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Cardiovascular Fitness and Quality of Life in Adolescents with Type 1 or Type 2 Diabetes

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Abstract

Purpose—This descriptive study of adolescents with type 1 or type 2 diabetes examined the relationships between cardiovascular fitness and physical activity (PA) with generic or health-related quality of life (QoL), glycemic control, and lipids.

Design and Methods—Graded ergometry testing for fitness, fasting assays for lipids, glycosylated hemoglobin (A1C), and self-reported PA and QoL instruments were completed with 151 adolescents.

Results—Adolescents with type 2 diabetes had lower fitness. Fitness was associated with improved lipids, A1C, health perception, and athletic competence in adolescents with type 1 diabetes.

Practice Implications—Interventions to encourage active lifestyles are imperative for adolescents with diabetes.

Keywords

Adolescents; diabetes, Type 1 or Type 2; fitness; physical activity; quality of life; quantitative

Diabetes mellitus (DM) is one of the most severe chronic diseases of childhood and adolescence (Dabelea & Klingensmith, 2008). For youth 10-19 years of age, type 1 DM remains the more common type with a prevalence rate of 2.28 per 1,000, compared to the much lower rate of 0.42 per 1,000 for those with type 2 DM (Liese et al., 2006). Current therapeutic regimens for adolescents with diabetes, regardless of the type, are based on self-management of pharmacological interventions with insulin and/or oral agents, medical nutritional therapy, and regular exercise to maintain glycemic control, preserve quality of life (QoL), and minimize future complications (American Diabetes Association, 2010). Although adolescents face many developmental and emotional challenges for managing their DM, the American Diabetes Association (2010) presently recommends that A1C values be maintained below 7.5% to improve long-term health outcomes. A major focus of pediatric multidisciplinary DM care is the attainment of optimal glycemic control (A1C) while ensuring high QoL (Ingerski, Laffel, Drotar, Repaske, & Hood, 2010). Glycemic control reflects the physiological outcome of DM management, whereas QOL represents the psychological perspective of treatment outcomes for individuals with DM.

As a major co-morbid consequence of DM, cardiovascular (CV) disease has potentially devastating effects on all aspects of QoL and is the leading cause of mortality for persons

with DM later in life (CDC, 2009). With increasing numbers of youth diagnosed with DM, more investigators have begun to examine the early onset of CV risks in youth with type 1 or type 2 DM (Jarvisalo et al., 2004; Margeirsdottir, Larsen, Brunborg, Overby, & Dahl-Jorgensen, 2008; Rodriguez et al., 2006). Regular exercise is known to improve glucose control, reduce known CV risk factors, and improve QoL (American Diabetes Association, 2010; Rachmiel, Buccino, & Daneman, 2007). Importantly, higher levels of exercise intensity are associated with increased physical fitness and even better glucose control in persons with type 1 or type 2 DM (Boule, Haddad, Kenny, Wells, & Sigal, 2001; Boule, Kenny, Haddad, Wells, & Sigal, 2003; Faulkner, Quinn, Rimmer, & Rich, 2005). Studies in adults with type 2 DM have shown that regular exercise improves CV fitness, hyperlipidemia, and A1C (Balducci et al., 2009; Zois et al., 2009). Despite the emphasis on exercise as a means for enhancing CV fitness, glucose control, and possibly improvements in lipid profile for adolescents with DM, the few available studies are limited to those with type 1 DM (Rachmiel et al., 2007). No studies report outcomes for adolescents with type 2 DM or the associations of CV fitness or physical activity to QoL. Thus, the purpose of this study was to explore the relationships between CV fitness (i.e., VO_{2peak}), as well as self-reported physical activity, with generic or health-related QoL, glycemic control, and lipid profile in adolescents with type 1 or type 2 DM.

