AEROBIC AND RESISTANCE EXERCISE PROTOCOLS FOR OVERWEIGHT AND OBESE CHILDREN: A SYSTEMATIC REVIEW

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Evidenced Based Practice Seminar III Research Project
submitted in partial fulfillment of the
requirements of the course: PT 7344
Physical Therapy Program
Angelo State University
May 8, 2015

Abstract

Background: In recent times, the prevalence of childhood obesity has been increasing in the United States. Obese individuals have been shown to be at an increased risk for developing health complications such as metabolic syndrome, type 2 diabetes (T2DM), and other cardiovascular disorders. Exercise is one of the methods used to prevent and treat obesity. Current exercise recommendations from the U.S. Department of Health and Human Services (USDDHS) and the American College of Sports Medicine (ACSM) are directed to healthy children or obese adults. However, they do not provide detailed exercise recommendations for overweight or obese children. This review derives aerobic and resistance exercise protocols for children with a body mass index (BMI) ≥25 from studies that have administered exercise prescriptions to overweight and obese children.

Methods: A systematic review using PubMed, CINAHL, MEDLINE, PEDro, and Cochrane databases was performed. Search terms used were combinations of: obese, overweight, children, adolescent, exercise, aerobic, and resistance. Quality assessment of articles was performed using the PEDro assessment tool.

Results: The primary search strategy yielded 10 studies for inclusion in this review. Seven studies utilized aerobic interventions and 3 utilized resistance interventions. The aerobic exercise protocol was derived by calculating the means of exercise parameters from the 7 aerobic studies. The resultant aerobic exercise protocol consisted of 47.1 minutes per session, 4 times per week at an intensity of 61.9% VO2 max or at least 150 bpm utilizing aerobic exercise equipment or aerobic games for at least 11.9 weeks. The resistance exercise protocol was derived by calculating the means of exercise parameters from the 3 resistance studies The

resistance exercise protocol resulted in 2 sets of 10 repetitions at 72.5% of the subjects 1 repetition max 2.3 times per week. A mean of 8 exercises were performed per session focusing on both lower and upper body exercises for 12 weeks.

Conclusion: Each exercise protocol was derived from studies that showed significant improvements in risk factors associated with metabolic syndrome, T2DM, and other cardiovascular diseases. These exercise protocols provide a viable exercise prescription specifically for risk factor reduction in overweight and obese children.

Introduction

Data collected between 2009-2010 showed that 17% of youth in the United States were obese.[1] A majority of overweight and obese children are likely to present with orthopedic complications, hypertension, dyslipidemia, abnormal glucose levels, and increased insulin resistance during childhood.[2] The presence of childhood obesity has been shown to have an increased prevalence of metabolic syndrome.[3] Metabolic syndrome is characterized by glucose intolerance, insulin resistance, central obesity, dyslipidemia, and hypertension, placing children at an increased risk for developing complications such as T2DM and cardiovascular disease (CVD).[3, 4, 5] Additionally, the onset of puberty has been shown to be accompanied with decreased insulin sensitivity and a decreased insulin response, further compounding the risk for developing T2DM and CVD.[6, 7] In order to prevent the development of these medical conditions, a reduction in the severity of the risk factors seen in obese children becomes crucial.

Exercise in children has been shown to improve fasting insulin, insulin resistance, and other CVD risk factors.[8] Recent studies have examined the impact exercise has on overweight and obese children. Aerobic exercise has been shown to be effective in improving insulin resistance in obese adolescents.[9] Resistance exercise has been shown to have improvements on BMI, waist circumference, and percent body fat in overweight and obese children.[10]

Current physical activity guidelines from the USDHHS recommends healthy youth achieve 60 minutes of daily physical activity and moderate to vigorous exercise at least 3 times per week.[11] However, the most recent exercise guidelines provided by the Department of Health and Human Services were last updated in 2008 and they do not provide exercise guidelines for overweight or obese children. The ACSM provides exercise guidelines for obese and overweight adults which

are consistent with exercise recommendations for healthy adults, however, recommendations for obese or overweight children are not specifically outlined.[12] The purpose of this systematic review is to provide aerobic and resistance exercise protocols for overweight and obese children shown to be effective in improving health conditions associated with metabolic syndrome, T2DM, and other cardiovascular diseases.

