Exercise Capacity and Cardiovascular/ Metabolic Characteristics of Overweight and Obese Individuals With Type 2 Diabetes

The Look AHEAD clinical trial

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OBJECTIVE — We examined associations of cardiovascular, metabolic, and body composition measures with exercise capacity using baseline data from 5,145 overweight and/or obese (BMI $\geq$25.0 kg/m^2) men and women with type 2 diabetes who were randomized participants for the Look AHEAD (Action for Health in Diabetes) clinical trial.

RESEARCH DESIGN AND METHODS — Peak exercise capacity expressed as METs and estimated from treadmill speed and grade was measured during a graded exercise test designed to elicit a maximal effort. Other measures included waist circumference, BMI, type 2 diabetes duration, types of medication used, A1C, history of cardiovascular disease, metabolic syndrome, β-blocker use, and race/ethnicity.

RESULTS — Peak exercise capacity was higher for men (8.0 ± 2.1 METs) than for women (6.7 ± 1.7 METs) ($P < 0.001$). Exercise capacity also decreased across each decade of age ($P < 0.001$) and with increasing BMI and waist circumference levels in both sexes. Older age, increased waist circumference and BMI, a longer duration of diabetes, increased A1C, a history of cardiovascular disease, having metabolic syndrome, β-blocker use, and being African American compared with being Caucasian were associated with a lower peak exercise capacity for both sexes. Hypertension and use of diabetes medications were associated with lower peak exercise capacity in women.

CONCLUSIONS — Individuals with diabetes who are overweight or obese have impaired exercise capacity, which is primarily related to age, female sex, and race, as well as poor metabolic control, BMI, and central obesity.

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Obesity is a chronic progressive condition that is increasing worldwide (1) and has reached epidemic proportions in the U.S. (2), where currently >60% of American men and women are either overweight or obese. The health and economic burdens of obesity are substantial (3). The future health burden is of great concern because obesity is a risk factor for both type 2 diabetes and cardiovascular disease (CVD) (4,5), each of which is responsible for marked increases in health care costs. Overweight and obese individuals have lower fitness levels due to being more sedentary than the general population (6) and having excess weight (7). Similarly, individuals with type 2 diabetes are also more likely to be overweight or obese, sedentary, and unfit (7). While studies in individuals with type 2 diabetes have demonstrated both an impaired cardiovascular response and a reduced aerobic capacity (8–12), the response of overweight and obese individuals with type 2 diabetes to exercise is not well documented, and available studies have a relatively small sample size (7,8). To our knowledge, the Look AHEAD (Action for Health in Diabetes) clinical trial has compiled the largest number of graded exercise tests completed on individuals who are overweight and have type 2 diabetes. Understanding the relationship of exercise capacity to risk factors is especially important because fitness level is a strong predictor of future morbidity and mortality in men and women with and without obesity and/or diabetes (10–16).

The aim of the present study is to examine the association of demographic, physical, and diabetes- and CVD-related measures with exercise capacity. This analysis was performed on baseline data before any interventions were assigned.

RESEARCH DESIGN AND METHODS

Look AHEAD is a 16-center randomized clinical trial of overweight and obese type 2 diabetic participants, aged 45–75 years, designed to evaluate the long-term effects (up to

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Abbreviations: CVD, cardiovascular disease; RPE, rating of perceived exertion.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

11.5 years) of an intensive weight loss intervention on the time to incidence for major cardiovascular events (17). A total of 5,145 participants between the ages of 45 and 75 years who had a BMI $\geq$25 kg/m^2 ($\geq$27 kg/m^2 if on insulin) and type 2 diabetes were recruited over a 2.5-year period for Look AHEAD. Of these individuals, 59.5% were women, 63.1% were white, 14.0% had a history of CVD, and 15.3% were on insulin.

Assessments

Full details of the Look AHEAD design and methods, as well as detailed screening, exclusion criteria, and the randomization process, are reported elsewhere (17); however, measures relevant to this report are briefly described herein. All measurements were taken by staffs that were centrally trained and certified on an annual basis. These measurements were carried out before randomization to the intervention groups.

