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| **CRITICALLY APPRAISED TOPIC** |

**FOCUSED CLINICAL QUESTION**

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| For a 50-year-old female who is moderately overweight and pre-diabetic, is combined resistance and aerobic exercise more effective than aerobic exercise alone in the prevention of diabetes? |

**AUTHOR**

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**CLINICAL SCENARIO**

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| Scenario: This patient presented to an outpatient clinic with complaints of knee pain. Following a successful physical therapy intervention that reduced her knee pain, the patient also expressed interest in trying to exercise more and lose weight. The treating physical therapist wants to know the best type of exercise prescription to provide to this patient, and whether she would benefit from incorporating resistance training into an aerobic exercise program.Rationale: As of 2016, over 29 million Americans have diabetes and an additional 89 million have prediabetes.1 Diabetes is a leading cause of death and can lead to additional health conditions such as stroke, heart disease, and kidney failure.1 Several key risk factors for developing diabetes include a sedentary lifestyle, family history of diabetes, overweight, and age 45 or older.1 The Centers for Disease Control recommends that a combination of physical activity and proper diet can reduce the risk of developing diabetes.1 As the prevalence of overweight and obesity continues to increase in the United States, physical therapists are confronted with treating patients who are at risk for developing diabetes and heart disease. For this population of patients, the typical exercise prescription is a walking program (or other sort of aerobic exercise), but it would be helpful to know if combined resistance and aerobic training would actually be more beneficial at preventing long-term negative health effects. |

**SUMMARY OF SEARCH**

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| * Ten studies were identified that met the inclusion/exclusion criteria of the search, including 7 randomized controlled trials, 1 non-randomized clinical trial, and 2 systematic reviews of randomized and non-randomized clinical trials. Three studies were selected for detailed review in this analysis.
* A combined aerobic and resistance exercise training program appears to be the most beneficial for the improvement of several metabolic and anthropometric risk factors associated with diabetes, including reduced fasting glucose levels, improved insulin resistance, decreased total body fat, decreased abdominal fat, decreased body weight, increased muscle mass, and decreased body mass index (BMI).
* Aerobic exercise alone has a greater effect than resistance exercise alone on improving insulin resistance, body weight, and BMI. Resistance training has a greater effect than aerobic training on fasting glucose levels and body composition through a simultaneous reduction in body fat and increase in lean muscle mass. Improved body composition and increased muscle mass may provide some limited protection against development of diabetes.
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**CLINICAL BOTTOM LINE**

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| Current research suggests that a combination of aerobic and resistance training is more beneficial than either exercise modality alone for the prevention of diabetes in patients who are overweight, obese, or have other risk factors for developing diabetes. While either aerobic or resistance training alone do have beneficial cardiometabolic and anthropometric effects, combination training is ideal for the improvement of several key markers of diabetes prevention. A combination program can significantly improve fasting glucose levels, insulin resistance, body fat percentage, waist circumference, abdominal fat, body weight, and BMI to a greater extent than either exercise modality can in isolation. The combination exercise program should meet standard recommendations of at least 150 minutes of moderate physical activity per week. |

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| ***This critically appraised topic has been individually prepared as part of a course requirement and has been peer-reviewed by one other independent course instructor*** |

**SEARCH STRATEGY**

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| **Terms used to guide the search strategy** |
| **P**atient/Client Group | **I**ntervention (or Assessment) | **C**omparison | **O**utcome(s) |
| adultmiddle-agemiddle ageoverweightobeseprediabet\*pre-diabet\*metabolic syndrome | resistance exercis\*resistance train\*weight train\*strength train\*aerobic exercis\*cardio\* exercis\* | aerobic exercis\*cardio\* exercis\* | diabeticdiabetesdiabetes mellitus [mh]prevention |

**Final search strategy:**

Search strategy for both PubMed and CINAHL:

1. adult OR middle-age OR middle age
2. overweight OR obese OR obesity OR prediabetes OR pre-diabetes OR prediabetic OR pre-diabetic OR metabolic syndrome
3. resistance exercis\* OR resistance train\* OR weight train\* OR strength train\*
4. aerobic exercis\* OR cardio\* exercis\*
5. diabetic OR diabetes OR diabetes mellitus [mh]
6. #2 AND #3 AND #4
7. **#6 AND prevention**

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| **Databases and Sites Searched** | **Number of results** | **Limits applied, revised number of results (if applicable)** |
| 1. PubMed
 | 56 Results using the search strategy above | * No additional limits applied
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| 1. Cochrane Library
 | 474 Results with the search strategy above | * Revised search: #1 AND #2 AND #3 AND #4 AND #5 AND prevention AND diabetes mellitus [mh]
* Revised search yielded 49 Results
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| 1. CINAHL
 | 60 results using the search strategy above | * No additional limits applied
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## INCLUSION and EXCLUSION CRITERIA

