip ratio in middle-aged individuals and poorly conditioned air force personnel (20,30).

Unfortunately, although there are significant changes in LBM and BF with RCT, the lower intensity and lower loads typically used during RCT may not impact the bone mineral density (BMD) portion of LBM even over 24 weeks of training (5). Although improvements in BMD have not been shown after prolonged RCT, reductions in BF and increases in LBM are positive outcomes from RCT that improve physiologic health.

EFFECTS OF CIRCUIT TRAINING ON PHYSIOLOGICAL MARKERS OF HEALTH

In addition to improvements in health as a result of changes in body composition, completing 10 weeks of circuit training performed 3 times per week using 50–60% of 1RM can produce significant increases in high-density lipoprotein cholesterol (HDL-C) (9). Similar increases in acute HDL-C levels (1 hour after exercise) were quantified after 1 bout of 3 set 10-station circuits using a work to rest ratio 30:30 seconds and similar exercise intensity (18). Decreases in low-density lipoprotein cholesterol and the total cholesterol to HDL-C ratio have also been seen in paraplegic individuals using an aerobic strength circuit and progressive overload scheme (24). There is also a benefit after 10 weeks of 3 circuits per day using 50–60% of 1RM demonstrating an increase in glucose disposal (9). Potential increases in glucose disposal may indicate that an RCT is a good exercise mode to control type II diabetes (8) and help control lipoproteins (23).

Additionally, improved vascular function (e.g., increased blood flow) has been seen as a result of circuit training using loads of around 60% of 1RM but only in individuals who had impaired blood flow (10) such as patients with coronary heart failure (14). There is data suggesting a positive health benefit from RCT on resting and exercising blood pressure both acutely and

chronically (20,28). Most of the evidence supports a moderate reduction of resting systolic and predominately diastolic blood pressure using an RCT at an intensity of 40% of 1RM (20).

Although there is no overwhelming evidence for the benefits of RCT on markers of health, it does appear that evidence exists suggesting similar benefits from RCT as seen with strength training. Circuit training could serve as an effective mode to positively influence metabolic variables (cholesterol and blood glucose), blood flow, and blood pressure. A single session of RCT provides a complete body workout while using low intensities and requiring a shorter total workout time (around 20–30 minutes)

IMPROVEMENTS IN STRENGTH

The focus of RCT can be maximal strength, strength endurance, muscle hypertrophy, increased connective tissue strength, and improved intermuscular coordination (3). Using loading percentages as low as 40–60% of 1RM during RCT has been shown to improve both lower-body and upper-body maximum strength in untrained men and women (10,31). However, application of this load (40–60% 1RM) to a trained population may prove less effective for developing maximal strength, so the RCT should use loads greater than 75% 1RM to improve maximal strength.

Even if cardiovascular exercise is included in the RCT program, strength gains are still seen in untrained or poorly trained individuals (20,29). Additionally, lighter loads (<60% of 1RM) used during only 1 circuit performed 3 times per week has been shown to improve muscular strength and, to a lesser extent, muscular power in untrained and poorly trained subjects (15,21,29). Also, sedentary men participating in a 10-station RCT, for 10 weeks, displayed a significant 15–42% increase in strength in pre- to postperformance values (13). Interestingly, 1 circuit was sufficient to increase maximum strength and muscle endurance but not isometric strength when compared with multiple circuits over 13 weeks of training in individuals who were slightly trained (<1 year of training) (15). It should be understood that these results do not suggest a wholesale acceptance of RCT for developing strength, but it may be an effective approach to enhancing strength in the individuals new to strength training.

Although when compared with traditional strength training, even with multiple sets, circuit training does not yield similar changes in strength (5) most likely because of the lower load (≤60% of 1RM). The difference between RCT and traditional strength programs in developing strength appears to be primarily because of the lower load not capable of generating enough stimulation for greater muscle recruitment even after 24 weeks of training (5).

RESISTANCE CIRCUIT TRAINING TARGET POPULATION

Therefore, the use of RCT is limited in the athletic population when strength gains are of primary importance. Although limited in use in the athletic population, the use of RCT in a special or the general population, where low-intensity loading still produces gains in strength, gives CPTs a valuable training method.