Waist circumference. Waist circumference was measured at the level of the iliac crest to the nearest 0.1 cm using the Gulick II tape measure (model 67020). Two measurements were obtained, with the average of these measurements used to represent the waist circumference.

Exercise capacity. Exercise capacity was assessed using a symptom-limited graded exercise treadmill test to voluntary exhaustion. The treadmill protocol was individualized to the comfortable walking speed for each participant by having the participant perform a brief walking acclimation procedure that included the following. Participants started walking on the treadmill at 1.5 mph on a level (0%) grade while speed was increased gradually by 0.5 mph units until the subject reached a brisk but comfortable self-selected walking speed or until 4.0 mph was achieved; this was the treadmill speed that was used for the maximal test.

After a brief rest period, the exercise test was initiated with the speed set at the predetermined level as described above and the grade at 0%. Speed remained constant throughout the test while the grade was increased by 1% each subsequent minute until voluntary exhaustion. During the last 10 s of each exercise stage and at the point of test termination, heart rate was measured from a 12-lead electrocardiogram and rating of perceived exertion (RPE) obtained using the 6- to 20-category Borg Scale (18). For safety, blood pressure was measured during the last 45 s of each even-minute exercise stage (i.e., stages 2, 4, 6, etc.) and at the point of test termination using a manual sphygmomanometer. Using standard test criteria of the American College of Sports Medicine (19), the test was terminated at voluntary exhaustion or if the patient reported signs or symptoms of exercise intolerance (i.e., ischemia, significant ST segment depression, or complex arrhythmias). For the exercise test to be considered valid, participants not on β-blocker medication had to achieve $\geq$85% of age-predicted maximal heart rate and $\geq$4 METs, whereas participants who were on a β-blocker medication had to achieve an RPE $\geq$18 and $\geq$4 METs. Peak exercise capacity expressed as METs was estimated from treadmill speed and elevation using standardized equations (19,20): $V\mathrm{O}_2$ (ml $\cdot$ kg^{-1} $\cdot$ min^{-1}) = [0.1 ml $\cdot$ kg^{-1} $\cdot$ meters^{-1} $\times$ S (meters $\times$ min^{-1})] + [1.8 ml $\cdot$ kg^{-1} $\cdot$ meters^{-1} $\times$ S (meters $\times$ min^{-1})] $\times$ G] + 3.5 ml $\cdot$ kg^{-1} $\cdot$ min^{-1}, where S = speed and G = grade in percent; METs = $V\mathrm{O}_2$ (ml $\cdot$ kg^{-1} $\cdot$ min^{-1})/3.5 ml $\cdot$ kg^{-1} $\cdot$ min^{-1}.

Metabolic syndrome. Metabolic syndrome was defined as having three or more of the following five criteria according to Grundy et al. (21): *1*) waist circumference $\geq$102 cm for men or $\geq$88 cm for women; 2) systolic blood pressure $\geq$130 mmHg, diastolic blood pressure $\geq$85 mmHg, or taking antihypertensive medication; *3*) fasting blood glucose $\geq$100 mg/dl or diagnosis of diabetes; *4*) fasting triglycerides $\geq$150 mg/dl; or *5*) HDL cholesterol $<$40 mg/dl for men or $<$50 mg/dl for women.

A1C. A1C was measured by a dedicated ion exchange, high-performance liquid chromatography instrument (Biorad Variant 11). Individuals whose A1C exceeded 11% were ineligible; they were thought to require more urgent care and were told to seek treatment. Such individuals could be rescreened after 3 months to reassess A1C eligibility.

