Cardiorespiratory Fitness Levels and its Correlates Among Adults with Diabetes

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ABSTRACT

Purpose: The purpose of this study is to report cardiorespiratory fitness levels among adults with diabetes and report differences by demographic (eg, body mass index) and behavioral (eg, physical activity) variables. **Methods:** Data from the 1999-2004 National Health and Nutrition Examination Survey (NHANES) were used in the analyses. Cardiorespiratory fitness was assessed using a non-exercise prediction equation and through a submaximal treadmill-based test using heart rate extrapolation. Participants completed a questionnaire to assess various demographic and behavior variables. Seventy eight participants met inclusion criteria and constituted the analyzed sample. **Results:** The majority (55.1%) of participants were estimated as having low or moderate cardiorespiratory fitness. Results showed that for both methods normal weight individuals had greater cardiorespiratory fitness than obese individuals, and for the non-exercise prediction equation, participants who sat during the day and did not walk very much had lower cardiorespiratory fitness (mean = 26.1 mL/kg/min [95% CI: 18.9-33.4]) than those doing heavy work or carrying heavy loads (mean = 34.6 mL/kg/min [95% CI: 30.2-39.1]). **Conclusion:** These results suggest that obese and inactive adults with diabetes may be at an increased risk for morbidities and mortality associated with low cardiorespiratory fitness. Physical therapists are encouraged to apply evidence-based principles for exercise prescription and physical activity counseling to help patients with diabetes regulate their blood glucose control and improve cardiorespiratory fitness.

Key Words: obesity, physical activity, physical therapy

INTRODUCTION AND PURPOSE

Cardiorespiratory fitness (ie, $\text{VO}_{2\text{max}}$) is strongly associated with various health outcomes, including cardiovascular disease and all-cause mortality.¹ Moderate to high levels of cardiorespiratory fitness may also play a protective role in diabetes,² as individuals with low cardiorespiratory fitness are more likely to be insulin resistant.³ Sawada and colleagues⁴ conducted a prospective study among 4,747 Japanese men without diabetes. After adjusting for age, body mass index (BMI), systolic blood pressure, family history of diabetes, smoking status, and alcohol intake, and after approximately 15 years, those with the highest cardiorespiratory fitness were at a 44% reduced risk for developing diabetes. Similarly, Sieverdes and colleagues⁵ used a prospective study design to examine the association between cardiorespiratory fitness and incidence of diabetes. During an average 18-year follow-up among over 23,000 men between the ages of 20 and 85, individuals with moderate and high cardiorespiratory fitness, had a 38% and 63% lower risk, respectively, of developing diabetes compared to those with low cardiorespiratory fitness; importantly, these results occurred after adjusting for age, examination year, survey response pattern, BMI, smoking, alcohol drinking, fasting glucose, chronic disease, and family history of cardiovascular disease or diabetes. Underscoring the importance of enhancing cardiorespiratory fitness among individuals with diabetes, Lyerly and colleagues⁶ showed that in over 3,000 women (mean age 47 years) with impaired fasting glucose or undiagnosed diabetes mellitus, followed for 16 years, women with moderate or high cardiorespiratory fitness had a 35% and 36% lower risk of mortality, respectively. The beneficial effects of enhanced cardiorespiratory fitness on insulin sensitivity is likely through physical activity-induced increases in glucose transporters (eg, glucose transporter-4 [GLUT-4]),⁷ breakdown of glycogen (ie, glycogenolysis) during physical activity that may facilitate glucose uptake,⁸ and expression of proteins in the insulin signaling pathway.⁹

Clearly, enhanced cardiorespiratory fitness is associated with numerous health benefits, including a reduced risk of developing diabetes and diabetes-related mortality. Studies examining cardiorespiratory fitness in adult cohorts

