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The Effect of High Intensity Interval Training vs Resistance-Based Circuit Training

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The Effect of High Intensity Interval Training (HIIT) vs. Resistance-based Circuit Training (RBCT) on Body Composition, Muscular Strength, and Muscular Endurance

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Abstract

High intensity interval training and resistance-based circuit training are both effective forms of exercise that promote muscular growth and can provide improvements in body composition. These different exercise methods were compared side-by-side in this study. The time commitment and intensity of each method were made uniform to yield the most accurate comparisons. Upon completion of the exercise regimen, each participant concluded by performing post-testing requirements that would be compared with their pre-testing results.

Introduction

In countries all around the world, there is an increasing percentage of people who have multiple risk factors for serious conditions, one of the biggest conditions being cardiovascular disease. One of the scariest facts about cardiovascular disease is that for the past couple of years, cardiovascular disease has been either one of, or the leading cause of death worldwide (1). With two of the risk factors for cardiovascular disease being obesity and hypertension, it is understandable to see how exercise can play a major role in combating this major health concern.

When it comes to exercise, there are an infinite amount of ways that it can be completed, solely based on any individual's preference to style, intensity, etc. However, in regard to more structured and refined styles of exercising, there were two that stood out. The first style of exercise being resistance-based circuit training. Circuit training on its own is any form of body conditioning, either endurance or resistance, that uses moderate to high intensities (3). An exercise circuit consists of the completion of all designated exercises in the prescribed program. In the case of resistance-based circuit training, the goal is to increase muscular strength and muscular endurance with the use of either free weights or resistance machines. This style of exercise was originally developed by two men by the names of R.E. Morgan and G.T. Anderson in 1953 (3). It was at the University of Leeds, in England where they designed a form of exercise that allowed people to workout at their own intensity while also including others in the circuit as well (7). The original design composed of 9 to 12 stations to be completed one after another by each participant, while only getting little amounts of rest between stations. The stations could be set up to require each participant to exercise for either a set period of time or number of repetitions. The original aim of this form of exercise was to cause each participant to utilize both, their aerobic, and anaerobic energy systems (3). Another appealing fact about resistance-based

circuit training is that it meets the guidelines for the American College of Sports Medicine for the recommended intensity of exercise for developing and maintaining cardio-respiratory fitness (7). This means that not only does this form of exercise elicit increases in muscular strength and muscular endurance, but it can also provide improvements in a person's cardiovascular health. As one can see, resistance-based circuit training will provide its participants with a number of health-related benefits, while also allowing people to complete the workouts in groups.

As stated earlier, there is a second form of exercise that is also very interesting. This form of exercise has become extremely popular in recent years for its quick results and effective use of time. It is known as High Intensity Interval Training and according to the American College of Sports Medicine, was the top fitness trend worldwide in 2014, and the second top fitness trend in 2015. High Intensity Interval Training is mostly known for being effective in producing musculoskeletal, metabolic, and cardiorespiratory improvements (2). This style of training has gained a lot of momentum in the fitness world due to the tissue adaptations it produces, similar to the adaptations produced by traditional aerobic training. However, what truly makes high intensity interval training so attractive to exercisers all around the world, is the time required to complete a session of the workout. One of the most common reasons to nonadherence to an exercise program or prescription is the lack of time commitment for exercising (1). That's where high intensity interval training comes up. High intensity interval training sessions can be completed in a time frame of 20-30 minutes, depending on the duration of each bout. High intensity interval training is a form of exercise that involves short bouts of high intensity effort, followed by short periods of either active or passive recovery (5). The origins of high intensity interval training can be traced all the way back to the early 1900's, when Olympic runner Paavo Nurmi and his trainer Lauri Pikhala began using an interval training system for their training

sessions (4). This form of interval training was also used by the Finnish gold medalist Hannes Kolehmainen during his Olympic training (4). It was during the mid 1900's that a German trainer named Woldemar Gerschler would take this new form of training and develop it even more (4). His training resembled today's style of interval training, in which he concentrated on shorter bouts of greater intensity, due to the fact that the periods of rest or light jogging that followed these bouts of high intensity allowed for partial restoration of energy (4). Research has shown that high intensity interval training not only provides improvements in aerobic fitness, but it also shows significant reductions in the fat mass of the whole body (1). Also, high intensity interval training has been known to show to increase insulin sensitivity in the body (6). This is important because increasing insulin sensitivity improves your body's ability to utilize glucose from carbohydrates for energy while exercising, or it can also be stored for later use. Increasing insulin sensitivity also aids in the prevention of Type II diabetes, which is another risk factor for cardiovascular disease. It is because of all these aforementioned factors that high intensity interval training has gained its popularity in the fitness world.