Literature Review

Diabetes management can be evaluated through the examination of individuals' glycemic control as well as their QoL. Measures of self-perceived QoL can help health professionals understand the impact of both the disease and its treatment. The American Diabetes Association (2010) suggests that clinicians include QoL assessments in DM care. For adolescents who face many developmental challenges for gaining increased responsibility to incorporate all aspects of DM management into their daily routine, including exercise, their perceptions of their own life quality is critical for knowing best approaches for treatment adherence.

In reviewing the existing research literature in both youth and adult populations with chronic illnesses, the relationship between *cardiovascular fitness* and *QoL* has rarely been investigated (Lindholm, Brevinge, Bergh, Korner, & Lundholm, 2003). Findings of health outcomes associated with exercise in adults with DM have been generated from research with those who have type 2 DM, indicating the fact that those with lower aerobic capacity, a measure of CV fitness, exhibited poorer measures of physical QoL (Rejeski et al., 2006). In other studies of older adults and post-menopausal women treated for breast cancer, CV fitness was found to be related to a physical or functional dimension of QoL (Courneya et al., 2003; Lindholm et al., 2003). Quality of life was correlated with CV fitness on both physiological and psychological dimensions in children with juvenile dermatomyositis (Takken et al., 2003) and on physical functioning dimensions and a general health scale in adolescents and adults with congenital heart disease (Hager & Hess, 2005).

There are no known systematic reviews to evaluate the effect of physical activity on QoL in individuals with type 2 DM, including adolescents. However, the effects of physical activity on overall QoL are well established in the general population and have been analyzed on various dimensions of QoL, including physical and social functioning, subjective well-being, emotion and mood, self-perception, and sleep quality. Even though the effectiveness of physical activity and exercise on physical health has been shown in numerous studies, less evidence is available to show if similar positive improvements in well-being or personal perceptions of health, which are common measures of QoL, can be seen in subjects with DM (Zanuso, Balducci, & Jimenez, 2009).

As an outcome of DM management, there is strong evidence from randomized clinical trials showing adolescents' perceptions of their own QoL can be reliably measured with good clinical utility (de Wit, Delemarre-van de Waal, Pouwer, Gemke, & Snoek, 2007; Delamater, 2009; Jacobson, Barofsky, Cleary, & Rand, 1988). One major gap is the lack of evidence on QoL for adolescents with type 2 DM, with current knowledge predominantly addressing views of those with type 1 DM. In a recent investigation conducted by the multisite SEARCH for Diabetes in Youth Study, youth with type 2 DM were reported to have lower QoL than those with type 1 DM (Naughton et al., 2008).

The remainder of the literature review presented here includes teens with type 1 DM. Past studies of adolescents with type 1 DM have demonstrated the positive effects of exercise on improvements of either glycemic control, CV fitness, or both (Faulkner, Michaliszyn, & Hepworth, 2010; Heyman et al., 2007; Landt, Campaigne, James, & Sperling, 1985; Marrero, Fremion, & Golden, 1988), but did not report associations with QoL. Some research findings indicate that QoL is lower among youths with DM compared with healthy children (Faulkner, 2003; Patino, Sanchez, Eidson, & Delamater, 2005; Varni, Burwinkle, Seid, & Skarr, 2003), but generally they tend not to rate themselves differently from their healthy peers (Ingersoll & Marrero, 1991; Wake, Hesketh, & Cameron, 2000). There is considerable evidence that higher QoL is associated with better glycemic control (Faulkner & Chang, 2007; Grey, Boland, Yu, Sullivan-Bolyai, & Tamborlane, 1998; Guttman-Bauman, Flaherty, Strugger, & McEvoy, 1998; Hanberger, Ludvigsson, & Nordfeldt, 2009; Hassan, Loar, Anderson, & Heptulla, 2006; Hesketh, Wake, & Cameron, 2004; Hoey et al., 2001), particularly for older adolescents who exhibit better A1C values with fewer worries about DM (Faulkner, 2003). As intensive insulin therapies have become more prominent for improving glucose control, QoL for teens has not been adversely affected by use of insulin pumps (McMahon et al., 2005; Mednick, Cogen, & Stresand, 2004; Valenzuela et al., 2006) or multiple injections per day (Wagner, Muller-Godeffroy, von Sengbusch, Hager, & Thyen, 2005).