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over short and long time periods have shown an inverse relationship between cardiorespiratory fitness levels and onset of impaired glucose tolerance or diabetes.^{4,10,11} However, we currently have a limited understanding of demographic and behavioral factors that are associated with cardiorespiratory fitness among adults with diabetes. Such information is important as this will identify individuals at further risk for morbidity and mortality. Furthermore, in order for physical therapists to develop and implement effective cardiorespiratory fitness programs for adults with diabetes, it is essential that they are informed of the key demographic and behavioral factors that influence cardiorespiratory fitness. To bridge this gap in the literature, the purpose of this study was to report cardiorespiratory fitness levels among adults with diabetes using data from the National Health and Nutrition Examination Study (NHANES), and determine if differences occurred by selected demographic and behavioral variables. Demographic variables included age, gender, race/ethnicity, education, marital status, income, and BMI. Behavioral variables included several measures of physical activity: average amount of physical activity per day, engagement in vigorous intensity and moderate intensity activity, and engagement in muscle strengthening activities.

METHODS

Design and Participants

Data from the NHANES were used in the analyses. To produce estimates with greater statistical reliability, data from the 1999-2000, 2001-2002, and 2003-2004 NHANES cycles were combined. In each of the 2-year cycles, participants were interviewed in their homes and subsequently examined in mobile examination centers (MEC). The study was approved by the National Center for Health Statistics ethics review board, with informed consent obtained from all participants prior to data collection. The NHANES, a major program of the National Center for Health Statistics, is publically accessible data that is part of the Centers for Disease Control and Prevention. The authors used NHANES data for secondary analyses.

Among the 31,126 participants in the 1999-2004 NHANES cycles, 30,158 remained after excluding those who were pregnant; 8,243 remained after excluding those who had missing estimates of cardiorespiratory fitness; 4,361 remained after excluding those who were under 18 years of age; and 78 remained after excluding those who did not have diabetes. These 78 adults with diabetes constituted the analyzed sample. It was not possible to determine whether participants had type 1 or 2 diabetes, as this was not specified in the NHANES questionnaire.

When comparing the 78 participants with diabetes and cardiorespiratory fitness data to the 217 participants with diabetes but without cardiorespiratory fitness data, those without cardiorespiratory fitness data were older (mean = 40.8 yrs vs. 37.1 yrs, $p = 0.0002$), had a higher BMI (mean = 34.6 kg/m² vs. 32.3 kg/m², $p = 0.05$), had a higher waist

circumference (mean = 110.1 cm vs. 104.5 cm, $p = 0.02$), and were less likely to participate in vigorous physical activity (26.9% vs. 44.8%, $p = 0.04$). Between these groups there were no differences with respect to gender, education, marital status, race-ethnicity, income, moderate-intensity physical activity, and muscle strengthening activities.

Measurement of Cardiorespiratory Fitness

Two methods were used to estimate cardiorespiratory fitness (ie, $\text{VO}_{2\text{max}}$) allowing for a comprehensive examination of the association between cardiorespiratory fitness and demographic and behavioral variables. The first method used to estimate $\text{VO}_{2\text{max}}$ was from an established non-exercise prediction equation developed by Jackson and colleagues¹² that is based on the participant's age, gender, BMI, and self-reported physical activity level. This prediction equation is shown below:

$$\text{Predicted } \text{VO}_{2\text{max}} = 56.363 + [1.921 * (\text{PA-R})] - [0.381 * (\text{age in years})] - [0.754 * (\text{BMI})] + [10.987 * (F = 0, M = 1)]$$

PA-R = Physical activity readiness code, ranging from 0 to 7. For example, a code of 0 is that the participant reported no regular recreation, sport, or physical activity. A code of 7 is that the participant reported participating in regular heavy exercise for more than 3 hours per week. Body mass index was calculated as the measured body weight in kg divided by the height squared in meters.