The inclusion of RCT is already a method of training in cardiac rehab setting (14) because of the reduced stress on the heart (30) even when compared with aerobic exercise (12). Improved strength has been observed in RCT program when using intensities around 40% of 1RM, although there is also the perception of improved functional strength within the same rehabilitation population (27,28). These lower strength training intensities allow for strength gains for deconditioned muscles, while preventing major increases in delayed onset muscle soreness and lower levels of perceived exertion, which is important for exercise adherence and safety in the rehabilitation (27) or untrained adult population.

There may also be an improvement to respiratory muscle strength and function based on the higher ventilation rate ($\dot{V}_E$) during RCT (4,12). Consider that after a period of inactivity from surgery, injury, or illness, there can be a lowering in respiratory function. These limitations experienced by the individual could manifest from a reduction in mitochondrial density, impaired vascular system, reduced hemoglobin, or loss of muscle strength, preventing higher demanding activities. If the individual is unable to walk or ride a bike for a prolonged period (approximately 30 minutes), then an RCT could provide a balance between brief bouts of work and rest. The work to rest ratio then can be changed because physical improvements occur that could lead to incorporation of prolonged aerobic activity or increased RCT duration. One RCT programming point that has been demonstrated in trained individuals is a drop in volume and load may not be needed with shorter rest periods (1), which is important as an untrained adult gains experience. These results should be encouraging for the CPT who has limited training time with their clients.

APPLICATION

Studies investigating the effects of RCT have focused on the health benefits and the general population. Applying the available RCT research along with established strength and conditioning principles will be used to form guidelines for program development. As previous literature suggests, rest is an important component to the overall program because it can influence adaptation, adherence, and recovery (3,11,30). There is no standardized work to rest ratio but rather guidelines that can be useful when accompanied by some common sense. Manipulation of the rest interval or work by increasing or decreasing either of these variables that will typically be indirect of one another with volume (time exercising) high and the rest time lowered. A key point here is to provide adequate time for rest between exercises, which may be longer or shorter based on an individual's response or adaptation to RCT.

Also, changes to the work to rest ratio may also be based on the ability of

a person to complete all repetitions during the work phase given any increase to resistance/load. The previous paragraph provides an example, although individual adaptations should not be overlooked by rigidly following a program design. There are limitations to using a percentage of maximum heart rate as a measure of aerobic intensity during RCT because of the error in the age-predicted formula (>10 bpm) (25) and more specifically the exercise pressor reflex (26). The activation of the exercise pressor reflex will result in changes in heart rate characterized by large peaks and valleys during rest intervals (16) without a concurrent linear increase in aerobic work (17). A suggested alternative option to measuring RCT intensity is some sort of rating of perceived exertion scale (12), which has been previously used with traditional resistance training (7).

Successful completion of an RCT program is also dependent on exercise order, which can also influence program cessation or adherence. Alternating from a lower to upper body, multijoint to single-joint exercises, or difficult to an easily executed exercise are presented (Tables 1, 2). Placement of exercises that require the greatest amount of mental concentration or force production would best be placed at the start of a circuit bout as to minimize the affect of fatigue. Desired adaptations of hypertrophy, strength, or power from RCT program should aid in developing exercise order to invoke the maximal response (11). Random exercise placement during an RCT session, although a novel approach, has fundamental flaws of undesirable fatigue increase, potential decreases in power production, increase of injury risk, and possibly the minimization of desired adaptations.

Table 1
RCT for the goal of enhancing overall health in a beginning participant

Exercise station	Work:rest (s)				
	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5
Chest Press	20:30; used for all exercises	20:25–20; used for all exercises	30:30; used for all exercises	30:25–20; used for all exercises	30:20–15; used for all exercises
Dumbbell Squats					
Lat pull-down					
SLDL					
Upright cycle					
Back row					
Upright cycle					
Shoulder press					
Leg press					
Recumbent cycle					
Dumbbell biceps curl					
Recumbent cycle					
Leg extensions					
Recumbent cycle					
Triceps elbow extensions					
Recumbent cycle					
Leg curl					
Upright cycle					
Abdominal crunch					
Back extension					

The circuit can be repeated more times as the person adapts to the training. Load used should be above the person's 12RM.