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| **Inclusion Criteria** |
| - Published in English- Systematic reviews, meta-analyses, randomized controlled trials, controlled trials, uncontrolled trials, prospective cohort studies, retrospective cohort studies- Published up to September, 2016- Studies of adult populations (at least 18 years old)- A protocol that includes either an aerobic exercise intervention, a resistance training intervention, or both |
| **Exclusion Criteria** |
| - Abstracts, conference proceedings, letters to the editor, dissertations, and narrative review articles- Case studies and case series |

**RESULTS OF SEARCH**

**Summary of articles retrieved that met inclusion and exclusion criteria**

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| **Author (Year)** | **Study quality score** | **Level of Evidence** | **Study design** |
| Choo (2014)2 | PEDro: 8/11 | 1b | Randomized Controlled Trial |
| Ho (2012)3 | PEDro: 5/11 | 2b | Randomized Controlled Trial  |
| Davidson (2009)4 | PEDro: 9/11 | 1b | Randomized Controlled Trial |
| Phillips (2012)5 | PEDro: 5/11 | 2b | Randomized Controlled Trial |
| Schmitz (2007)6 | PEDro: 7/11 | 1b | Randomized Controlled Trial |
| Chaudhary (2010)7 | PEDro: 4/11 | 2b | Non-randomized clinical trial |
| Seo (2010)8 | PEDro: 5/11 | 2b | Randomized Controlled Trial |
| Balducci (2010)9 | PEDro: 8/11 | 1b | Randomized Controlled Trial |
| Aguiar (2014)10 | AMSTAR: 6/11 | 1a | Systematic Review and Meta-Analysis (included RCTs, quasi-experimental, pre-post, and two-group comparison studies) |
| Pattyn (2013)11 | AMSTAR 4/11 | 1a | Systematic Review and Meta-Analysis of randomized and non-randomized clinical control trials |

**BEST EVIDENCE**

The following 3 studies were identified as the ‘best’ evidence and selected for critical appraisal. Reasons for selecting these studies were:

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| * Choo (2014) – This was a high quality RCT with high internal validity based on the PEDro score. This study very closely matches both the population and intervention of interest in my clinical question. It examined the impact of resistance, aerobic, and combined exercise training (resistance and aerobic) on the cardiometabolic profile of women with excess abdominal fat. According to the study, excess abdominal fat is a useful measure for determining the risk of developing cardiac disease or diabetes.
* Davidson (2009) – This study was a high quality RCT with high internal validity based on the PEDro score. The study directly relates to the clinical question as it directly compares resistance training, aerobic training, and combined training (resistance and aerobic). Insulin resistance, which is a significant risk factor in developing diabetes, was utilized as a primary outcome measure in the study.
* Schmitz (2007) – This was a moderate to high quality RCT with good internal validity. The study examines the effect of strength training on adiposity in pre-menopausal women. The article discusses how adiposity in women is directly related to the development of diabetes, so the outcome measures in the study relate well to my clinical question.
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**SUMMARY OF BEST EVIDENCE**

**(1) Description and appraisal of *Effects of weight management by exercise modes on markers of subclinical atherosclerosis and cardiometabolic profile among women with abdominal obesity: a randomized controlled trial* by Choo et al. (2014)**