The second method used to estimate $\text{VO}_{2\text{max}}$ was through heart rate extrapolation during a treadmill-based submaximal test. At the MEC, participants aged 12-49 years old were eligible for the treadmill-based cardiorespiratory fitness component. More than 50 questions or measurements from the household interview and examination at the MEC were used as exclusion criteria.¹³ For example, participants were excluded from the treadmill test based on certain medical conditions (eg, previously diagnosed with coronary heart disease or self-reported heart problems), medications (eg, beta blockers), physical limitations (eg, difficulty walking up 10 steps without resting), limits on resting heart rate (ie, > 100 beats per minute) and blood pressure (systolic blood pressure > 180 mmHg; diastolic blood pressure > 100 mmHg), irregular resting heart rates (> 3 irregular beats per minute), and other reasons specified by the participant or MEC physician or staff (eg, hospitalized in the previous 3 months).

The protocol employed was a submaximal treadmill protocol, including a 2-minute warm-up period, two 3-minute exercise stages, and a 2-minute cool-down period. Participants were assigned to one of 8 treadmill protocols. Differences between protocols included the initial intensity level and rise in the incline per stage. The participant's predicted $\text{VO}_{2\text{max}}$ using the non-exercise prediction equation was used to select the appropriate protocol. The objective of each protocol was to elicit a heart rate that was approximately 75% to 80% of the participant's age-predict-

ed maximum heart rate (ie, 220-age) by the conclusion of the test. Because the relationship between heart rate and oxygen consumption is assumed to be linear during exercise,¹⁴ $\text{VO}_{2\text{max}}$ was estimated by measuring the heart rate response to known levels of submaximal work. Classification of cardiorespiratory fitness was based on the reference cut-points used for adults 20-49 from the Aerobics Center Longitudinal Study (ACLS).^{14,15} Low level of cardiorespiratory fitness was defined as an estimated $\text{VO}_{2\text{max}}$ below the 20th percentile of the ACLS data of the same gender and age group; moderate fitness was defined as a value between the 20th and 59th percentile, and high fitness level was defined as at or above the 60th percentile. Fitness levels were determined using the VO_2 data from the heart rate extrapolation method.

Assessment of Diabetes Status

Administered in the home, participants were asked several questions related to diabetes. Participants were asked (1) if they ever had been told by a doctor or health professional that they had or have diabetes or sugar diabetes, (2) if they are now taking insulin, and (3) if they are now taking diabetic pills to lower blood sugar. In the present study, participants who answered yes to any of these 3 questions were considered to have diabetes. A subsample of the NHANES participants was examined in a morning fasting session. Fasting glucose was measured from a blood sample and participants with a fasting glucose level of 126 mg/dL or higher were also considered to have diabetes.¹⁶

Demographic and Behavioral Correlates of $\text{VO}_{2\text{max}}$

Information about age, gender, race/ethnicity, marital status, education, and income were obtained from a questionnaire. Several physical activity variables were self-reported including average level of physical activity per day, categorized into:

- *sitting during the day and not walking about very much,*
- *stands or walks about a lot during the day but does not have to carry or lift things very often,*
- *lifts light loads or climbs stairs or hills often, and*
- *does heavy work or carries heavy loads.*

Other physical activity variables evaluated included:

- *engaging in vigorous activity over the last 30 days lasting at least 10 minutes in duration, engaging in moderate activities over the last 30 days lasting at least 10 minutes in duration and*
- *engaging in muscle strengthening activities in the last 30 days.*

During examination at the MEC, waist circumference was measured using standard procedures.

Data Analysis

All statistical analyses were performed using STATA (version 10.0, College Station, TX). Means and standard errors were calculated for continuous variables and proportions were calculated for categorical variables. To compare $\text{VO}_{2\text{max}}$ estimates across different groups (eg, normal weight, overweight, obese) of each categorical variable, a one-way analysis of variance (ANOVA) was employed. Post-hoc tests were carried out among the ANOVAs that were significant or marginally significant. To assess the strength of the association between the significant variables, eta-squared (η^2) values were calculated.¹⁷ Statistical significance was set at an alpha of 0.05.