Although QoL has been studied extensively over the past three decades, it remains a construct that is not easily defined or measured (Ferrans, 1990, 1996; Giannakopoulos et al., 2009). Scholars of QoL have studied various components of this variable as both subjective perceptions of general viewpoints of well-being in physical, psychological, and social domains (i.e., generic QoL) and as one's self-appraisal within a disease-related context of personal health (i.e., disease-specific QoL; Eiser & Morse, 2001; Faulkner, 2003; Hanberger et al., 2009; Ravens-Sieberer & Bullinger, 1998; Wallander, Schmitt, & Koot, 2001). Studies specifically targeting QoL for individuals managing a chronic health condition have narrowed the terminology to health-related quality of life (HRQoL).

Although numerous authors have proposed definitions of the concept of HRQoL, Wilson and Cleary (1995) were the first to link clinical variables to personal perception of HRQoL. Ferrans, Zerwic, Wilbur, & Larson (2005) further explicated these relationships by incorporating biological functions, symptoms, functional status, and general health perceptions as outcomes with increasing complexity and possessing causal associations with overall HRQoL. However, these authors suggested that reciprocal relationships may exist among these outcomes, which can be influenced by individual factors. For example, functional status may be measured as functional capacity such as aerobic capacity, also known as CV endurance or fitness, and relate both to overall HRQoL and to measures of biological function, such as lipid profile and glycemic control in individuals with DM. Thus, the notion of exploring the interrelationships of *individual* factors, such as physical activity, or fitness, with HRQoL, as well as with *biological* functions, reflected by glycemic control and lipid profiles was identified to further delineate overall health status in adolescents with type 1 or type 2 diabetes.

Purpose

The specific intent of this study was to describe the relationships between the current CV fitness (i.e., VO_{2peak}) levels of adolescents with type 1 or type 2 DM, as well as their self-reported physical activity expenditure over the past week, with generic or health-related QoL, glycemic control, and lipid profiles. We examined these relationships for the entire sample and separately for those with type 1 DM or type 2 DM. For the purposes of this paper, the term QoL is used to reflect more broad dimensions of personal well-being and competence, as well as DM-specific measures of QoL.

Design and Methods

This study is part of a larger, cross-sectional descriptive investigation addressing CV risks in adolescents with either type 1 or type 2 DM. The original investigation explored personal, behavioral, and sociodemographic factors that predispose youth with DM to the development of CV risks. The study inclusion and exclusion criteria, and data collection procedures have been published in detail previously (Faulkner et al., 2005). Therefore, only a summary of those measures described elsewhere is provided here.

Sample and Setting

Adolescents between 13 and 18 years of age with a primary diagnosis of either type 1 or type 2 DM who were receiving routine care at a large, university-based, metropolitan pediatric DM center in the Midwest were eligible to participate. Adolescents were required to have a diagnosis of DM for at least 1 year. This criterion allowed for control of the expected variations in blood glucose levels that can occur during the initial year after diagnosis, when insulin and other medication regimes require more frequent adjustments. To minimize inclusion of any adolescent who may have overt developmental delays or other limitations in cognitive or behavioral functioning, participants were required to be at or within 2 years of age-appropriate grade level in school.