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| **Aim/Objective of the Study/Systematic Review:** |
| The objective of the study was to determine the differential outcomes of aerobic exercise, resistance exercise, and combined aerobic and resistance exercise on indicators of subclinical atherosclerosis, anthropometry, and the cardiometabolic profile of females with excess abdominal fat during a weight management program. |
| **Study Design** |
| * Single-blind randomized controlled trial
* Baseline measurements were taken of all study participants prior to group allocation
	+ Homogeneity of groups assessed with the following: one-way ANOVA, X2, and Fisher’s exact test
* Participants were randomly allocated to treatment groups with a computer program
* Assessors were blinded to group allocation
* 12-month study with 3 different allocation groups – aerobic exercise, resistance exercise, combined exercise
	+ All participants (except for 20 individuals in the aerobic group) also received behavioral therapy
* 12-month study period was divided into 2 treatment protocols for all 3 groups:
	+ Diet only: Months 1-3
	+ Diet plus exercise intervention: Months 4-12
* Outcome measures were reassessed after 3, 6, and 12 months
* All outcome data were blinded until conclusion of study after 12 months
* Modified intention-to-treat (ITT) analysis and per-protocol (PP) analysis performed
* Statistical analyses performed with use of STATA 10.0
* P-value ≤ 0.05 used to determine all statistically significant values
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| **Setting** |
| The subjects were recruited from an urban community in Seoul, South Korea. The specific location of the study was not provided, but the authors report that all exercise interventions were conducted in a public fitness center. |
| **Participants** |
| * 110 subjects were included in the study and randomized to three different groups
	+ Aerobic group: N = 50; Resistance group: N = 30; Combination group: N = 30
	+ Authors stated that 21 subjects were needed per group to achieve 80% power for detection of a statistically significant difference in the primary outcome measure
* All subjects were women between the ages of 18 and 65 years with abdominal obesity
	+ Participants were healthy with no history of cardiovascular disease, cancer, or diabetes
* Recruitment Method: subjects were recruited over a one-year period starting and ending in November (2010-2011) with use of fliers, posters, telephone calls, and media advertisements to various local organizations (health centers, religious centers, university campuses, and online)
* Sample Type: Convenience
* Key Demographics
	+ 100% female subject population
	+ Mean Age = 43.1 years (SD = 9.0)
	+ Number of subjects with obesity-related health conditions: Mean = 27 (SD = 24.5) – included hypertension and dyslipidemia
	+ Number of subjects post-menopause: Mean = 32 (SD = 29.1)
	+ Number of current smokers: Mean = 6 (SD = 5.5)
	+ Body Mass Index (BMI): Mean = 28.5 (SD = 0.36)
	+ Waist circumference: Mean = 94.8cm (SD = 7.80)
* The subjects were similar at baseline on all key demographic variables (socioeconomic factors, health-related factors, indicators of atherosclerosis, anthropometric measurements, cardiometabolic profile, diet, and cardiorespiratory conditioning) – Two exceptions listed:
	+ Subjects in the resistance group were more likely to be married (p = 0.037) than in the other groups
	+ Subjects in the aerobic group were less likely to take lipid-lowering medications (p = 0.007)
* 92 out of the original 110 subjects (84%) were included in the Modified intention-to-treat analysis
	+ These subjects had at least one measurement of FMD across four time periods
* 49 out of the original 110 subjects (45%) were included in the Per-protocol analysis
	+ These subjects met the 100% follow-up criteria at 12 months (five total assessment periods) and were available for follow-up
* The authors did not provide detailed information about the reasons for subject drop-out. The authors stated that many subjects were “lost to follow-up,” but did not explain this designation.3 Other reasons included subjects moved away, declined participation, lost contact, became injured, or became pregnant.
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| **Intervention Investigated** |
| * All three groups participated in a 12-month weight-loss program that incorporated behavioral therapy, diet, and exercise (only the exercise intervention varied between groups)
* Behavioral therapy – 12 sessions during the first 6 months
* Diet only (first 3 months) – Personalized calorie intake and fat intake recommendations based on subject weight
* Diet plus exercise (last 9 months) – diet intervention continued with addition of different exercise modalities
	+ Exercise interventions for each group described below
	+ Exercise sessions occurred in a public fitness center, supervised by exercise trainers in a group session (the qualifications of the exercise trainers were not addressed in the study)
 |
| *Control 1 – Aerobic Training Group* |
| * Diet intervention continued in same manner
* 60 minutes of aerobic exercise training, 3 times per week for 9 months
* 30 minutes of treadmill walking followed by 30 minutes of stationary cycling
* Target heart rate of 50-70% of maximum
* 20 subjects in this group did not receive the behavioral therapy intervention. However, the results from these 20 subjects were not significantly different from the rest of the group, so for the purposes of this study the results were reported together).
 |
| *Control 2 – Resistance Training Group* |
| * 60 minutes of resistance exercise training, 3 times per week for 9 months
* Upper body resistance exercises: chest press, lat pulldown, abdominal crunches, and back extensions
* Lower body resistance exercises: leg press, calf raise, leg curl, and leg extensions
* Loads originally set at 40% of maximum upper body strength, and 50% of maximum lower body strength
* 2 sets, 8-12 repetitions, 90 second rest interval for each exercise
* Loads were increased by 5% increments every three weeks or when subject could perform 15 repetitions of a particular exercise
 |
| *Experimental – Combined Aerobic and Resistance Training Group* |
| * 60 minutes of combined exercise training: 30 minutes of resistance training followed by 30 minutes of aerobic exercise, 3 times per week for 9 months
* Upper body and lower body resistance exercises (same exercises performed as described above for the resistance training group)