Methods

Search Strategy

The review was conducted by locating articles published before August 2014 through searches of PubMed, CINAHL, MEDLINE, PEDro, and Cochrane databases. Search terms used were combinations of: obese, overweight, children, adolescent, exercise, aerobic, and resistance. Additional articles were located through a review of retrieved article reference lists.

Inclusion and Exclusion Criteria

Inclusion criteria for article selection were: randomized controlled trials, human subjects ≤18 years of age, published in English, peer reviewed, exercise was the only intervention implemented on the test group, all intervention group test subjects had a BMI ≥25, test subjects were not diagnosed with T2DM. Exclusion criteria for articles consisted of non-peer reviewed articles, non-randomized controlled trials, dietary restrictions placed on the intervention group, no statistically significant improvements, and exercise intensity, frequency, or mode not documented in the study.

Exercise Protocol Derivation

Exercise protocols were derived by calculating the means of components essential to developing an exercise prescription. The aerobic exercise protocol was derived by calculating the means of exercise intensity, frequency, and duration from each aerobic exercise study satisfying all inclusion and exclusion criteria. The resistance exercise protocol was derived by calculating the means of intensity, frequency, repetitions, number of sets, and number of exercises performed per exercise session from each resistance exercise study satisfying all inclusion and exclusion criteria.

Statistical Analysis

To avoid misrepresentation of the presented data, a meta-analysis was not conducted due to a lack of uniformity in expression of aerobic and resistance exercise prescriptions in terms of exercise intensity.

Quality Assessment

Article quality assessment was performed using the PEDro assessment tool which assessed study internal validity and interpretability. The PEDro scale has been shown to be a valid measure of methodological quality of clinical trials and has a reliability rating of "fair" to "good" when rating the quality of randomized controlled trials.[13,14] Articles were scored on a 10 point scale out of 11 items on the PEDro assessment tool.

Results

Search Results

The main search strategy yielded 1,265 hits. Articles were then subjected to a title and abstract screening, which resulted in 25 studies being chosen for further consideration. Upon further screening, 5 studies were excluded due to having placed dietary restrictions on the intervention group. Nine were excluded because they did not provide a workout intensity used in their exercise protocol. One study was excluded because it was not a randomized controlled trial. After all exclusions were made, a total of 10 studies were included, 7 studies utilizing aerobic exercise as the primary intervention and 3 studies utilizing resistance exercise as the primary intervention. Search results are shown in Fig. 1. Seven studies were conducted in the United States, 1 was conducted in China, 1 in Australia, and 1 in Tunisia.

Study Quality Assessment

An assessment of the study quality according to the PEDro assessment tool is presented in Table 1. Quality scores of the studies were low to moderate with a mean PEDro score of 5.9 out of 10. Scores ranged from 4[15] to 7.[16,17,18] All trials performed between group comparisons, random allocation, and point estimates and estimates of variability. Only 1 study had blinded subjects.[18] Based on our study population, it was expected there would be minimal studies with blinded test subjects.

Aerobic Exercise

Seven studies were used to examine the effect aerobic exercise had on children or adolescents with a BMI of ≥25. Four hundred fifty-four subjects participated in the aerobic studies with an average age of 11.9 (range 9.4-15.0) and 51% were males. Four studies utilized stationary cycling, ellipticals, or treadmills as their primary exercise mode. Three studies utilized aerobic

games such as relay races, basketball, jump rope, and other school yard games as their exercise mode.