RESULTS

Table 1 displays the demographic characteristics of the analyzed sample. Table 2 shows the mean/proportion values for the cardiorespiratory and physical activity variables. The majority (60.2%) of participants were obese, and 55.1% of the participants had estimated cardiorespiratory fitness in the low or moderate categories (Table 2). The majority of participants reported standing or walking a lot during the day without carrying or lifting things very often (60.2%); few participants lifted light loads or had to climb stairs or hills often (15.3%) or did

Table 1. Demographic Characteristics of the Analyzed Sample

Variable	Mean/Proportion (95% CI)
Age (yrs) (n = 78)	37.1 (34.9-39.2)
% Female (n = 35 for male; 43 females)	55.1 (43.8-66.4)
BMI (kg/m ²) (n = 78)	32.3 (30.9-33.7)
Waist circumference (cm) (n = 78)	104.5 (101.2-107.8)
Weight Status	
% Normal Weight (BMI < 25) (n = 11)	14.1 (6.2-22.0)
% Overweight (BMI = 25-29.9) (n = 20)	25.6 (15.7-35.5)
% Obese (BMI ≥ 30) (n = 47)	60.2 (49.1-71.3)
Education	
% High School Graduate/GED Equivalent or less (n = 39)	53.4 (41.7-65.1)
% Some College or College Graduate or Above (n = 34)	46.5 (34.8-58.2)
Marital Status	
% Married or Living with Partner (n = 37)	48.6 (37.1-60.1)
% Widowed, Divorced, Separated or Never Married (n = 39)	51.3 (39.8-62.8)
Race-Ethnicity	
% Mexican American (n = 26)	33.3 (22.6-44.0)
% Non-Hispanic White (n = 11)	14.1 (6.2-22.0)
% Non-Hispanic Black (n = 20)	25.6 (15.7-35.5)
% Other Race (n = 21)	26.9 (16.8-36.9)
Annual Income	
% Under \$20,000 (n = 17)	26.1 (15.1-37.1)
% \$20,000+ (n = 48)	73.8 (62.8-84.8)

Table 2. Cardiorespiratory Fitness and Physical Activity Variables

Variable	Mean/Proportion (95% CI)
VO_{2max} – Heart Rate Extrapolation (n = 78)	38.1 (35.7-40.4)
VO_{2max} – Non-Exercise Equation (n = 78)	26.7 (24.5-28.9)
Fitness Level (%)	
Low (n = 22)	28.2 (17.9-38.4)
Moderate (n = 21)	26.9 (16.8-36.9)
High (n = 35)	44.8 (33.5-56.1)
Average level of physical activity each day (%)	
Sits during the day and not walk about very much (n = 11)	14.1 (6.2-22.0)
Stands or walks about a lot during the day, but does not have to carry or lift things very often (n = 47)	60.2 (49.1-71.3)
Lifts light loads or has to climb stairs or hills often (n = 12)	15.3 (7.1-23.5)
Does heavy work or carries heavy loads (n = 8)	10.2 (3.3-17.1)
Aerobic Exercise (%)	
Vigorous exercise in past 30 days	
Yes (n = 35)	44.8 (33.5-56.1)
No (n = 43)	55.1 (43.8-66.4)
Moderate exercise in past 30 days	
Yes (n = 35)	44.8 (33.5-56.1)
No (n = 43)	55.1 (43.8-66.4)
Muscle strengthening activities in past 30 days (%)	
Yes (n = 14)	17.9 (9.2-26.6)
No (n = 64)	82.0 (73.3-90.7)

heavy work or carried heavy loads (10.2%). Similarly, 82% reported not engaging in muscle strengthening activities. Table 3 displays the mean cardiorespiratory fitness, using both the heart rate extrapolation method and non-exercise prediction equation, across demographic and physical activity variables.