* 1 set, 8-12 repetitions, 90 second rest interval for each exercise (one fewer set for the combined group compared to the resistance group)
* 15 minutes of treadmill walking followed by 15 minutes of stationary cycling (target heart rate of 50-70% of maximum)
 |
| **Outcome Measures**  |
| * Primary Outcome Measure
	+ Flow-Mediated Dilation (FMD) – measurement of acute endothelial function and atherosclerosis
		- Measured at the brachial artery with ultrasound, reported as percent dilation (%)
* Secondary Outcome Measures
	+ Carotid-Femoral Pulse Wave Velocity (PWV) – measurement of atherosclerosis
		- Arterial stiffness measurement from carotid to femoral arteries, reported in meters per second (m/s)
	+ Carotid Intima-Media Thickness (IMT) – measurement of chronic vascular abnormalities
		- Measurement of the thickness of the carotid artery, reported in millimetres (mm)
	+ Body Weight (kg)
	+ Lean Body Mass (kg)
	+ Waist Circumference (cm)
	+ Systolic Blood Pressure (mmHg)
	+ Total Cholesterol (mg/dL)
	+ Low-density Lipoprotein (LDL) Cholesterol (mg/dL)
	+ High-density Lipoprotein (HDL) Cholesterol (mg/dL)
	+ Triglycerides (mg/dL)
	+ Fasting Glucose (mg/dL)
	+ Maximum Oxygen Consumption in (VO2max reported in mL/kg/min)– cardiorespiratory fitness measurement
* The study did not mention where or by whom the assessments were performed
 |
| **Main Findings** |
| * The main findings of the study were reported in both an ITT and PP analysis. The ITT analysis includes 92 out of the original 110 subjects (84%), and the PP analysis includes 49 out of the original 110 subjects (45%).
* In the ITT analysis, all three groups demonstrated similar statistically significant improvements from baseline to 12 months for PWV, IMT, body weight, waist circumference, LDL cholesterol, HDL cholesterol, total cholesterol, and VO2max. However, there were no statistically significant differences observed for any outcome measure between the three intervention groups in the ITT analysis.
* In the PP analysis, only fasting glucose showed a statistically significant difference between intervention groups. The combination group demonstrated a statistically significant improvement in fasting glucose compared to both the aerobic and resistance training groups.
* In the PP analysis, baseline values for the mean and standard deviation of fasting glucose in the combination group were 84.9 and 8.05, respectively, and declined to 81.91 and 5.95 after 12 months. This is a treatment effect of -2.99 in the combination group with a small to medium effect size as measured by Cohen’s d of 0.422. These results were reported with a p-value = 0.034 and a 95% confidence interval calculated at 0.19-5.79 for the mean difference of 2.99.
* It should be highlighted that only the PP analysis, and not the ITT analysis, showed a statistically significant improvement in fasting glucose. Therefore, the results should be considered with caution.
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| **Original Authors’ Conclusions** |
| In women with excess abdominal fat, a combination exercise program that includes aerobic and resistance training may be more effective at reducing fasting glucose levels compared to either exercise intervention alone. All three diet plus exercise interventions were effective at improving the cardiometabolic profile and reducing risk for disease in the study population.  |
| **Critical Appraisal** |
| **Validity** |
| * PEDro Scale score: 8/11 indicating that this is a good quality RCT – The key limitations of this RCT were that the subjects were not blinded, therapists/trainers who administered therapy were not blinded, and outcome measures were available for less than 85% of subjects (although it was close with 84% follow-up rate).
* There was a significant drop-out rate in the study, with outcome measurement data across all five assessment periods only available for 49 out of 110 subjects. This high rate of drop-out may have introduced attrition bias into the study. The authors attempted to remedy this with the ITT analysis, but only 92 subjects were included in this analysis. Therefore, there was a high percentage of the original 110 subjects who were not included in either the ITT or the PP analysis. The authors did acknowledge this limitation, but reported that attrition rates of this level may be common in community based weight-management programs.
* Lack of blinding of participants and trainers to group assignment may have introduced bias into the study. Furthermore, the researchers did not discuss this limitation and did not indicate the extent to which it may or may not have influenced the results.
* Since the study included a concurrent diet intervention during the exercise protocols in all three groups, it is difficult to state with certainty that the observed results occurred exclusively due to the exercise intervention.
* All participants were South Korean females, so it may be inappropriate to extrapolate the results to other racial or demographic groups.
 |
| **Interpretation of Results** |
| Given the stated purpose of the study and the limited conclusions made by the authors, the results do seem to be clinically meaningful in several important ways. First, all three intervention groups demonstrated significant improvements in several key outcome measures, including PWV, IMT, body weight, waist circumference, LDL cholesterol, HDL cholesterol, total cholesterol, and VO2max. These outcome measures are all important indicators of cardiometabolic health, with significant implications for the development of cardiovascular disease or diabetes. Therefore, the findings of the study show that all three interventions were effective at improving the subjects’ health profiles.Second, the combination group demonstrated a statistically significant improvement in fasting glucose levels compared to the aerobic or resistance exercise only groups. Since fasting glucose level is a key measure in the onset of diabetes, these results should be considered. However, the reduction in fasting glucose levels was only observed in the PP analysis, so the significance of the findings is somewhat limited. Additionally, the authors did not discuss whether the treatment effect of 2.99 and an effect size of 0.422 are clinically meaningful.As the authors discuss in the study, it is well established in the literature that exercise plus diet programs are effective at improving the cardiometabolic health profile. Overall, the results of this study indicate that all three types of exercise intervention can provide similar positive health effects. |