Four aerobic studies reported significant improvements in aerobic fitness with a mean VO2 peak improvement of 4.0 ml/kg/min (range of 2.4-9.0 ml/kg/min).[19, 16, 17, 20] Three studies reported significant reductions in waist circumference and percent body fat with a mean reduction of 3.9 centimeters (cm) (range 1.7-8.0 cm) and 1.6% (range 0.84-2.6%), respectively.[17, 21, 22] Additionally, throughout the 7 studies, a single occurrence of a significant improvement of insulin resistance, general adiposity, visceral adiposity by volume, visceral adiposity by weight, low density lipoprotein (LDL), high density lipoprotein (HDL), arterial endothelial function, brachial artery flow-mediated dilation (FMD), BMI, fat free mass, central adiposity, body weight, triglycerides, insulin concentration, percent fat mass, and peak workload and metabolic equivalent of task (MET) capacity was reported.[17, 20, 21, 22, 23] See Table 2 for a summary of the aerobic intervention studies.

The calculated aerobic exercise parameters from the 7 aerobic studies consisted of 47.1 minutes per session (range 40-60 minutes), 4 times per week (range 3-5 times per week) at an intensity of 61.9% VO2 max (range 50-70% VO2 max) or at least 150 bpm utilizing aerobic exercise equipment or aerobic games for at least 11.9 weeks (range 8-16 weeks).

Resistance Exercise

Three studies were used to examine the effect resistance exercise had on children with a BMI ≥25. One hundred forty-four subjects participated in the resistance intervention studies with an average age of 14.2 (range 12.3-15.4) and 76% were males. All 3 studies performed upper and lower body exercises during each workout session. Two studies performed bench press, leg

press, biceps curls, and hamstring curls during each session.[17,18] The remaining study performed the chest press and leg press on alternating days.[15] The remainder of the exercises from all studies targeted the remaining large muscle groups for the upper and lower body.

All 3 resistance studies reported significant improvements in upper and lower body strength through 1 repetition maximum (1RM) of bench press and leg press.[17, 15, 18] A mean increase of 11.9 kg (range 11.6-13.7 kg) was reported for upper body strength. A mean increase of 41.2 kg (range of 29.8-50.9 kg) was reported for lower body strength. Two studies reported significant improvements in BMI and waist circumference with a mean reduction of 0.3 kg/m^2 (range 0.01-0.5 kg/m^2) and 2.0 cm (range 0.8-3.2 cm), respectively.[17, 18] Throughout the 3 studies, a single occurrence of a significant improvement of aerobic fitness, general adiposity, percent body fat, fat free mass, body weight, skeletal muscle, muscular strength index, total strength, insulin sensitivity, and upper, lower, and total body strength normalized per body weight was reported.[17, 15, 18] See Table 3 for a summary of the resistance intervention studies.

The calculated resistance exercise parameters from the 3 resistance studies consisted of 2 sets of 10.1 repetitions (range 8-12 repetitions) at 72.5% of the subjects 1RM (range 70-75 % 1RM) or a 16.5 rating of perceived exertion (RPE) 2.3 times per week (range 2-3 times per week). A mean of 8.7 exercises (range 5-11 exercises) were performed per session focusing on both lower and upper body exercises for 12 weeks (range 8-16 weeks).

Discussion

An adequate amount of literature exists showing the many health benefits exercise provides for overweight and obese children.[8, 9, 10] In order to apply the benefits of these findings, an exercise prescription specific to this population is needed. The distinguishing factor of our protocols is

that our recommendations were derived from results seen in children with a BMI ≥25 and not from healthy youth or the obese adult population. The results of this systematic review expand on previous studies and outline a more specific exercise prescription for reducing cardiovascular and metabolic risk factors in overweight and obese children.