Measures and Instruments

Cardiovascular Fitness—Cardiovascular fitness is the direct measure of maximal oxygen uptake during a participant's exercise of progressive intensity (i.e., VO_{2peak}) and the value is expressed relative to body weight (i.e., ml/Kg/min). The SensorMedics® VMAX29 cardiopulmonary metabolic cart and cycle ergometer (SensorMedics, Yorba Linda, CA) were used for exercise testing in this investigation. Each participant performed the McMaster cycle test (American College of Sports Medicine, 2000; Paridon et al., 2006) to measure VO_{2peak} . The McMaster cycle test is a recommended protocol for youth because it is based on the height of the adolescent and uses a gender-specific workload, with a total optimal exercise time to exhaustion of approximately 8 to 12 minutes. Resting systolic and diastolic blood pressure were recorded along with repeat measures every 2 minutes during exercise testing. Continuous electrocardiographic monitoring occurred throughout testing.

Physical Activity Recall—The Physical Activity Recall (PAR) is an interview devised to obtain information from the research participant regarding duration, frequency, and intensity of physical activity for the previous 7 days (Sallis, Buono, Roby, Micale, & Nelson, 1993). The instrument was designed for a short recall period for increased accuracy, to be simple to administer, and to be useful with both males and females. Validity in relation to direct observation and test-retest reliability for use of the PAR with children and adolescents has been demonstrated (Sallis et al., 1993; Sallis et al., 1985). Participants are asked to describe all activities they undertook and the number of hours of sleep they got during the previous 7 days. Examples of light, moderate, hard, and very hard activities are provided so that

participants can classify the types of physical activity in which they participated. Scores on the PAR are reported as average daily METS (metabolic equivalents). METS are multiples of resting metabolic rate. Resting metabolic rate equals approximately 1 kilocalorie per kilogram of weight per hour (kcal/Kg/hr). Thus, the total energy expenditure per day is derived from the intensity level of physical activities in combination with the frequency and duration of those activities (McArdle, Katch, & Katch, 2001).

Laboratory Assays—Glycosylated hemoglobin (A1C) is a standard measure of glycemic control over the previous 90 days (Little et al., 2001). For the current study, A1C was determined by using EDTA whole blood analysis with high performance liquid chromatography (BioRad Laboratories, Hercules, CA). Measurement of A1C was obtained at the time of data collection, and an average of values over the past year was also computed to reflect a longitudinal measure of glycemic control. The Beckman Synchron CX-7 Analyzer (Beckman-Coulter Instruments Corporation, Brea, CA, USA) was used to determine total cholesterol, triglycerides, and HDL-c. LDL-c was calculated using the Friedewald equation (Friedewald, Levy, & Fredrickson, 1972).

Diabetes Quality of Life for Youth—The disease-specific QoL measure was the Diabetes Quality of Life Measure for Youth (DQoL; Ingersoll & Marrero, 1991). This instrument is a modification of the Diabetes Quality of Life Instrument (Jacobson et al., 1988) developed for the Diabetes Control and Complications Trial (DCCT; DCCT Research Group, 1993). The revised instrument was composed of a 17-item *Diabetes Life Satisfaction* scale, a 23-item *Disease Impact* scale, and an 11-item *Disease-Related Worries* scale. A general single item self-rating of overall health was also included. Original Cronbach's alpha reliabilities for the subscales ranged from .82 to .85. For this study, reliability coefficients for the total sample ranged from .82 to .89, and from .77 to .91 for subgroups based on type of DM. Each item is scored on a scale of 1 to 5 (1 = never or very unsatisfied to 5 = all of the time or very satisfied). Subscale totals indicate levels of life satisfaction, impact, and worries about DM. Content validity was established by the independent review of a pediatric diabetologist, nurse practitioner, social worker, and educational psychologist, all of whom specialize in pediatric DM.