**(2) Description and appraisal of *Effects of Exercise Modality on Insulin Resistance and Functional Limitation in Older Adults* by Davidson et al. (2009)**

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| **Aim/Objective of the Study/Systematic Review:** |
| The objective of the study was to compare the effects of aerobic exercise, resistance exercise, and combined aerobic and resistance exercise on insulin resistance and functional limitation in older adults with abdominal obesity. |
| **Study Design** |
| * Parallel design randomized-controlled trial
* Baseline measurements were conducted prior to group allocation
* Subjects were stratified by sex and then randomly allocated to groups – method of randomization was not discussed
* Subjects and fitness personnel were not blinded to group allocation
* Assessors were blinded to group allocation
* 6-month study that included four different allocation groups – aerobic exercise, resistance exercise, combined exercise, and a non-exercise control
* The study included a dietary intervention for all subjects in all four groups
	+ All subjects participated in 9 one-hour nutrition education sessions
	+ A nutritionist provided tailored diet recommendations for participants to maintain a steady caloric intake throughout the study.
	+ This was included as a feature of the study in order to determine whether observed changes occurred due to study intervention instead of diet.
* All primary and secondary outcome measures were recorded at baseline and at the conclusion of the study after 6 months.
* All intervention effects were assessed with an intent-to-treat (ITT) analysis
* Sample size was selected in order to achieve 80% statistical power
 |
| **Setting** |
| The study was conducted at a single center at Queen’s University, Kingston, Ontario, Canada. The researchers provided no additional information about the setting. |
| **Participants** |
| * 136 subjects age 60-80 years, including 57 men and 79 women
	+ Males – Mean age = 67.7 years, SD = 5.1 years
	+ Females – Mean age = 67.5 years, SD = 5.1 years
* This was a convenience sample in which participants were recruited with the use of posters, mailings, newspapers, and radio announcements.
* Eligible participants were required to be abdominally obese (waist circumference of at least 102 cm in men and 88cm in women), a non-smoker, and have a stable weight over the previous 6 months.
* Participants did not have chronic health conditions, such as heart disease, stroke, or diabetes that would limit participation in the study.
* Subjects were randomly allocated to one of four groups:
	+ Control group: N = 22 (11 men, 11 women)
	+ Resistance exercise group: N = 36 (15 men, 21 women)
	+ Aerobic exercise group: N = 37 (17 men, 20 women)
	+ Combined exercise group: N = 35 (14 men, 21 women)
* There were 19 drop-outs during the study, primarily due to musculoskeletal pain.
* 117 subjects completed the study and were available for follow-up.
* Groups were similar at baseline for key demographic variables.
 |
| **Intervention Investigated** |
| * *Common interventions for all groups:*
* Diet intervention for healthy eating and weight maintenance as described above
* Exercises were supervised by designated personnel – specific qualifications of personnel not discussed
* Intervention location not provided
 |
| *Control – No exercise* |
| * Diet intervention
* No aerobic or resistance exercise protocol
 |
| *Experimental 1 – Resistance exercise* |
| * 3 days per week on non-consecutive days
* 9 different resistance exercises during each session for a total body workout (chest, shoulders, biceps, triceps, glutes, quadriceps, hamstrings, and abdominal muscles)
	+ One set of all exercises performed to fatigue
* 20 minutes per session, total of 60 minutes of exercise per week
 |
| *Experimental 2 – Aerobic exercise* |
| * 5 days per week
* 30 minutes of walking on a treadmill (moderate intensity with a target heart rate of 60-75% of max)
* Total of 150 minutes of exercise per week
 |
| *Experimental 3 – Combined Resistance and Aerobic exercise* |
| * 3 days per week on non-consecutive days
* 9 different resistance exercises during each session for a total body workout (chest, shoulders, biceps, triceps, glutes, quadriceps, hamstrings, and abdominal muscles)
	+ One set of all exercises performed to fatigue
* 30 minutes of walking on a treadmill (moderate intensity with a target heart rate of 60-75% of max)
* Total of 150 minutes of exercise per week
 |
| **Outcome Measures** |
| * Primary Outcome Measures
	+ Metabolic
		- Fasting insulin level (mg/dL)
		- Insulin resistance (M/I), “rate of glucose uptake per unit of insulin per kilogram of skeletal muscle per minute x100”(128)
	+ Functional Limitation
		- Chair stands (number)
		- Arm curls (number)
		- 2-minute step test (number of steps)
		- 8-foot up-and-go (s)
		- Combined improvement (all 4 tests – reported as z score)
* Secondary Outcome Measures
	+ Anthropometric
		- Body weight (kg)
		- Body mass index (BMI): weight (kg)/ height squared (m2)
		- Waist circumference (cm)
	+ Muscle and fat – measured via MRI
		- Total skeletal muscle (kg)
		- Upper body skeletal muscle (kg)
		- Lower body skeletal muscle (kg)
		- Total fat (kg)
		- Total abdominal fat (kg)
		- Visceral fat (kg)
		- Abdominal subcutaneous fat (kg)
		- Fat to muscle ratio
* All measurements were conducted at Queen’s University, Kingston, Ontario, Canada by blinded assessors
 |