Aerobic Recommendations

Based on our calculations of aerobic exercise parameters, we recommend obese and overweight children perform at least 47 minutes of aerobic activity 4 times per week at 62%VO2 max or at least 150 bpm for at least 12 weeks utilizing aerobic exercise equipment or aerobic games. As previously mentioned, the USDHHS recommends healthy youth achieve at least 60 minutes of daily physical activity and moderate to vigorous exercise at least 3 times per week.[11] The ACSM aerobic exercise recommendations for overweight or obese adults recommend adults exercise at least 5 days a week, 30-60 minutes a day at an initial exercise intensity of 40-60% heart rate reserve.[12] Our exercise parameters are fairly similar to the ACSM's recommendations in all aspects, however, our aerobic exercise recommendations provide more specific exercise parameters based on more current evidence that has applied aerobic exercise prescription specifically to overweight or obese children. The aerobic interventions included in this review utilized either standard aerobic exercise equipment or common school yard games as their primary mode of exercise indicating significant improvements can be achieved in multiple settings. With regards to risk factor reduction, multiple aerobic intervention studies reported improvements in waist circumference and VO2 peak. Children with larger waist circumferences have been shown to have a significantly higher prevalence of developing metabolic syndrome in adulthood when compared to youth with smaller waist circumferences.[24] Individuals with an improved VO2 peak, have been shown to have lower rates of cardiovascular disease and overall

mortality.[25] Additional improvements in cardiovascular disease and metabolic syndrome risk factors were seen throughout the 10 studies. However, these benefits only occurred in a single instance throughout the 10 studies. These results may be attributed to unforeseen benefits of aerobic exercise prescription in this population. Nevertheless, due to these reported health improvements, our aerobic exercise protocol may prove to be an effective and viable option for application to overweight or obese children.

Resistance Recommendations

Based on our calculations of resistance exercise parameters, we recommend obese and overweight children perform at least 2 sets of 10 repetitions at 72% of the subject's 1RM 2 times a week. At least 8 exercises focusing on the large muscle groups of the upper and lower body should be performed per session for at least 12 weeks. The ACSM's resistance exercise recommendations for healthy adults recommend adults perform 2-4 sets of 8-12 repetitions at 60-80% 1RM 2-3 times a week performing exercise that focus on the large muscle groups of the upper and lower body.[12] The resistance protocol we derived was similar to the ACSM's recommendations for resistance training in healthy adults, however, our recommendations provide more specific and current resistance exercise parameters that have been applied to overweight and obese children. In our review, all 3 studies reported an increase in upper and lower body strength.[15,17,18] Roberts et. al. reported how increased muscle strength through resistance training in men resulted in a decreased prevalence of metabolic syndrome risk factors [26]. In addition to increased strength, 2 studies reported reductions in waist circumference.[17,18] As previously mentioned, Spolidoro et. al. reported reductions in waist circumference were also beneficial in reducing metabolic syndrome risk factors.[24] Therefore, our resistance exercise

protocol may also prove to be a viable option for use by overweight and obese children for health improvements.

Potential Benefits of Combination Exercise

Several studies were excluded from this review because they did not only measure aerobic or resistance exercise prescriptions. Studies that performed a combination of aerobic and resistance exercise were excluded because of the inability to derive an exercise protocol that was strictly based on only aerobic or resistance components. Despite these exclusions, significant health improvements were seen when a combination of aerobic and resistance exercise were applied to this population.

A combination of aerobic and resistance modes may be a viable option for use by this population. Schwingshackl et. al. and Roberts et. al. have suggested than an addition of an aerobic component to a resistance training regimen would increase the overall health improvements seen in adults who only utilize resistance training.[26, 27] Farpour-Lambert et al and Kim et. al. utilized a combination of aerobic and resistance interventions without dietary restrictions on overweight and obese children.[28, 29] Their combined weekly exercise volume corresponded well with each of our derived weekly exercise volumes. Significant improvements reported in these studies were insulin resistance, percent body fat, BMI, systolic blood pressure, and total cholesterol; all metabolic syndrome risk factors, suggesting a combination of resistance and aerobic exercise is beneficial for this population.

Potential Benefits of Dietary Restrictions

The addition of dietary restrictions plus aerobic or resistance interventions were excluded from this study to gauge the impact of only exercise on risk factor reduction in this population.

