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Overweight predicts poorer exercise capacity in congenital heart disease patients☆

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ABSTRACT

Background: Overweight (OW) and obesity (OB) are endemic in the United States and affect adolescents and adults with congenital heart disease (ACHD). Defining the burden of excess weight on the cardiovascular system in ACHD is the goal of this study. Limitation of exercise capacity due to overweight or obesity might be reversible with weight loss and improve quality of life for ACHD adults.

Methods: Exercise tests performed using a Bruce protocol and measurement of maximum oxygen consumption were retrospectively reviewed on 418 CHD patients. OW and OB were defined as the 85–95 or >95 percentile respectively for age and gender or by adult criteria. Severity of CHD was assigned based on criteria published in standard guidelines.

Results: 63 patients had mild, 198 moderate, and 157 severe heart disease. Each ACHD group was 32 to 34% OW or OB. Measured exercise time (ET) of CHD patients with moderate or severe heart disease was less than that of controls in each weight categories. However, OB or OW people have shorter ET than their normal weight peers with CHD. Multiple regression using ET as the dependent variable finds that female sex, relative BMI, and VE/VCO2 at peak exercise are all associated with lesser ET with high significance. Peak heart rate is associated with greater ET, with borderline significance. Severity of heart disease is not independently associated with ET.

Conclusions: OW and OB are strongly associated with reduced ET in persons with congenital heart disease. Losing weight may improve exercise capacity in ACHD.

1. Introduction

The prevalence of overweight and obesity in children and adolescents in the US has increased significantly in the last three decades [1]. Overweight is defined as having excess body weight for height from fat, muscle, bone, water, or a combination of these factors [2]. Obesity is defined as having excess body fat [3]. Empirically, overweight is defined as BMI above the 85% and below the 95% for age and obesity as BMI above the 95th percentile for age.

The proportion of adolescents and adults with congenital heart disease (CHD) with overweight and obesity parallels that of the general population. Exercise restrictions or concerns about capacity to exercise in persons with CHD may lead to a higher prevalence of poor fitness. Ferns et al. demonstrated reduced exercise capacity in boys and girls who were obese compared with their peers over the age range 4 to 18 years. Obese participants had higher heart rates early in exercise than those of normal weight [4]. Higher resting heart rates have been demonstrated in children who are obese compared to their lean peers [5]. Obesity in children, as well as adults, is associated with endothelial dysfunction and multiple markers of inflammation raising concern about additional burden to people with structural heart disease [6].

The population of adolescents and adults with congenital heart disease is increasing rapidly leading to interest in evaluating morbidity associated with excess weight in this population.

2. Methods

We retrospectively examined the results of clinically indicated exercise tests obtained over a three year period, all of which utilized the Bruce treadmill protocol. We excluded individuals with pacemakers, and included 418 tests of adolescents and adults with CHD. Congenital heart disease was stratified into mild, moderate, severe using criteria in the guidelines of the American Heart Association and American College of Cardiology. Beta blockers were prescribed in 13 CO and 86 CHD patients. Patients with no structural heart disease had test indications of chest pain, arrhythmia, dyspnea, or other symptoms. Parameters extracted included maximum oxygen consumption, maximum

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exercise time (seconds), RER, maximum respiratory rate, beta blocker treatment, presence of pacemaker, maximum respiratory rate, ethnicity, gender, VE/VCO2 at peak exercise. Patients were allocated to one of three groups based on body mass index: normal, overweight, or obese using age specific criteria for adolescents and adults.

Comparisons were made of congenital heart disease patients to controls. Differences in each parameter between groups were assessed by non-parametric analysis and t test of means.

Using maximum exercise time as a dependent variable, multiple logistic regression analyses were made including cases and controls in the dataset and the independent variables sex, age, VE/VCO2 at peak exercise, pre-exercise systolic blood pressure, relative BMI, severity of heart disease, and maximum heart rate. Additional analysis was made for the dependent variable VE/VCO2 at peak exercise. Median RER was 1.1 (SD 0.1) for both cases and controls indicating good exercise effort during testing.

The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki as reflected in a priori approval by the human research committee at Children's National Medical Center.

3. Results

3.1. Demographics

The distribution of cases in the study sample is outlined in Table 1. The study sample included exercise tests of 418 patients with congenital heart disease (CHD). Distribution of weight as normal, overweight, or obese was similar in the two groups. Demographic variables BMI range, beta blocker usage, severity of heart disease, VE/VCO2, and BNP are all highly correlated.