Statistical analysis

Analyses were restricted to randomized participants and were performed using SAS (version 9.1; SAS Institute, Cary, NC). Descriptive statistics were presented as means ± SD for continuous variables and frequency distribution for categorical variables. General linear models were used to examine bivariate relationships of maximum METs with age, BMI, waist circumference, race/ethnicity, A1C, diabetes medication, β-blocker use, and the presence of metabolic syndrome, CVD history, and hypertension. Sex-specific models were fitted to generate least-squares means and P values with adjustment for the effects of age, BMI, or both. Results are tabulated in Table 1. Variables that were significantly related to the maximum METs in bivariate analyses were then entered into sex-specific multiple linear regression models. Age, BMI, waist circumference, duration of diabetes, and A1C were included in these models as continuous variables. Backward selection was used to construct the final models. Residual plots were examined to evaluate the adequacy of models.

RESULTS

— A total of 5,145 participants (2,082 men and 3,063 women) met the eligibility criteria and were enrolled in the clinical trial. Participants had a mean age of 58.7 ± 6.8 years (59.9 ± 6.7 years for men and 57.9 ± 6.8 years for women). Mean BMI was 35.9 ± 5.9 kg/m^2 (35.2 ± 5.5 kg/m^2 for men and 36.5 ± 6.1 kg/m^2 for women). Mean waist circumference was 118.5 ± 13.4 cm for men and 110.8 ± 13.4 cm for women.

Age, sex, ethnicity, and exercise capacity

Exercise capacity was higher for men (mean METs 8.0 ± 2.1) compared with that for women (mean METs 6.7 ± 1.7, $P < 0.0001$), and exercise capacity decreased across each decade of age ($P < 0.0001$). Because of the sex differences, subsequent analyses were performed separately for men and women and were also adjusted for age. Examination of race/ethnicity demonstrated that when compared with Caucasian participants, exercise capacity was lower for African-American participants ($P < 0.001$) (Table 1).

Heart rate, RPE, and β-blockade

There were no significant differences between the sexes for peak heart rate achieved during the graded exercise test. However, peak heart rate was lower ($P < 0.01$) for participants using a β-blocker medication (130.6 ± 19.2 units) than for those not using a β-blocker medication (153.2 ± 14.0 units). When expressed as a percentage of age-predicted maximum heart rate, similar differences were observed (81.9 ± 11.6 vs. 94.8 ± 7.9 units for β-blockade and non–β-blockade, respectively; $P < 0.0001$). Results also demonstrate that the criterion of RPE $\geq$18, which was used as a marker of maximal effort for those on β-blockade, was achieved regardless of β-blocker

Table 1—*Influence of BMI, waist circumference, race/ethnicity, diabetes- and CVD-related measures, CVD history, and metabolic syndrome on peak METs*