For both methods used to estimate cardiorespiratory fitness, males had greater cardiorespiratory fitness compared to females. Additionally, for both methods, normal weight individuals had greater cardiorespiratory fitness than obese individuals. For the non-exercise prediction equation, normal weight individuals (39.8 mL/kg/min [95% CI: 35.1-44.5]) had higher cardiorespiratory fitness than overweight individuals (30.5 mL/kg/min [95% CI: 27.9-33.2]), and overweight individuals had greater cardiorespiratory fitness than obese individuals (22.0 mL/kg/min [95% CI: 19.8-24.3]). Lastly, for the non-exercise prediction equation, participants who sat during the day and did not walk very much (26.1 mL/kg/min [95% CI: 18.9-33.4]) or who stood or walked about a lot (25.2 mL/kg/min [95% CI: 22.6-27.7]) had lower cardiorespiratory fitness than those doing heavy work or carrying heavy loads (34.6 mL/kg/min [95% CI: 30.2-39.1]). The correlation coefficient between the

two methods used to estimate cardiorespiratory fitness was 0.31 ($p < 0.01$), which demonstrates only modest evidence of construct validity. This also helps explain some of the discrepant findings, such as the significant association between physical activity and cardiorespiratory fitness when using the non-exercise prediction equation compared to the non-significant association when using the heart rate extrapolation method.

DISCUSSION AND CONCLUSIONS

It is well established that cardiorespiratory fitness is inversely associated with impaired glucose tolerance or diabetes; however, fewer investigations have examined demographic and behavioral factors that are associated with cardiorespiratory fitness among adults with diabetes. This study showed that, similar to individuals without diabetes, among individuals with diabetes, those who had lower levels of physical activity and a higher BMI generally had lower levels of cardiorespiratory fitness. This is particularly concerning in that, not only may their condition of diabetes increase their risk for premature mortality and cardiovascular disease,^{18,19} but low levels of cardiorespiratory fitness is an independent predictor of mortality even after adjusting for co-morbidities predicting mortality risk.²⁰ Consequently, enhancing cardiorespiratory fitness levels among adults with diabetes is a public health priority.

These findings showed that estimates of cardiorespiratory fitness were lower in the non-exercise prediction equation, which is consistent with other studies.²¹⁻²⁴ For example, Kolkhorst and Dolgener²¹ predicted young adult males to have a VO_{2max} of 46.4 mL/kg/min using a non-exercise prediction equation, compared to a measured VO_{2max} of 10 units higher (ie, 56.7 mL/kg/min). Additionally, although both methods used to estimate VO_{2max} provided similar conclusions regarding the association between cardiorespiratory fitness and weight status, discrepant findings emerged for the physical activity variable. When using the non-exercise prediction equation, individuals who were more physically active had higher cardiorespiratory fitness levels, which is consistent with other studies among persons with diabetes;²⁵ however, when using estimates from the heart rate extrapolation method, no significant findings emerged. These discrepant findings are likely attributable to the methods used to estimate VO_{2max} and the amount of measurement error involved in each method. Both methods have measurement error, with the majority of the measurement error in the heart rate extrapolation method coming from the estimate of maximal heart rate (ie, 220-age). Jackson et al¹² showed that the heart rate estimation formula can result in considerable measurement error, especially among hypertensive individuals, with this formula overestimating maximal heart rate by as much as 22 beats per minute compared to measured maximal heart rate. The non-exercise prediction used in the present study is also not perfect, as all prediction equations have measurement error. However, empirical evidence

Table 3. Mean Cardiorespiratory Fitness Stratified by Demographic Characteristics and Physical Activity Variables