Additional studies have analyzed the impact a dietary intervention coupled with an exercise intervention has on risk factor reduction in children with a BMI ≥25. Suh et. al. and van der Heijden et. al. conducted aerobic interventions coupled with a dietary component in their studies.[30, 31] Both studies restricted test subject caloric intake and encouraged a proper intake of protein, fats, and carbohydrates. The aerobic exercise protocols used by Suh and van der Heijden were similar to the derived aerobic protocol of this study and saw similar improvements in cardiovascular and metabolic syndrome risk factors. In addition, both studies also reported improvements in insulin resistance. Of the 10 studies used in this review, only Davis et.al. reported significant improvements in insulin resistance.[16] A dietary component coupled with exercise may be necessary to facilitate insulin resistance improvements, a risk factor for T2DM and metabolic syndrome.

Practical Application

The recommended aerobic exercise intensity of our protocol is 62% VO2 max or at least 150 bpm. With regards to practical application, time or equipment constraints may prevent clinicians or clients from prescribing or maintaining an accurate exercise intensity when they are expressed in this manner. Therefore, in order to make the monitoring of aerobic exercise intensity more practical, an alternative expression of exercise intensity may be necessary. Foster et. al. examined the relationship between aerobic exercise intensity and test subjects' abilities to carry on a conversation during aerobic exercise via the Talk Test. The Talk Test measures the amount of effort test subjects must exert to converse during exercise and correlates the effort into percentages of max heart rate or RPE. They demonstrated using the Talk Test was a fairly accurate method to gauge exercise intensity, primarily sub-maximal exercise, based on test subjects' abilities to carry on a conversation during exercise.[32] Therefore, we believe using the

Talk Test and exercising at a rate to where the subject is able to carry on a conversation comfortably corresponds well with the aerobic exercise intensity derived from our aerobic protocol.

The recommended resistance exercise intensity of our protocol is 72% 1RM. Performing maximum resistance testing may be time consuming and may put children at unnecessary safety risks. In order to maintain the safety of the children and increase the practical application of our resistance exercise protocol, the 1RM for each exercise may be expressed in terms of RPE. Eston et. al. demonstrated that by using the Borg Scale, RPE could be used accurately to extrapolate a one repetition maximum from lower and upper body exercises.[33] An RPE of 20 correlated well with 1RM and RPEs in the 15-17 range correlated well with 60-70% 1RM. Therefore, we believe that maintaining an RPE at the 15-17 range throughout a resistance exercise session correlates well with the intensity we derived for our resistance exercise protocol. These intensity conversions should increase the practical applications of our exercise protocols.

Compliance

Despite the well documented benefits of exercise for this population and providing the convenience of detailed exercise protocols, the issue of compliance becomes a major barrier to health improvements. Nader et. al. reported youth begin to fall below the recommended activity level of 60 minutes per day at around 13-14 years of age.[34] Mitchell et. al. reported youth who engaged in increased sedentary behavior between the ages of 9 to 15 years of age had higher BMI's, including youth in the 90th percentile.[35] Therefore, alternatives to conventional aerobic and resistance exercise modes may be necessary in order for this population to attain the amount of exercise necessary to decrease health risk factors. Carson et. al. surveyed over 3,000 U.S. adolescents from 2007-2012. The youth surveyed averaged 7.5 hours a day sitting with 38% and

22% reporting spending >2 hours a day in front of a television or computer, respectively.[36] With the relatively large amount of time spent in front of a television or computer screen, active video games which incorporate aerobic or resistance components may be a practical alternative to conventional exercise methods.

Limitations

The primary limitation of this review is the small amount of evidence available that fulfilled our inclusion and exclusion criteria (7 aerobic randomized controlled trials and 3 resistance randomized controlled trials). Therefore, the small amount of available data limits the significance of our exercise recommendations derived from these randomized controlled trials, particularly the resistance exercise recommendations. Additionally, the low to moderate quality of our randomized controlled trials on the PEDro scale also limits the significance of our findings. Additional higher quality randomized controlled trials would increase the significance of our exercise recommendations. Despite the paucity of evidence, our review provides the foundation for further research into exercise prescription for this growing population.