	Overall			Men			Women	
Variable	Mean ± SE	*P*	*n*	Mean ± SE	*P*	*n*	Mean ± SE	*P*
Age (years)*								
45–49	7.8 ± 0.08	<0.0001	149	9.0 ± 0.17	<0.0001	403	7.4 ± 0.08	<0.0001
50–59	7.5 ± 0.04		893	8.4 ± 0.07		1,481	6.9 ± 0.04	
60–69	6.8 ± 0.04		846	7.5 ± 0.07		1,006	6.2 ± 0.05	
70–75	6.2 ± 0.10		191	6.8 ± 0.15		171	5.6 ± 0.12	
BMI category (kg/m^2)†								
Overweight	8.5 ± 0.06	<0.0001	339	9.3 ± 0.10	<0.0001	422	7.9 ± 0.07	<0.0001
Class I (30–34.9)	7.8 ± 0.04		837	8.5 ± 0.06		979	7.2 ± 0.04	
Class II (35–39.9)	6.9 ± 0.04		531	7.5 ± 0.08		880	6.5 ± 0.05	
Class III (≥40)	5.8 ± 0.05		373	6.2 ± 0.09		776	5.5 ± 0.05	
Waist circumference category‡								
1	7.5 ± 0.07	<0.0001	318	8.9 ± 0.12	<0.0001	641	7.1 ± 0.07	<0.0001
2	7.6 ± 0.06		602	8.4 ± 0.08		425	6.8 ± 0.07	
3	7.0 ± 0.05		282	8.0 ± 0.10		914	6.7 ± 0.05	
4	7.3 ± 0.06		451	7.7 ± 0.09		371	6.5 ± 0.07	
5	6.7 ± 0.06		422	6.9 ± 0.12		709	6.2 ± 0.06	
Race†								
African American (not Hispanic)	6.7 ± 0.07	<0.0001	189	7.6 ± 0.15	0.0283	614	6.4 ± 0.06	<0.0001
Native American/Alaskan Native	6.9 ± 0.12		55	8.4 ± 0.27		203	6.5 ± 0.11	
Caucasian	7.3 ± 0.03		1,579	7.9 ± 0.05		1,664	6.7 ± 0.04	
Hispanic	7.3 ± 0.07		194	8.1 ± 0.14		483	6.9 ± 0.07	
Asian/Pacific Islander/other/mixed/missing	7.7 ± 0.15		63	8.3 ± 0.25		98	7.3 ± 0.16	
A1C (%)§								
<7.0	7.4 ± 0.03	<0.0001	960	8.2 ± 0.06	<0.0001	1,396	6.8 ± 0.04	<0.0001
≥7.0	7.1 ± 0.03		1,120	7.8 ± 0.05		1,666	6.6 ± 0.03	
Diabetes medication§								
No medication, no insulin	7.5 ± 0.07	<0.0001	228	8.3 ± 0.12	<0.0001	413	7.0 ± 0.07	<0.0001
Medications only	7.2 ± 0.03		1,444	8.0 ± 0.05		2,012	6.7 ± 0.03	
Insulin only	6.7 ± 0.11		77	7.4 ± 0.20		146	6.3 ± 0.11	
Insulin and medication	6.9 ± 0.06		308	7.7 ± 0.10		443	6.3 ± 0.07	
β-Blocker use†								
No	7.3 ± 0.03	<0.0001	1,619	8.1 ± 0.05	<0.0001	2,555	6.7 ± 0.03	<0.0001
Yes	6.9 ± 0.06		461	7.4 ± 0.09		507	6.3 ± 0.07	
Metabolic syndrome§								
No	7.9 ± 0.10	<0.0001	148	8.5 ± 0.15	<0.0001	160	7.2 ± 0.11	<0.0001
Yes	7.1 ± 0.02		1,932	7.9 ± 0.04		2,902	6.6 ± 0.03	
CVD history†								
No	7.2 ± 0.03	0.0085	1,638	8.1 ± 0.05	<0.0001	2,782	6.7 ± 0.03	0.0001
Yes	7.0 ± 0.07		442	7.5 ± 0.10		280	6.3 ± 0.10	
Hypertension history†								
No	7.7 ± 0.07	<0.0001	300	8.5 ± 0.12	<0.0001	512	7.2 ± 0.07	<0.0001
Yes	7.1 ± 0.03		1,780	7.9 ± 0.05		2,550	6.6 ± 0.03	

*Least-squares means from model adjusting for BMI; *P* values refer to overall significance of variable of interest adjusting for BMI. †Least-squares means from model adjusting for age; *P* values refer to overall significance of variable of interest adjusting for age. ‡Men: category no. 1, <105 cm; 2, 105–114.9 cm; 3, 115–119.9 cm; 4, 120–129.9 cm; 5, ≥130 cm; women: 1, <100 cm; 2, 100–104.9 cm; 3, 105–114.9 cm; 4, 115–119.9 cm; 5, ≥120 cm. §Least-squares means from model adjusting for age and BMI; *P* values refer to overall significance of variable of interest adjusting for age and BMI.

usage (19.5 ± 0.8 vs. 19.4 ± 1.2 units for β-blockade and non–β-blockade, respectively).

Body composition, metabolic syndrome, and exercise capacity

Exercise capacity expressed as METs was lower for participants with higher BMI and higher waist circumference (Fig. 1). BMI and waist circumference were each independently associated with exercise capacity, with participants in the lowest BMI category and lowest quintile of waist circumference having the highest level of fitness (Table 1). After adjusting for both age and BMI, higher waist circumference was still independently associated with lower exercise capacity for both men and women (both $P < 0.001$). Exercise capacity (METs) was lower for participants with a history of CVD and/or hypertension and for those using β-blocker medication (each $P < 0.001$) (Table 1).