3.2. Exercise time

Cases that were of normal weight exercised longer than cases that were overweight or obese. Table 2 shows maximum ET for CHD stratified both by relative body mass index and by severity of heart disease.

ET is associated with relative body mass index for all patients stratified by severity of heart disease; mild, moderate or severe. As expected maximum oxygen consumption shows the same association; peak heart rate is not associated with degree of overweight in patients with moderate or severe disease. Obese patients have shorter ET than overweight patients or patients of normal weight with the same severity of heart disease. Within the group of patients with severe heart disease, for example, maximum exercise time was 462.9 s for normal weight patients, 381.2 s for overweight patients, and 326.6 s for obese patients, a loss of 136.3 s or 29% of the exercise time of patients with severe heart disease and normal weight.

When patients are stratified by relative BMI, only in patients of normal weight are maximum exercise time, maximum oxygen consumption, and maximum heart rate associated significantly with severity of heart disease. In patients with obesity or overweight maximum exercise time and maximum heart rate are not associated with severity of heart disease; the association of VO2 with severity persists with moderate significance (P0.027).

Males exercised longer than females in CHD cases and controls across the range of disease severity. In males with mild or moderate disease, maximum heart rate was significantly higher than in females but this difference was absent in controls or cases with severe disease.

Table 1
Population characteristics.

Parameter	Congenital heart disease
	N (%)
Male	214 (51)
Female	204 (49)
Race	
White	282 (67)
African American	96 (23)
Hispanic	17 (4)
Asian	5 (1)
Not specified	18 (4)
Heart defect severity	
Mild	63 (15)
Moderate	198 (47)
Severe	157 (38)
BMI range	
0–85%	260 (67)
85–95%	78 (19)
95–100%	60 (14)
Continuous	Mean (SD)
Age	24.3 (8.5)
BMI	24.5 (5.3)
Weight (kg)	70.5 (16.3)
Height (cm)	169.6 (10.3)

418 people comprised the study population, of whom 19% were overweight and 14% obese.

Table 2
Exercise parameters stratified by relative body mass index and severity of heart disease.

Severity	BMI	No	Variable	Case
				Mean (SD)
Mild	Normal	43	Max ET	565.6 (176.6)*
			Max HR	180.5 (13.9)*
			Max VO2	38.8 (9.5)*
	OW	15	Max ET	418.7 (141.6)
			Max HR	157.1 (20.3)
			Max VO2	28.1 (7.5)
	OB	5	Max ET	357.0 (153.1)
			Max HR	164.6 (18.3)
			Max VO2	23.7 (7.0)
Moderate	N	131	Max ET	459.4 (154.9)*
			Max HR	161.7 (24.6)
			Max VO2	29.9 (8.4)*
	OW	34	Max ET	422.7 (140.2)
			Max HR	161.7 (24.6)
			Max VO2	26.8 (7.2)
	OB	33	Max ET	367.0 (140.2)
			Max HR	158.7 (20.2)
			Max VO2	23.8 (8.2)
Severe	N	106	Max ET	464.7 (141.6)*
			Max HR	154.7 (30.3)
			Max VO2	27.8 (7.4)*
	OW	29	Max ET	381.2 (140.2)
			Max HR	160.4 (20.2)
			Max VO2	24.8 (5.9)
	OB	22	Max ET	326.6 (114.2)
			Max HR	150.4 (25.6)
			Max VO2	19.6 (4.7)

By ANOVA maximum exercise time and VO2 max are significantly different for increasing BMI categories in each category of severity of heart disease, marked by *. Maximum heart rate is associated with increasing BMI only in patients with mild heart disease.

3.3. Blood pressure

Subjects had significantly increased pre-exercise systolic and diastolic blood pressure with increasing body mass category as shown in Table 3. Post-exercise systolic and diastolic blood pressures also were significantly higher in subjects with OW or OB compared to those of normal weight across categories of gender or severity of heart disease. The higher post-exercise blood pressures do not represent greater exercise effort since, in fact, overweight and obese patients had shorter exercise times. See Table 3.

3.4. Association of exercise time to independent variable

Using multiple regression, we analyzed ET as a dependent variable to gender, age, VE/VCO2 at peak exercise, pre-exercise systolic blood