Variable	HR Extrapolation		Non-Exercise Prediction Equation	
	VO ₂ (95% CI)	Test-Statistic	VO ₂ (95% CI)	Test-Statistic
Gender		P = 0.002, η^2 = 0.12		P < 0.001, η^2 = 0.47
Male	42.0 (38.5-45.5)		34.1 (31.7-36.5)	
Female	34.9 (32.0-37.7)		20.8 (18.6-22.9)	
Weight Status		P = 0.01, η^2 = 0.10		P < 0.001, η^2 = 0.44
Normal Weight	44.5 (39.2-49.8) ^a		39.8 (35.1-44.5) ^b	
Overweight	40.5 (34.7-46.2)		30.5 (27.9-33.2) ^c	
Obese	35.5 (33.0-38.1)		22.0 (19.8-24.3)	
Education		P = 0.35		P = 0.91
High School Graduate/GED Equivalent or less	39.1 (36.2-42.1)		25.9 (22.7-29.2)	
Some College or College Graduate or Above	36.8 (32.7-40.9)		26.1 (23.6-28.7)	
Marital Status		P = 0.27		P = 0.64
Married or Living with Partner	39.6 (35.8-43.3)		26.4 (23.6-29.2)	
Widowed, Divorced, Separated or Never Married	36.9 (33.9-39.9)		27.4 (23.9-30.9)	
Race-Ethnicity		P = 0.23		P = 0.48
Mexican American	41.3 (36.9-45.6)		25.2 (21.2-29.3)	
Non-Hispanic White	37.8 (33.1-42.6)		29.0 (24.2-33.8)	
Non-Hispanic Black	37.2 (32.2-42.1)		25.3 (21.6-29.1)	
Other Race	35.1 (30.9-39.2)		28.7 (24.0-33.4)	
Income		P = 0.94		P = 0.83
Under \$20,000	38.6 (33.4-43.9)		27.7 (22.0-33.5)	
\$20,000+	38.4 (35.4-41.5)		27.2 (24.6-29.7)	
Average level of physical activity each day		P = 0.56		P = 0.07, η^2 = 0.09
Sits during the day and not walk about very much	39.5 (32.8-46.2)		26.1 (18.9-33.4) ^d	
Stands or walks about a lot during the day, but does not have to carry or lift things very often	36.9 (33.6-40.2)		25.2 (22.6-27.7) ^e	
Lifts light loads or has to climb stairs or hills often	41.4 (36.6-46.3)		28.0 (21.7-34.4)	
Does heavy work or carries heavy loads	37.8 (33.8-41.8)		34.6 (30.2-39.1)	
Aerobic Exercise				
Vigorous PA in past 30 days		P = 0.93		P = 0.38
Yes	38.0 (34.7-41.2)		27.8 (24.6-31.0)	
No	38.2 (34.8-41.5)		25.9 (22.9-28.8)	
Moderate PA in past 30 days		P = 0.37		P = 0.52
Yes	36.9 (33.7-40.1)		27.5 (24.2-30.8)	
No	39.0 (35.7-42.4)		26.1 (23.1-29.0)	
Muscle strengthening activities in past 30 days		P = 0.96		P = 0.30
Yes	37.9 (33.2-42.7)		29.1 (23.0-35.3)	
No	38.1 (35.4-40.8)		26.2 (23.9-28.5)	

^a Significant difference between normal weight and obese (p = 0.009, η^2 = 0.09).

^b Significant difference between normal weight and overweight (p = 0.001, η^2 = 0.13). Significant difference between normal weight and obese (p < 0.001, η^2 = 0.41).

^c Significant difference between overweight and obese (p < 0.001, η^2 = 0.20).

^d Sits during the day and not walking very much marginally different than doing heavy work (p = 0.05, η^2 = 0.05).

^e Stands or walks about at a lot significantly different than doing heavy work (p = 0.01, η^2 = 0.08).

does support the utility of this prediction equation, as the difference between predicted $\text{VO}_{2\text{max}}$ and measured $\text{VO}_{2\text{max}}$ has shown to be $< 0.1 \text{ mL/kg/min}$.¹² This prediction equation has also been cross-validated in independent samples.^{26,27} Given this, it is sensible to suggest that regular participation in physical activity is associated with higher cardiorespiratory fitness among adults with diabetes. Our findings, however, did not demonstrate a link between cardiorespiratory fitness and exercise (ie, engaging in moderate or vigorous aerobic exercise within the last 30 days). This is likely a result of the self-reported exercise behavior variable not truly representing the participant's habitual or chronic physical activity patterns. To overcome the inherent limitations associated with self-reported exercise, future related studies are encouraged to use an objective measure of physical activity (eg, accelerometer or pedometer).