Moreover, participants using medications to control their diabetes had a lower level of fitness than individuals not using these medications even after

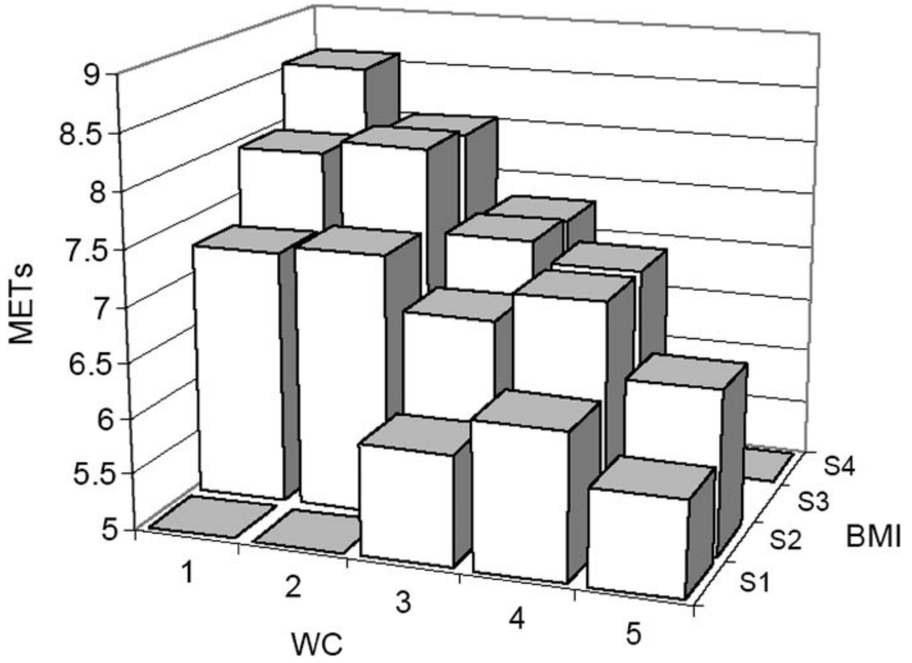

Figure 1—*Influence of BMI and waist circumference (WC) on METs. Waist circumference categories: for men, category no. 1 = <105, 2 = 105–114.9, 3 = 115–119.9, 4 = 120–129.9, and 5 = ≥130 cm; for women, category no. 1 = <100, 2 = 100–104.9, 3 = 105–114.9, 4 = 115–119.9, and 5 = ≥120 cm. BMI categories: subgroup 1(S1), 25–29.9; subgroup 2(S2), 30–34.9; subgroup 3(S3), 35–39.9; and subgroup 4(S4), ≥40 kg/m^2.*

adjustment for BMI ($P < 0.001$). Metabolic syndrome was present in 94.0% of participants and was more prevalent in women (94.8%) than in men (92.9%). Exercise capacity was lower ($P < 0.0001$) in participants with metabolic syndrome even after adjustment for BMI (Table 1).

Factors influencing exercise capacity. The sex-specific multiple linear regression models of estimated independent mediators of fitness showed that for men, older age, increased waist circumference and BMI, a longer duration of diabetes, increased A1C, a prior history of CVD, metabolic syndrome, use of β-blocker medication, and being African American compared with being Caucasian were significant variables in explaining lower exercise capacity (Table 2). For women, older age, increased waist circumference and BMI, a longer duration of diabetes, increased A1C, hypertension, prior history of CVD, having metabolic syndrome, use of diabetes medication, use of β-blocker medication, and being African American compared with being Caucasian were significant variables in explaining lower exercise capacity (Table 2).