| **Main Findings** |
| * The findings were presented with Mean and Least Squares Means (SE). There were no statistically significant differences across sex within treatment groups, so all results were collapsed across sex.
* Metabolic Measurements: Insulin resistance improved significantly (P<0.05) in the aerobic and combined groups compared to the control and resistance groups. In the combined group, insulin resistance improved by 9.22 (1.33), a 43% improvement, and in the aerobic group, insulin resistance improved by 6.51 (1.27), a 31% improvement. There were no statistically significant changes in insulin resistance for either the control or the resistance groups from baseline.
* Anthropometric Measurements: Body weight and BMI improved significantly in both the aerobic and combined groups compared to the control and resistance groups (P<0.05). Body weight decreased by 2.31kg in the combined group and 2.77kg in the aerobic group; BMI decreased by 0.84 in the combined group and 0.96 in the aerobic group. All three intervention groups showed similar significant improvements (P<0.05) in waist circumference compared to the control group.
* Muscle and Fat Measurements: There was a statistically significant decrease in total fat (P<0.05) in both the combined and aerobic groups compared to the control and resistance groups. Total fat decreased by 3.38kg in the combined group and 3.03kg in the aerobic group. Measurements of abdominal, visceral, and subcutaneous fat also decreased significantly in the combined and aerobic groups compared to control, but not in the resistance group. Amount of skeletal muscle increased significantly (P<0.05) in both the combined and resistance groups compared to the control and aerobic groups.
* Functional Limitation Measurements: All intervention groups demonstrated similar statistically significant improvements (P<0.05) compared to control for functional limitation outcome measures. Additionally, the combined exercise group demonstrated significant improvement in functional limitation outcome measures compared to the aerobic group (P<0.05), but not the resistance group.
 |
| **Original Authors’ Conclusions** |
| In older individuals who were previously sedentary and overweight, a combination exercise program that incorporates both resistance and aerobic training is ideal for reducing insulin resistance and decreasing functional limitations. |
| **Critical Appraisal** |
| **Validity** |
| * PEDro Scale score: 9/11 which indicates that this is a good quality RCT. The primary limitations of the study were that subjects and exercise supervision personnel were not blinded to group allocation, which may have introduced bias into the study.
* 19 subjects dropped out of the study, but the authors accounted for this by completing an ITT analysis for all subjects who were originally allocated to a group.
* The study did a good job of controlling diet and caloric intake so that the authors could isolate and explain the findings based on exercise intervention alone. The authors also reported good adherence to the exercise protocols due to strict instruction and supervision from personnel.
* The study participants were 98.5% Caucasian older men and women, so it may be difficult to extrapolate the results to other races, ethnicities, or age groups.
* One potential limitation not discussed by the authors was that the resistance training group performed significantly less total exercise compared to either the aerobic or combined groups (60 minutes compared to 150 minutes per week). The authors could have investigated the effects of a higher volume of resistance training for a more accurate comparison to the other groups.
* The baseline data were presented as mean and standard deviation and were separated by sex. However, the findings of the study were collapsed by sex and only the differences from baseline were reported as mean and Least Squares Mean. This made it difficult to compare the findings with the baseline data in order to calculate effect sizes and interpret clinical significance.
 |
| **Interpretation of Results** |
| The results of the study and the conclusions made by the authors seem reasonable, especially regarding the effects of combined or aerobic exercise on insulin resistance. The manner in which the data were presented made it difficult to interpret effect sizes, but the reported improvements in insulin resistance of 43% and 31% in the combined and aerobic groups, respectively, are compelling.Both combined and aerobic exercise had significant improvements on the anthropometric outcomes of body weight, BMI, and waist circumference, which are all important factors when considering an individual’s risk of developing chronic disease, including diabetes. While resistance training may be important for functional mobility in older adults, there was little evidence presented in this study to suggest that resistance training is beneficial for diabetes prevention, as measured by insulin resistance and anthropometric measurements. Therefore, the findings from this study suggest that aerobic exercise, either alone or in combination with resistance training, is the most important exercise modality for diabetes prevention. However, since the strength training group performed significantly less total exercise per week than either the aerobic or combination exercise groups, it is difficult to state with certainty that resistance training has no benefits. |