Conclusion

For overweight and obese children, we recommend performing at least 45-50 minutes of aerobic activity at a comfortable conversation level of intensity at least 4 times a week. The aerobic exercise mode may be left up to the individual's preference as long as frequency and exercise intensity are maintained. Possible options may include utilizing a treadmill, stationary bike, team sports, or school yard games. If a resistance mode of exercise is preferred, we recommend performing 2 sets of 10 repetitions while maintaining a constant RPE of 15-17 throughout the exercise session at least 2 times a week. Each exercise session should consist of at least 8

exercises focusing on the large muscle groups of the upper and lower body during each session such as the bench press or leg press. Both protocols should be performed for at least 12 weeks, however, as with any exercise program, a lifelong continuation of exercise is necessary. As previously mentioned, dietary modification may also be implemented to increase risk factor reduction. Additionally, aerobic and resistance modes of exercise may be combined to maintain variety and compliance.

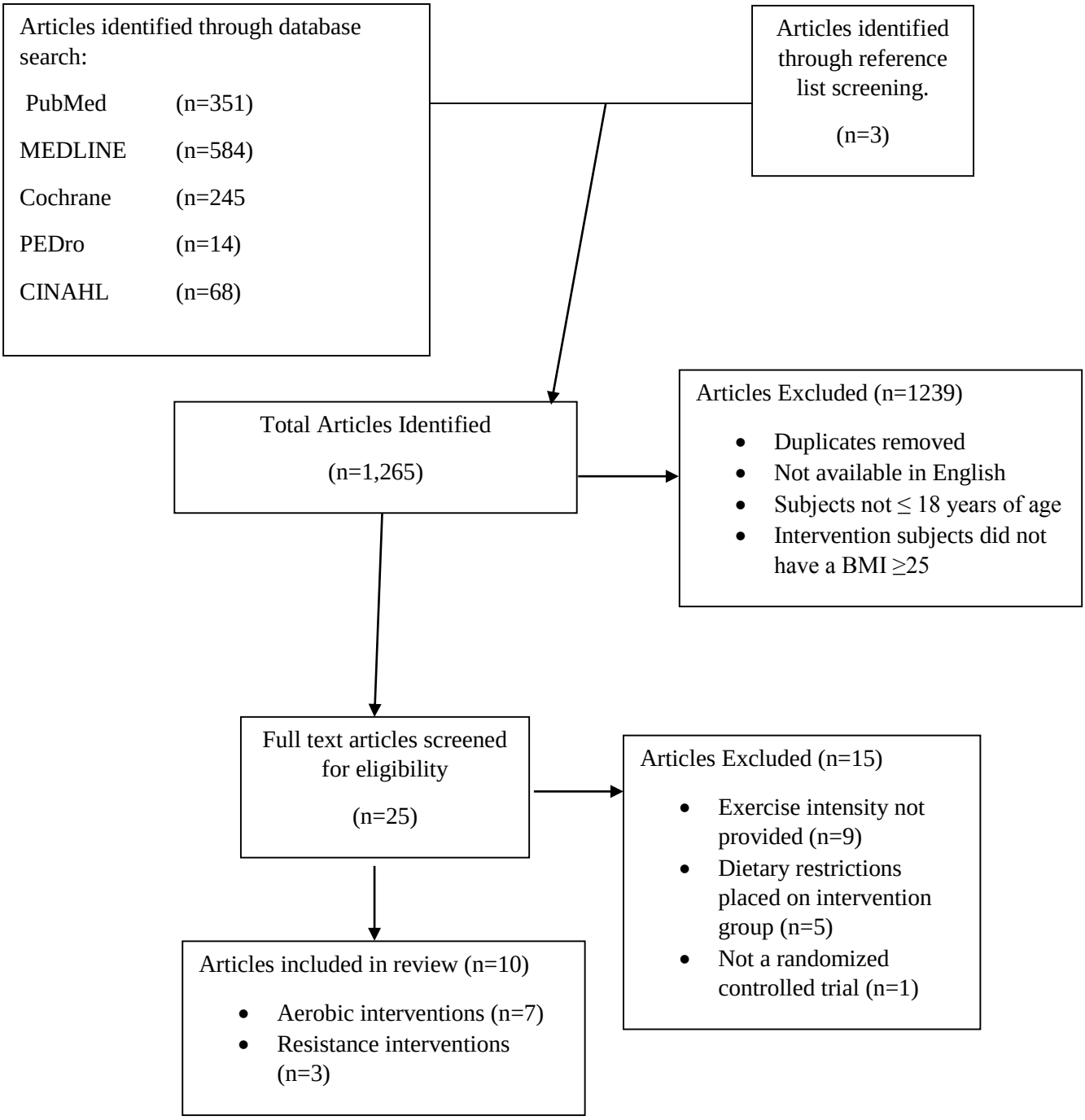

Figure 1: Search results.

Aerobic Intervention	**PEDro Score**	**Eligibility Criteria**	**Random Allocation**	**Concealed Allocation**	**Baseline Comparability**	**Blind Subjects**	**Blind Therapists**	**Blind Assessors**	**Adequate Follow-up**	**Intention-to-Treat Analysis**	**Between-group Comparisons**	**Point Estimates and Variability**