Self-Perception Profile for Adolescents—The generic QoL measure was the Self-Perception Profile for Adolescents (Harter, 1988). It measures judgments of competence or adequacy based upon the adolescent's personal perceptions and was used as a measure of generic QoL. The complete instrument consists of 45 items comprising 9 specific subscales and uses a structured alternative format whereby the adolescent must decide which kind of teenager is most like him or her, and then whether the item is sort of true or really true for him or her. For this study, only 3 subscales were used: *Athletic Competence*, *Scholastic Competence*, and *Global Self-Worth*. This instrument format presents four choices for the respondent and minimizes the tendency for socially desirable responses. Each item is scored from 1 (low competence) to 4 (high competence), using a numerical scoring key. The original Cronbach's alpha reliabilities of subscales ranged from .74 to .92. Factor analysis of four sample groups revealed that specific subscales defined their own factor (Harter, 1988). In this study, reliability coefficients for the total sample ranged from .72 to .82. For adolescents with type 1 versus type 2 DM, subscale coefficients ranged from .77 to .85 compared with a range of .56 to .76, respectively. For those with type 2 DM, the scholastic competence subscale coefficient was .56 and global self-worth was .65, both lower than .70, an acceptable measure of internal consistency (Devellis, 2003).

Procedures

Human subjects protection review and approval were conducted at the University of Illinois at Chicago, the location of the Clinical Research Center where data collection occurred, and at the University of Chicago, the location of subject recruitment. Parents provided study permission for their adolescents' participation and adolescents gave assent. The University of Arizona Institutional Review Board, where the principal investigator is now employed, also granted approval for continuing analysis and reporting of study findings.

Adolescents were scheduled for a morning appointment after an overnight fast of at least 10 hours. Standing height and weight were measured in centimeters and kilograms, respectively. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters. Gender and age-adjusted BMI (Kg/m^2) percentile was calculated using United States Centers for Disease Control syntax files (Centers for Disease Control, 2000). Tanner stage of sexual maturity was determined by a pediatric endocrinologist or nurse practitioner a few weeks before the day of data collection. Following fasting laboratory tests, adolescents were given a light breakfast and completed study questionnaires and the PAR interview. Exercise testing occurred approximately 1 hour after admission to the Clinical Research Center.

Data Analysis

All data were analyzed using SPSS Version 16.0 (SPSS, Inc., Chicago, IL). Descriptive statistics were used for demographic data and t-tests were used to detect differences in clinical data between adolescents with type 1 versus type 2 DM. Pearson Correlation Coefficients were used to examine associations between CV fitness or physical activity expenditure with the outcome variables of A1C, lipids, DM-related or generic QoL for the total sample and for each subgroup, those with type 1 or type 2 DM.

Results

A convenience sample of 151 adolescents with diabetes participated (109 type 1 DM; 42 type 2 DM). Table 1 presents the gender, race, age, onset age, duration of DM, and Tanner stage and clinical findings for the two groups. The racial mix for each group is reflective of epidemiological data for childhood diabetes (Dabelea et al., 2007). Consistent with the typical age of onset, which is commonly higher for those with type 2, a similar pattern emerged with the data presented here. Thus, the duration of DM was significantly less for those with type 2. Although the median Tanner stage was the same for the groups, a significant difference occurred since 52% of the adolescents with type 1 had a Tanner stage 5, whereas 71% of those with type 2 had a Tanner stage 5.

Body mass index and the gender and age-adjusted BMI percentile for adolescents with type 2 were significantly greater than for those with type 1, reflective of the more characteristic overweight noted with the former group. Systolic and diastolic blood pressure and triglycerides were significantly higher in those with type 2; whereas, HDL-c, CV fitness, and physical activity expenditure (METs) were significantly lower than for those with type 1. The mean values of HDL-c, triglycerides, and blood pressure for adolescents with type 2 would not be considered abnormal using normative data (Falkner, Gidding, Portman, & Rosner, 2008; Maahs et al., 2008; McCrindle, 2010); however, the standard deviation of these measures reveal a number of subjects who did have elevated lipids and systolic and diastolic blood pressure. There were no significant differences in recent or average A1C levels between the groups. Although the A1C values for both groups were higher than ADA recommendations for glucose control in adolescents, the values are within the ranges reported for pediatric diabetes centers (de Beaufort et al., 2007).