**(3) Description and appraisal of *Strength training and adiposity in premenopausal women: Strong, Healthy, and Empowered study* by Schmitz et al. (2007)**

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| **Aim/Objective of the Study/Systematic Review:** |
| The purpose of this study was to determine if a strength training program could help prevent increases in abdominal fat and body fat percentage in premenopausal women between the ages of 25 and 44. This is an important consideration since the majority of American women in this age range gain 1-2 pounds every year, placing them at an increased risk of chronic disease, including diabetes. |
| **Study Design** |
| * Single-blind randomized controlled trial
* Measurements were conducted at baseline, one year, and two years
	+ Baseline homogeneity was assessed with t-tests for continuous variables and chi-square tests for categorical variables.
* Participants were stratified by age (25-34 vs. 35-44) and percent body fat (above median vs. below median) and then randomly allocated to group by a blinded staff member.
* Assessors were blinded to group allocation.
* Subjects and exercise supervision personnel were not blinded to allocation.
* Power analysis (based on pilot study of unpublished data from authors’ prior research)
	+ Body fat percentage: 64 subjects needed per group to achieve 90% power to detect a decrease of 1.63% body fat (0.2 effect size)
	+ Intra-abdominal fat: 71 subjects needed per group to achieve 85% (0.3 effect size)
* 2-year study period with a treatment group (strength training) and a control group
* All subjects were asked to maintain current diet throughout the duration of the study.
* Physical activity levels were tracked by having subjects wear accelerometers on at least 4 days of the week.
* Adherence to strength training protocol was tracked by fitness professionals at fitness center
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| **Setting** |
| All treatment participants were provided with fitness center memberships to the Young Women’s Christian Association (YWCA) of Minneapolis, Minnesota. Further details regarding study location were not provided. |
| **Participants** |
| * 164 women were randomly assigned to either the treatment group (N=82) or the control group (N=82)
* The primary eligibility criteria were the following: females aged 25-44, body mass index (BMI) of 25-35, premenopausal, non-smoker, and relatively sedentary (no more than 3 days/week physical activity)
* Recruitment Method: Women were recruited via flyers, mailings, and broadcast media from the Minneapolis-St. Paul area from July 2002 to June 2003
* Sample Type: Convenience
* Key demographics
	+ 100% female subjects
	+ Age – mean and standard deviation (SD): Treatment group = 36 (5), Control = 36 (6)
	+ Ethnicity – percentage (%)
		- Black – Treatment group = 29%, Control = 27%
		- White – Treatment group = 59%, Control = 61%
		- Other – Treatment group = 12%, Control = 12%
* Subjects were similar at baseline for all key demographics
* At one year, 71 treatment group subjects and 67 control group subjects were available for follow-up
* At two years, 70 treatment group subjects and 63 control group subjects were available for follow-up
 |
| **Intervention Investigated** |
| *Control* |
| * Subjects were provided with a standard brochure from the American Heart Association. Recommendations were for 30 minutes of physical activity on more than half of the days of the week.
 |
| *Experimental* |
| * All exercise sessions performed at the YWCA
* First 16 weeks – two times per week, supervised by a fitness professional
	+ One hour fitness sessions
	+ Instruction on basic injury prevention stretches
	+ Slow progressive introduction to strengthening exercises (progression from weight machines to free weights)
	+ Total body resistance exercise performed, with a progression to 3 sets, 8-10 repetitions
* Remainder of 1st year – continued two times per week, unsupervised except for as described below
	+ “Booster sessions” (567) conducted by a fitness professional every 12 weeks
	+ Weekly reminder phone calls from fitness professionals were conducted if a subject missed two previous exercise sessions
	+ Continued progressive increases in weight
* Year 2 – two times per week, unsupervised, “booster sessions” and phone calls continued
	+ 45 minute sessions
	+ Transition for a muscle building/strengthening to a strength maintenance program allowed for shorter exercise sessions
	+ Subjects performed 2 sets of each exercise in circuit fashion with the same level of weight
 |
| **Outcome Measures** |
| * Primary outcome measures
	+ Percent body fat (%)
	+ Intraabdominal fat (cm2) – measured by computed tomography (CT)
* Secondary outcome measures
	+ Body mass (kg) – digital scale measurement
	+ Body mass index (BMI; kg/m2)
	+ Fat mass (kg) – measured by dual-energy X-ray absorptiometry (DXA)
	+ Lean mass (kg) – measured by DXA
	+ Subcutaneous abdominal fat (cm2) – measured by CT
* Assessments performed by administrators who were blinded to group assignment
* Location of administration not provided
 |
| **Main Findings** |
| * Data presented as Mean and Standard Deviation (SD)
* At two years, the strength training group demonstrated a significant decrease (P=0.01) in body fat percentage of 3.68% (0.99) compared to a decrease of 0.14% (1.04) in the control group, a 3.5% net treatment effect in favor of the experimental group.
* At two years, the control group demonstrated an increase in intraabdominal fat of 21.36cm2 (5.34). The strength training group had an increase of 7.05cm2 (5.07) in intraabdominal fat, which was significantly attenuated (P=0.05) compared to the control, with a net treatment effect of 14.3% in favor of the experimental group.
* Compared to control, the strength training group had non-significant improvements in body mass, BMI, fat mass, lean mass, and subcutaneous fat measures.
 |
| **Original Authors’ Conclusions** |
| A strength training program may be beneficial to prevent increases in body fat percentage and lessen the increases in intraabdominal fat that commonly occur in premenopausal women between 25 and 44 years of age who are already overweight or obese. |
| **Critical Appraisal** |
| **Validity** |
| * PEDro Scale score: 7/11 which indicates that this is a fair to good quality RCT. The key limitations of this study were that allocation to group assignment was not concealed, subjects and exercise personnel were not blinded, and outcome measures were available for less than 85% of subjects at one and two-year follow-up (at one year, there was an 84% follow-up rate, and at two-years there was an 81% follow-up rate).
* Strengths of the study include the following: power analysis with adequate sample sizes in order to detect defined effect sizes for percentage body fat and intraabdominal fat; recruitment techniques targeted at minority groups to ensure an ethnically diverse sample; long-term intervention of two years; and monitoring of physical activity levels through objective measurement
* Limitations of the study include the following: adherence to exercise protocols was only 76% during year one and dropped to 61% during year two; lack of tight control for the influence of diet changes on outcome measures (diet was based on self-report only)
* The study would have benefited from the inclusion of an aerobic exercise group in order to compare the results of strength training to aerobic training. Additionally, the authors could have analyzed any possible dose-response benefits from an increased volume or frequency of resistance training since subjects in this study only exercised twice per week.
 |
| **Interpretation of Results** |
| Despite the limitations of the study as described above, the findings are clinically significant due to the magnitude of the effects observed in the experimental group compared to the control group. A decrease in body fat percentage of 3.68% in the experimental group represents a significant improvement in both the amount of fat free muscle mass and a decrease in total body fat compared to the control group. Similarly, the experimental group had significantly less intraabdominal fat gains compared to the control group. Both of these findings offer strong support for the efficacy of a strength training program for abdominally obese or overweight premenopausal women.As discussed in the study, prior research has shown that aerobic exercise has a significant beneficial effect on abdominal fat in overweight or obese subjects. However, there is less research regarding the benefits of strength training on this population, so this study offers strong support for the utilization of strength training either alone or in combination with an aerobic exercise program. |