Ferguson et al,1999[23]	5/10	x	x		x				x		x	x
Kelly et al,2004[19]	6/10	x	x		x			x	x		x	x
Sun et al,2011[21]	5/10	x	x		x				x		x	x
Davis et al, 2012[16]	7/10	x	x	x	x				x	x	x	x
Lee et al,2012[17]	7/10	x	x	x	x				x	x	x	x
Regieg et al, 2013[22]	6/10		x		x				x	x	x	x
McCormack, et al,2013[20]	5/10	x	x		x				x		x	x
Resistance Intervention	**PEDro Score**											
Shaibi et al,2006[15]	4/10	x	x		x						x	x
Benson et al, 2008[18]	7/10	x	x		x	x		x		x	x	x
Lee et al,2012[17]	7/10	x	x	x	x				x	x	x	x

Table 1: Article quality assessment utilizing the PEDro assessment tool.

Study	N	Gender (M/F)	Age	Intervention Type	Study Length (weeks)	Frequency (sessions/week)	Duration of Workout (minutes)	Intensity
Ferguson et al,1999[23]	79	26/53	9.5	AT, CON	16	5	40	150 bpm
Kelly et al,2004[19]	20	09/11	10.9	AT, CON	8	4	30 or 50	50-60% VO2 progressed to 70-80% VO2
Sun et al,2011[21]	42	25/17	13.6	AT, diet, AT+diet, CON	10	4	40	50% VO2
Davis et al, 2012[16]	222	94/128	9.4	High dose AT, Low dose AT, CON	13	5	20 or 40	150 bpm
Lee et al,2012[17]	45	45/0	15	RT, AT, CON	12	3	60	60-75% VO2
Regieg et al, 2013[22]	28	16/12	10.7	AT, CON	16	4	60	70-85% HR max
McCormack, et al,2013[20]	18	5/13	13	AT, CON	8	3	20 to 35	60-80% HRR

Table 2: Aerobic study characteristics. AT, Aerobic Training; CON, Control; bpm, beats per minute; RT, Resistance Training; VO2, VO2 peak; HRR, Heart Rate Reserve.