CONCLUSIONS

Body composition and exercise capacity

In this large cohort of overweight/obese individuals with type 2 diabetes, greater impairment of exercise capacity (METs) was associated with increasing levels of general and central obesity. There is further reduction in fitness with increasing age, a longer duration of diabetes, increased A1C, a history of CVD, having metabolic syndrome, β-blocker use, and being African American compared with being Caucasian in both sexes. Additionally, for women there was greater fitness reduction with hypertension and use of diabetes medications. This is supported in a review by Stewart (22) reporting that individuals with diabetes have impaired endothelial function, diminished left ventricular diastolic function, and increased arterial stiffness, all of which could contribute to reduced exercise capacity and to an increased risk of future cardiovascular events.

Age and exercise capacity

The predicted peak exercise capacity in healthy, normal-weight populations of men and women declines naturally with age (23,24). The typical decline in METs with age is ~5–10% per decade for both sexes, and exercise capacity in women is ~20% lower than in men across the age range. We found these same age and sex trends in Look AHEAD. We also found that when the exercise capacity data are placed into the four categories of overweight and class I, II, and III obesity, there is a corresponding decline of ~10–15% per weight category (Table 1). This has previously been demonstrated by Wei et al. (11) and others (12). While general and central obesity are independently associated with lower exercise capacity, the synergistic influence of increased fatness is even more dramatic. As shown in Fig. 1, individuals in the most favorable quintile of general and central obesity had nearly twice the exercise capacity of those in the least favorable quintile. The importance of fitness over fatness has recently been addressed by Church et al. (25), who demonstrated a steep inverse gradient between fitness and mortality in a cohort of men with documented diabetes, an association independent of BMI. This suggests that exercise programs that can improve fitness levels, independent of weight loss, have the potential to limit the mortality risk in individuals with type 2 diabetes, although this is yet to be definitively determined.

Metabolic syndrome, A1C, medications, ethnicity, and exercise capacity

Exercise capacity was also lower for those with metabolic syndrome and higher A1C and for those on β-blocker therapy and/or using insulin. A recent study by Ugur-Altun et al. (7) examined the relationship between exercise capacity and metabolic variables in 48 men and 42 women with type 2 diabetes and found that a reduced exercise capacity was also associated with increased insulin resistance, lower peak heart rate, and an increased likelihood of an abnormal test. Wong et al. (26) studied 393 individuals with metabolic syndrome without a history of clinical cardiovascular disease to determine the relationship between myocardial and vascular function and exercise capacity. Their study sample was similar to the Look AHEAD cohort with respect to age, sex, BMI, waist circumference, blood pressure, presence of diabetes (95%) and MET capacity. They found a positive relationship ($P < 0.001$) among the number of metabolic syndrome components and impaired echocardiographic indexes of left ventric-

Table 2—*Multiple linear regression with the maximum METs as the outcome by sex (men and women)*

	β	SE	Test statistic	*P*
Men				
BMI (kg/m^2)	−0.0960	0.01463	−6.56	<0.0001
Waist circumference (cm)	−0.0407	0.00599	−6.79	<0.0001
Age (year)	−0.0009	0.00005	−16.96	<0.0001
Self-reported diabetes duration (years)	−0.0164	0.00637	−2.58	0.0099
CVD history	−0.2776	0.10233	−2.71	0.0067
Metabolic syndrome	−0.4056	0.15857	−2.56	0.0106
β-Blocker use	−0.3681	0.09557	−3.85	0.0001
Race/ethnicity				
African American	−0.5214	0.13681	−3.81	0.0001
Native American	−0.0119	0.23663	−0.05	0.9600
Hispanic	−0.0534	0.13596	−0.39	0.6946
Other/mixed race	−0.0731	0.22517	−0.32	0.7453
A1C (%)	−0.1565	0.03422	−4.57	<0.0001
Female				
BMI (kg/m^2)	−0.1118	0.00692	−16.17	<0.0001
Waist circumference (cm)	−0.0119	0.00320	−3.71	0.0002
Age (years)	−0.0916	0.00414	−22.13	<0.0001
Self-reported diabetes duration (years)	−0.0141	0.00441	−3.19	0.0014
Hypertension	−0.1538	0.07698	−2.00	0.0458
CVD history	−0.1842	0.09177	−2.01	0.0448
Metabolic syndrome	−0.3913	0.12457	−3.14	0.0017
Diabetes medication				
Medication but no insulin	−0.2536	0.07850	−3.23	0.0012
Insulin only	−0.4588	0.14523	−3.16	0.0016
Both medication and insulin	−0.4286	0.10750	−3.99	<0.0001
β-Blocker use	−0.2432	0.06713	−3.62	0.0003
Race/ethnicity				
African American	−0.2473	0.06634	−3.73	0.0002
Native American	−0.1852	0.10640	−1.74	0.0818
Hispanic	0.0742	0.07506	0.99	0.3227
Other/mixed race	0.3449	0.14608	2.36	0.0183
A1C (%)	−0.0587	0.02370	−2.48	0.0133