SLDL = Straight leg deadlift.

In a health-focused RCT, the individual should strive for a greater work and shorter rest interval to maintain a higher percentage of $\dot{V}O_2$ and higher exercising heart rate. By achieving a higher mean percentage $\dot{V}O_2$max and mean heart rate during exercise, possible improvement in HDL-C, lower total cholesterol, decreased resting systolic and diastolic blood pressure, and a reduction in BF percent can be obtained (20,22,23,28).

The exact exercises selected for the circuit may have an impact on health adaptations but are dependent on the individual's initial evaluation and should be safe to perform. The precise number of stations are subjective, which should be adjusted accordingly to the individual's ability, time allotted for the session, and the potential of improving the chance of desired adaptations. Incorporating a cardiovascular exercise at a low intensity (<65% $\dot{V}O_2$max) can aid in lactate removal and decrease blood acidosis resulting from the resistance training bouts (24).

Table 1 presents an RCT for health improvements in a novice adult trainer. There will be some strength increases from the program, but the overlying goal is improved health and not maximal strength performance. An RCT used to maximize training time yet develop maximal strength in the adult population would benefit if using an undulating guide to provide overload and unloading sessions over a training cycle. The factors that can be undulated during each session are load, repetition goal, or percent intensity. To insure that rest time is enough for full recovery of a previously exercised muscle group, alternating between upper and lower body is recommended, and by using large muscle group/multijoint exercises instead of using numerous single-joint exercises, time can be saved.

Table 2 has a list of 8 resistance training stations to be completed during a resistance training circuit focused on developing maximal strength in an intermediate trained individual. The list in Table 2 may seem short for

Table 2
RCT with the goal of enhancing strength in intermediate-level weight trainers or less

Exercise	Rep goal:rest				
	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5
Clean combo	6RM:120 s	6RM:90 s	3RM:90 s	6RM:60 s	2RM:120 s
Back squat DB chest press Deadlift 1-arm DB row	Same volume and intensity for remaining exercises	Same volume and intensity for remaining exercises	Same volume and intensity for remaining exercises	Same volume and intensity for remaining exercises	Same volume and intensity for remaining exercises
MB abdominal pullover	12 reps:120 s	12 reps:90 s	15 reps: 90 s	15 reps: 60 s	20 reps:120 s
MB torso rotation	12 reps:120 s	12 reps: 90 s	15 reps: 90 s	15 reps: 60 s	20 reps:120 s
Good mornings	10 reps:120 s	10 reps:90 s	12 reps: 60 s	12 reps: 60 s	15 reps:120 s

The circuit could be repeated for 2–3 more times as a person adapts.

DB = Dumbbell; MB = medicine ball.

a large training group, but adjustments can be made for the best fit to the individual's needs and goals following specific adaptations to imposed demands or size of the training group increases. Exercise selection should follow the specificity rule of attempting to use exercises that will strengthen the primary muscles used in an individual's occupation, daily activities, or recreation sport. RCT may or may not be the best approach for increasing maximal strength based on the limited research, but in the time constraints placed on individuals, the circuit approach may provide the needed stimulus.

CONCLUSION

The decision by a CPT to use circuit training programs should be based on the research, environment, equipment, client's current training status, and size of the class or exercise group. Circuit training has its value in saving time, but like any other program, it does have limitations. Those limitations are found in setting the pace (transition time between exercises) of the circuit, familiarity of the selected exercises, the monitoring of the progression toward training goals, and remembering that RCT variables may need to be adjusted every 4–8 weeks to ensure continued improvements in health and performance variables (i.e., strength and aerobic capacity). Even after decades of research, the application and understanding of where circuit training fits in an effective training program has yet to be elucidated. However, circuit training holds promise as a viable training method for meeting the demands for more time efficient programs and for introducing creative and novel training schemes for those seeking improvements in health.

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