Similar to findings in the general population,²⁸ we found that among adults with diabetes, weight status was associated with cardiorespiratory fitness; with overweight and obese individuals, who comprised 85% of the sample, were estimated to have lower cardiorespiratory fitness than normal weight adults. The obesity prevalence in this sample of adults with diabetes (60.2%) is nearly twice that reported among adults in the general population (32.2%).²⁹ Furthermore, the mean cardiorespiratory fitness for obese participants was in the relatively low category (22.0 mL/kg/min for the prediction equation and 35.5 mL/kg/min for HR extrapolation).^{14,15} This finding is not surprising given the link between obesity and diabetes,³⁰ but does indicate that not only are adults with diabetes at risk for diabetic-related health consequences, but also negative health outcomes associated with obesity.

A limitation to this study is the cross-sectional study design and the relatively small sample size, which is likely a result of the extensive exclusion criteria for the cardiorespiratory fitness test. This small sample size prevented gender-stratified analyses; thus, future prospective studies employing a larger sample size and conducting gender-specific analyses are warranted. As a result of the relatively small sample size, it was not appropriate to use the NHANES sample weights. To provide nationally representative estimates, NHANES supplies 'sample weights' that are assigned to each participant. Each 'sample weight' indicates the number of people in the US population represented by the participant in NHANES. Our findings may lack generalizability to other adults with diabetes as these findings are not intended to represent all US adults with diabetes but rather reflect associations in NHANES participants with evidence of diabetes. Given that participants with diabetes who had cardiorespiratory fitness data, compared to those with diabetes without cardiorespiratory fitness data, had a lower BMI and more likely to participate in vigorous-intensity physical activity, the association between cardiorespiratory fitness and weight status and physical activity in the present study is likely to be underestimated. Major strengths to this study

include the use of an objective measure of cardiorespiratory fitness, examining the cardiorespiratory fitness among adults with diabetes, and examining potential demographic and behavioral factors associated with cardiorespiratory fitness among adults with diabetes.

Overall, our findings suggest that overweight and obese adults with diabetes, in particular, may be at an increased risk for mortality and morbidity due to low levels of cardiorespiratory fitness. Physical therapists are therefore encouraged to prescribe age- and condition-appropriate, exercises to enhance cardiorespiratory fitness particularly among this subpopulation of adults with diabetes. When doing so, it is recommended that clinicians not focus on weight management as the main reason for initiating and maintaining an exercise program to enhance cardiorespiratory fitness, but rather emphasize the role of exercise in reducing the risk of morbidity and mortality.³¹ The reason behind this is that overweight and obese adults may be dissatisfied with their weight loss, and if this is the focus of the program, they, in turn, may be more likely to have a relapse or discontinue the exercise program altogether. When feasible, it is suggested that clinicians encourage lifestyle physical activity such as taking the stairs instead of the elevator, parking farther away in the parking lot at the store, or pacing while talking on the phone. Particularly among adults with diabetes, lifestyle activity may be a more palatable approach than structured exercise for people with long-standing sedentary lifestyles and increased likelihood of concurrent co-morbidities, such as arthritis, that may make it difficult to engage in sustained bouts of exercise. Not only may lifestyle activity be a more palatable approach, but current evidence indicates that lifestyle activity may influence various health outcomes to the same magnitude as sustained, structured exercise.³²

To help regulate blood glucose control and improve cardiorespiratory fitness in patients, physical therapists are encouraged to use evidence-based patient counseling techniques when promoting lifestyle activity.³³ Physical therapists should consider tailoring counseling approaches to the desires, needs, and preferences of each patient such as motivational interviewing and cognitive behavioral therapy, which have been shown to be effective in adults with diabetes.^{34,35} Additionally, physical therapists specifically identifying physical activity-related barriers (eg, depression, weakness, fear of falling, and low outcomes expectation) and prescribing strategies to overcome these barriers may be an effective tool to increase exercise adherence rates following discharge from physical therapy.³⁶

In summary, this study indicates that the majority of adults with diabetes have relatively low cardiorespiratory fitness and that physical activity and weight status may influence cardiorespiratory fitness among this population. Consequently, physical therapists are encouraged to incorporate evidence-based physical activity counseling techniques in their practice to assist patients with diabetes in improving glycemic control and cardiorespiratory fitness.

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