**EVIDENCE SYNTHESIS AND IMPLICATIONS**

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| **Evidence Synthesis**The evidence reviewed in this analysis suggests that a combination of aerobic and resistance training is more beneficial than either resistance or aerobic training alone for the prevention of diabetes in individuals who are at high risk for developing diabetes. While none of the studies directly tested individuals with clinically diagnosed prediabetes, subjects generally were at an increased risk for developing diabetes based on several risk factors including overweight, obesity, and sedentary lifestyle.1 Choo, et al found that aerobic, resistance, and combination exercise training were all effective at improving several markers of cardiometabolic health including LDL cholesterol, HDL cholesterol, total cholesterol, body weight, and BMI.2 However, only combination training showed a significant improvement in fasting glucose levels, which is a primary consideration for patients with diabetes or prediabetes.2 Both combination and aerobic training were effective at significantly improving insulin resistance and decreasing waist circumference in abdominally obese older individuals.4 However, Schmitz et al illustrated that strength training alone can lead to improved body composition through attenuated increases in intraabdominal fat, decreased body fat percentage, and increased lean muscle mass despite no net decrease in body weight or BMI.6 Overall, the quality of evidence is good to support the conclusion that there are limited benefits to aerobic or resistance exercise alone, and that a combination of both forms of exercise is ideal for improving the risk factors of developing diabetes.**Implications for Clinical Practice**Since all three forms of exercise showed some improvement on diabetes risk factors, clinicians should discuss the positive health benefits of both aerobic and resistance training with patients. Current recommendations from the Centers for Disease Control includes at least 150 minutes of moderate physical activity per week, with some form of exercise most days of the week.12 To combine established recommendations with the findings from this analysis, the ideal exercise prescription should include a minimum of 150 minutes per week of combined aerobic and resistance training, with some physical activity on most days. However, any exercise is likely better than none, so patients should be educated and encouraged to engage in any level of physical activity that can realistically be implemented into their routines. Regarding the focused clinical question and patient scenario presented at the beginning of this analysis, the physical therapist should specifically recommend a combination of aerobic and resistance training for optimum diabetes prevention.In applying these findings to specific patients, physical therapists and other clinicians should utilize best judgement regarding individualized exercise recommendations. Clinicians should obtain a detailed subjective history from the patient and perform an objective assessment in order to ensure that the training protocol is safe and indicated for the particular patient. Clinicians should also consider patient age, occupation, and other recreational activities in which the patient participates. For example, resistance training becomes even more important for adults over the age of 60 in order to prevent functional decline and the associated increased risk for cardiac disease or diabetes.4 Clinicians may also establish referrals for fitness centers and trained exercise personnel in order to ensure safe design and implementation of exercise programs.**Implications for Future Research**Future research should focus on the potential for a dose-response relationship between all three forms of exercise and diabetes risk factors. In the study by Davidson, et al, subjects in the resistance training group only performed 60 minutes of resistance training per week, and in the study by Schmitz et al, participants only engaged in resistance training on two days per week. Therefore, it is possible that there was an insufficient dose of resistance training and that a greater volume or frequency of resistance exercise may have a greater effect on cardiometabolic health, body weight, and body composition. Future research should also analyze the effectiveness of moderate to high intensity circuit training, which incorporates simultaneous aerobic and resistance exercise, to compare the benefits with more traditional training programs. |

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