Upon the completion of researching these two different methods of exercising, the research team that I was included in decided to ask a simple question regarding these exercise protocols. Which of the two exercise methods is better? More specifically, which of the two methods would provide the greatest improvements in muscular strength, muscular endurance, and body composition? We proposed that by comparing the two exercise methods over the same period of time, at the same intensity, and with participants who all met the same inclusion material, we would be able to determine which of the two methods provided people with the greatest improvements for their efforts. It was our hope that this study would help people determine which style of exercise would provide them with the health benefits they desired.

Subject Recruitment

Adult males between the ages of 18-45 years were recruited to participate in this study. Subjects were recruited from Western Michigan University's student and employee population by posted flyers in the Student Recreation Center and College of Education and Human Development as well as announcements made in courses offered in the Department of Human Performance and Health Education. Subject recruitment was also open to the surrounding areas of Kalamazoo, Portage and Comstock. The subjects must be healthy and couldn't have a previous musculoskeletal injury in the past six months. They also couldn't have any chronic illness, cancer, cardiovascular disease, COPD or hypertension. The American College of Sports Medicine (ACSM) identifies the age range of 18-45 as low risk individuals for high intensity exercise.

The subjects were asked to maintain their customary nutritional regimen and normal activities of daily living, but refrain from engaging in any structured exercise outside the study throughout the study period. This included any weight lifting or intense aerobic exercise. The male population was selected for recruitment due to the differences in metabolic rates compared to the female population. Factors such as total energy expenditure, body composition, overall body mass, and hormone fluctuation during the menstrual cycle are all variables that could potentially cause adverse effects that might result in inaccurate data.

Informed Consent

If a potential subject was interested in the study, one of the researchers would briefly go over the outline of the study and what would be required of the individual. If the prospective

subject met the general inclusion and exclusion criteria and still wanted to participate in the study, they were be invited to an orientation meeting. During the meeting, the researchers would thoroughly explain the research protocol, the risks and benefits of the study, and would then give the individual a copy of the informed consent contract. The individual would then read and sign the informed consent document and fill out the Minnesota Leisure Time Activity Questionnaire. The questionnaire is used to score the individual's activity levels, and determine whether or not that individual met the inclusion requirements of the study. At this point, the subjects completed their body mass index measurement, were assessed with skinfold and girth measurements, and recorded baseline measurements of 1RM bench/leg press, 50% 1 RM to failure on bench, Vo2 max test, and 10RM for each exercise that will be listed in the 'methods' portion. The researchers then asked the subject to schedule times that the participant would be willing and able to complete the various testing and exercise sessions.

Instrumentation

Heart Rate Monitor: This instrument was used to make sure subjects reached the target heart rate during the HITT/RBCT testing visit.

Body Composition: Skinfold assessments were completed using a skinfold caliper and body fat percentage was calculated using a 7-site skinfold calculation.

WATT Bike: The cycle ergometer was used for the HIIT sessions and workload reached no lower than 50 W during recovery periods. Workload could be adjusted during sprints to achieve the target HR for each subject.

Rating of Perceived Exertion (RPE): This is a 15-point scale used to assess perceived exertion, or how hard you feel like you are working at any given time. The scale ranges from 6 to 20 with

verbal anchors such as “very light,” “somewhat hard” and “very hard” [5]. It is based on the physiological changes that occur during exertion such as increased heart rate, breathing rate and sweating but is a psychological measure. This was used for the pre and post testing of the VO_2 max.

Methods

There was no control group for this study due to the fact that we were looking at pre and post measurements of the applied interventions. A baseline 1RM / 10RM testing procedure was carried out one week prior to beginning the protocols to ensure safety when performing the 7 resistance training exercises. 5-minutes of low intensity riding on a resistance bike was used to provide sufficient warm up for the subjects before engaging in any of the testing protocols. Baseline and follow-up testing measurements such as body composition, aerobic capacity and muscle mass / endurance were all kept confidential and emphasized in the informed consent process. Orientation consisted of the researchers walking the subjects through the informed consent, which included the purpose of the study, the benefits and risks of the study, and their right to withdraw from the study at any time. Following the subjects’ signing of the informed consent forms, baselines were taken for both groups on: 1RM for Bench press and Leg press, body composition, Vo2 max. If the subject was placed in the RBCT protocol, they would also perform 10 repetition maximum (RM) tests for chest press, shoulder press, lateral pulldown, seated row, leg press, leg curl, and leg extension.