Study	Exercise Protocol	Conclusion
Ferguson et al,1999[23]	First 20 min. participants utilized treadmills, cycles, rowers spending 5 minutes on each. The next 20 min. consisted of group games.	Significant improvements in insulin sensitivity, triglycerides, and percent body fat.
Kelly et al,2004[19]	Performed stationary cycling at 50-60% VO2 peak for at least 5 weeks. Gradually increased to 50 min. at 70-80% VO2 peak for the last 2 weeks.	Significant improvements in HDL, VO2 peak, and arterial endothelial function.
Sun et al,2011[21]	Exercised using a combination of jogging, running at a moderate speed, jumping rope, and group activities such as basketball, volleyball, and badminton games.	Significantly reduced central adiposity, waist circumference, and LDLs in intervention group not under caloric modification.
Davis et al, 2012[16]	Two groups participated in school yard games (jump rope, basketball, soccer). The high dose group exercised 20 min. twice a day. Low dose group exercised 20 min. once a day.	Significant results were seen in both 20 and 40 minute groups. Improvements in insulin resistance, VO2 peak, and reduced general and visceral adiposity. Larger improvements seen in the high dose group.
Lee et al,2012[17]	Exercised on treadmills, ellipticals, or stationary bikes. Week 1 was 40 min. at 50% VO2 peak. Progressively built up to 60 min at 60-75% VO2 peak by week 2.	Significant reductions in body weight, waist circumference, VO2 peak, total adiposity, and subcutaneous and visceral fat.
Regieg et al, 2013[22]	Utilized aerobic team sports, relays, and racing maintaining an intensity of 70-85% HR max	Significant improvements in BMI, waist circumference, fat free mass, and aerobic capacity.
McCormack , et al,2013[20]	Utilized stationary cycling at 60-80% HRR initially for 20 min. progressing to 35 min. by the end of the 8 weeks.	Significant improvements in VO2 peak and intramyocellular lipid content.

Table 2 Continued: HDL, High Density Lipoprotein; LDL, Low Density Lipoprotein

Study	N	Gender (M/F)	Age	Intervention Type	Study Length (Weeks)	Frequency (sessions/week)	Duration of Workout (minutes)	Intensity	Rep/Sets	Number of Exercises per Session
Shaibi et al,2006[15]	21	21/0	15.4	RT, CON	16	2	60	70-80% 1RM	12.5x2	5-6
Benson et al, 2008 [18]	78	46/32	12.3	RT or CON	8	2	-	16.5 RPE	8x2	11
Lee et al,2012[17]	45	32/0	15	RT, AT, CON	12	3	60	70% 1RM	10x2	10

Table 3: Resistance study characteristics. RT, Resistance Training; CON, Control; 1 RM, 1 Repetition Maximum; AT, Aerobic Training; RPE, Rating of Perceived Exertion.

Study	Exercise Protocol	Conclusion
Shaibi et al,2006[15]	An alternating combination of exercises was performed on non-consecutive days of the week. Day 1 compound lower body exercises and isolated upper body exercises, Day 2 compound upper body exercises and isolated lower body exercises. Exercises were leg press, bench press, lat. pull-down, leg curls, leg extension, biceps curl, triceps pushdown, and shoulder press. A progressive loading was used: Week 1-4: 1x10-15 reps 62-71% 1 RM. Week 5-10: 2x13-15 reps 74-88% 1 RM. Week 10-16: 3x8-12 reps. 92-97% 1 RM. 5 min. of warm up and cool down were performed.	Significant improvements in insulin sensitivity, fat free mass, and upper and lower body strength.
Benson et al, 2008[18]	A total of 11 exercises were performed during each session. 5 upper body (bench press and various open chain movements targeting the triceps and biceps brachii), 4 lower body (squat and various open chain movements targeting hip abductors, hamstring, and calf muscles), and 2 abdominal exercises	Significant improvements in waist circumference, percent body fat, BMI, and upper and lower body strength
Lee et al,2012[17]	Performed 10 exercises during each session: leg press, leg extension, leg flexion, chest press, latissimus pull down, seated row, biceps curl, and triceps extension with stack weight equipment. In addition, a single set each of push-ups and sit-ups were performed. Utilized a progressive loading: Week 1-4: 1-2 sets of 8-12 reps at 60% 1 RM. Final 8 weeks 2 sets of 8-12 reps to failure. 1-2 min. rest between each set.	Significant improvements in body weight, VO2 peak, waist circumference, BMI, total adiposity, insulin sensitivity, subcutaneous and visceral fat, and upper and lower body strength.

Table 3 continued: 1 RM, 1 Repetition Maximum.

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