Reference levels for CVD history, metabolic syndrome, hypertension, and β-blocker use were the absence of these factors. For race, the reference level was Caucasian. For use of diabetes medication, the reference level was no use.

ular systolic and diastolic strain, reduced arterial compliance, and a significant decline in exercise capacity. While none of these measures have been collected in the Look AHEAD trial, these are likely explanations for the mechanisms behind the impairments seen in this cohort.

We also found that African Americans had a lower exercise capacity than Caucasians, which may be a reflection of the lower levels of physical activity reported in African Americans than in Caucasians (27–29). This may influence body weight, and in this cohort, African Americans have higher levels of general and central obesity. Moreover, West et al. (30) have recently demonstrated that African American women are less responsive to weight loss intervention programs than Caucasian women, which may again reflect differences in physical activity.

Central obesity and exercise capacity

Central obesity is a strong determinant of diabetes and cardiovascular disease risk and is also associated with vascular and autonomic dysfunction and impaired cardiovascular fitness (31). In a 9-year follow-up study, Koh-Banerjee et al. (32) demonstrated that reduced levels of physical activity were associated with increased waist circumference, even after adjustment for BMI. Others (33,34) have found similar results relating fitness and visceral obesity. Our findings highlight that waist circumference, a marker of central obesity, is an important determinant of exercise capacity and warrants further research regarding its independent influence on cardiovascular risk. This point has been made recently by Yusuf et al. (35), who revealed that when waist circumference is taken into account, BMI, a marker of general obesity, has little or no relationship to risk of cardiovascular events. This underscores the importance of using physical activity interventions in individuals with type 2 diabetes, since improved fitness levels are associated with significant reductions in visceral adipose tissue and, consequently, the associated risks of increased morbidity and mortality from type 2 diabetes and cardiovascular disease independent of BMI (36).

Strengths

A major strength of this study is the large number of individuals (n = 5,145) included of both sexes and the inclusion of an adequate number of individuals from ethnic groups other than Caucasian (African American, n = 803; Native American/Alaskan Native, n = 258; Hispanic, n = 677; and Asian/Pacific Islander/other/mixed, n = 161). This is also the largest study of overweight/obese individuals with type 2 diabetes who have undergone graded exercise testing.

Limitations

The results of this study may not be representative of all individuals with type 2 diabetes in this age range because of specific inclusion/exclusion criteria. Since only overweight/obese individuals were included, this will bias the trend toward greater comorbidities and lower fitness than would be expected. Conversely, each participant also had to meet a minimum fitness level of 4.0 METs, which excluded the very unfit and those with a limited ability to sustain a regular exercise routine, which was a major aspect of the subsequent behavioral intervention.

In summary, among men, having a lower exercise capacity was associated with older age, higher BMI, increased waist circumference, longer duration of diabetes, increased A1C, history of CVD, β-blocker use, having metabolic syndrome, and being African American compared with being Caucasian. Among women, in addition to the same determinants as men, having hypertension and use of diabetes medications also contributed to a lower exercise capacity. In addition to reduced exercise capacity, central obesity is also a risk factor for diabetes and cardiovascular disease. Thus, the present data emphasize the need for interventions to target central obesity rather than just BMI, given the known relationship of increased visceral adipose tissue to both type 2 diabetes and cardiovascular disease.

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