The body composition was taken using a 7-site skinfold measurement and girth measurements. These techniques use a variety of points across the body that, when assessed by the proper technician, can be used to calculate the approximate fat/fat free masses of the body.

The basic implementation of this technique is to pinch a small amount of skin with your fingers, followed with the caliper in order to get a numerical value of the distance between the two clasps of the caliper. Once all measurements are taken they can be input into a skinfold calculation to determine the fat/fat free masses. Both Graduate Researchers were certified and fully practiced in the use of this measurement of body fat percentage. The sites of measurement were chest, midaxillary, triceps, subscapular, abdomen, suprailiac and thigh.

Aerobic capacity was measured during the pre and post intervention sessions following both protocols. The main variable used to determine improvement was a Vo2 max test taken at the pre and post intervention time periods. The Vo2 max test is one that involves measuring gas exchanges, using a gas analyzer, in the body during maximal effort aerobic activity. The test was completed on a stationary Watt bike. The higher the number for Vo2 max calculated, the greater the body's ability to utilize oxygen during exercises. Hence, the greater the aerobic capacity for that individual.

Muscular endurance was measured by performing the bench press using 50% of the subject's initial 1RM in the bench press for as many repetitions as possible to muscular failure with proper form. Successful performance was achieved if the subject displayed a five-point body contact position (head, upper back, and buttocks firmly on the bench with both feet flat on the floor), touched the bar to his chest, and executed a full lock-out. Muscular endurance testing was carried out after assessment of muscular strength to minimize the potential of metabolic stress interfering with performance. Once the subject was no longer able to complete another repetition without assistance, the test ended and the total amount of full repetitions was counted. The higher the number achieved directly correlated with any increases in muscular endurance.

Baselines collected during the first session were 10 RM tests to determine the load for each resistance training exercise. Testing began with a warm up of 10 repetitions at 50% of the subjects 10 RM. After 1-minute rest, subjects attempted to perform a 10 RM at the predicted load. If more or less repetitions were performed, the load was adjusted and subjects would attempt their 10 RM again after a 3-minute rest period. This procedure was repeated for all seven exercises in the protocol.

Muscular strength Upper- and lower-body strength was assessed by a 1RM test in the bench press and leg press exercises. These exercises were chosen because they are well-established measures of maximal strength. Subjects reported to the lab having refrained from any exercise other than activities of daily living for at least 48 hours prior to baseline testing and at least 48 hours prior to testing at the conclusion of the study. Maximal testing was consistent with recognized guidelines established by the National Strength and Conditioning Association (1). Subjects performed a general warm-up prior to testing, which consisted of light cardiovascular exercise lasting approximately 5-10 minutes. A specific warm-up set of the given exercise of 5 repetitions was performed at ~50% 1RM followed by one to two sets of 2-3 repetitions at a load corresponding to ~60-80% 1RM. Subjects then performed sets of 1 repetition of increasing weight for 1RM determination. Three to 5 minutes of rest was provided between each successive attempt. All 1RM determinations were made within 5 attempts. Successful 1RM for bench press was achieved if the subject displayed a five-point body contact position, lowers the bar to his chest, and executes full elbow extension. For the 1RM leg press, proper form was assessed by both athletic training graduates. The attempt was deemed successful when subjects were able to fully perform a squatting motion through the full range of motion with proper form. The 1RM leg press testing was conducted prior to the 1RM bench press with at

least 5 minutes as a rest period separating tests. Two members of the research team supervised all testing sessions. Lifts were measured by the maximum weight possible a subject could successfully complete one repetition. Improvements were marked at any point the subject increased weight during the regular workouts as well as the maximal testing at the end of the study. The comparison of pre / post intervention maximum tests gave us a numeric value of strength gained from each protocol per subject.

After all the initial measurements had been completed, the subjects returned after a minimum of 24 hours' rest for their first session. Participants were pair-matched according to baseline body fat percentage levels in order to most accurately compare exercise protocols and then randomly assigned to 1 of 2 groups: A circuit training group (RBCT) that performed a 30-minute resistance training protocol, or a HIIT group that performed a 30-minute cardiovascular exercise protocol. The subjects assigned to the RBCT group went through a protocol that consisted of 7 exercises for the major muscle of the body: chest press, shoulder press, lateral pulldown, seated row, leg curl, leg press, and leg extension. This protocol was performed in the Student Recreation Center building in the weight room. Permission for the use of the weight room was obtained prior to the start of the study. For each of the seven exercises, three sets of 10 repetitions were performed with a 90 second rest in between sets. Before starting the resistance training protocol, subjects would complete a 5-minute bike warm up. However, if they were placed in the HIIT group, they would complete the high intensity aerobic protocol. The HIIT protocol was as follows, after a 3-minute warm-up at 50% HRmax, subjects performed 10 × 60-second intervals at a workload corresponding to 90% HRmax interspersed with 60 s of active recovery at 50 Watts. The session concluded with a 2-minute cooldown at 50% HRmax. HIIT training and baseline testing was carried out on a WATT bike.

The chosen program was repeated for three non-consecutive days a week for eight weeks. During each session, at least one researcher was present to verify completion of session and insure safety. At the end of the eight weeks, the subject would re-test all measurements from the pre-testing and be able to see the improvements made during the intervention.

Results

Due to the length of the study, and the time commitment required of the researchers, there were a total of five participants that completely finished. Of the five that finished, three of the participants completed the HIIT protocol, while the other two completed the RBCT protocol. Upon their completion of the study, each individual was rewarded $100 for their participation in the study. To examine the improvements made by the individuals in each protocol, all of the recorded numbers from their body composition measurements and their lifts were compared side by side.

Figure 1

Measurements	DR003	DR004	DR006
1 RM Bench Press	Increased 20 lbs	Decreased 5 lbs	Decreased 5 lbs
1 RM Leg Press	Increased 90 lbs	Decreased 35 lbs	Increased 50 lbs
Endurance Bench Press	Ø	Ø	Increased 8 reps
Body Fat %	Decreased 2.1%	Decreased .22%	Decreased 3.05%
Upper Arm Girth	Decreased in size	Increased in size	Decreased in size
Upper Leg Girth	Increased in size	Decreased in size	Increased in size

Figure 1 is a representation of the members who completed the HIIT protocol. It was expected to see decreases in the muscular strength and muscular endurance of these individuals, due to the fact that their protocol strictly consisted of workouts on the stationary WATT bike. However, two of the individuals actually increased their 1 RM leg press. This is a result of the fact that the muscular strength of their legs still increased during their protocol due to the high intensity exercise that the completed on the bike. The HIIT members also all showed decreases in overall body fat percentage, with one individual decreasing their body fat percentage by more than 3%. The girth measurements were also as expected, the arm girth measurements were expected to decrease in the HIIT group due to their arms not being exercised throughout the study. The leg girth measurements on the other hand, were in fact expected to increase due to the expectation of muscle density to increase from the high intensity exercise of the legs.

Figure 2

Measurements	DR002	DR005
1 RM Bench Press	Increased 5 lbs	Increased 20 lbs
1 RM Leg Press	Increased 50 lbs	Increased 20 lbs
Endurance Bench Press	Increased 4 reps	Increased 10 reps
Body Fat %	Decreased .66%	Increased .44%
Upper Arm Girth	Increased in size	Increased in size
Upper Leg Girth	Increased in size	Increased in size

Figure 2 is a representation of the two participants that completed the RBCT protocol. These individuals also showed the improvements in each category that were expected. Both individuals

showed increases in both of their 1 RM tests, along with their endurance bench press tests. One of the individuals however, did show an increase in body fat percentage. Due to the fact that it was a very minimal increase, we expect that it is attributed to a component of the individual's lifestyle outside of the study such as their diet. Along with the increases in each of the lifts, the members of the RBCT protocol also saw increases in both girth measurements. This shows that both individuals had an increase in the muscle density of their arms and legs. This was an expected outcome for the members of the RBCT protocol, as resistance based training is known for its results in improving muscular strength and endurance.

Conclusion

Based on the data that has been gathered from this study thus far, the results support the fact that both exercise protocols do have positive impacts on body composition, muscular strength, and muscular endurance. In regards to which of the two protocols is more effective, it depends on what overall outcome an individual is seeking. For example, if someone was looking for whichever of the two methods of training is more effective at reducing overall body fat percentage, I would recommend high intensity interval training based on the results of this study. On the other hand, this study also demonstrated the fact that resistance based circuit training is more effective at improving muscular strength and endurance. Hopefully the fitness world will continue to grow and expand, and potentially create an even newer and more efficient method of exercising.

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