In terms of DM-related or generic QoL, adolescents did not differ significantly depending on their type of DM. Only the global measure of health perception was lower for those with type 2 (3.10 ± 0.72 vs. 2.58 ± 0.84 , $t = 3.50$, $df = 61.0$, $p = .001$). Table 2 presents the correlations among CV fitness with lipids and A1C for the total sample and for each group. Although the total sample had significant associations between CV fitness and lower LDL-c, triglycerides, and average A1C, those with type 1 DM specifically, but not type 2 DM, exhibited significant lowering of total cholesterol, LDL-c, triglycerides and both recent and average A1C values. No significant associations between physical activity expenditure with lipids and A1C were found (See Table 3).

Table 4 and Table 5 present the significant associations between CV fitness and physical activity expenditure with DM-related and generic QoL. The total sample and specifically those with type 1 revealed more positive perceptions of personal health and athletic competence when adolescents were more physically fit. Physical activity expenditure was also positively associated with health perception for those with type 1. The total sample, and again those with type 1, had better views of scholastic competence and global self-worth when they were more physically active.

Discussion

This investigation is the first to explore possible associations among the *objective* measure of physical fitness or the *subjective* measure of self-reported physical activity expenditure with either biological or QoL outcomes in adolescents with diabetes. Findings of this study indicate that for adolescents with type 1 DM, being more physically fit can lead to better overall glucose control and a reduction in serum lipids. These associations are consistent with earlier reports of the benefits of exercise for adolescents with type 1 (Faulkner et al., 2010; Heyman et al., 2007; Rachmiel et al., 2007). Although these same findings were not supported by associations with subjective measures of self-reported physical activity expenditure, positive views of health, academic performance, and self-esteem were noted for those with type 1 when they were more physically active. Being more physically fit had the added benefit of positive health perception and believing they could excel athletically. The lack of associations between physical activity expenditure and glucose control or lipids may be related to the limitation of using subjective recall for physical activity over a 1-week time period that is possibly not the most valid measure for comparison with biological outcomes, reflective of the past 2 to 3 months.

For adolescents with type 2, the lack of significant associations between CV fitness and physical activity expenditure with glucose control, lipids, or DM-related and generic QoL measures was not expected. Possible explanations for these findings relate to the smaller sample size and the lower reliability coefficients for the Self-Perception Profile subscales of *Scholastic Competence* and *Global Self-worth*, all factors limiting the power to detect significance. Although the Self-Perception Profile was normed with ethnically diverse samples when first developed, further testing with minority populations in different geographical areas may be necessary.

Considering the smaller sample size for adolescents with type 2 DM, one may ponder the reason for fewer subjects who participated in the study given the attention on pediatric obesity and growing numbers being diagnosed with type 2. As indicated by the prevalence data for pediatric DM discussed in the opening paragraph, this study is representative of typical clinical populations seen in pediatric DM clinics. The review of relevant research evidence on which to base practice decisions for promoting physical activity for adolescents with type 2 demonstrates a major gap in knowledge. This gap is likely due to challenges in accurate diagnosis and recruitment of youth with type 2 DM because many may remain

undiagnosed since they often do not exhibit the classic symptoms of polyuria, polyphagia, and polydipsia seen with type 1 DM.

How Do I Apply This Evidence to Nursing Practice?

The highest level of research evidence is derived from well-designed, randomized clinical trials (Bajard, Chabaud, Perol, Boissel, & Nony, 2009). However, nurses are frequently faced with making decisions on the best available evidence, which may be descriptive inquiry or clinical case presentations. This study supports moderate associations between fitness levels and better metabolic health, reflected by lipid profiles and glucose control, as well as health perception for adolescents with type 1 DM. Adolescents who were more physically active also identified themselves as having good to excellent health, and exhibiting greater academic abilities and overall self-worth, all measures of generic QoL.

Although no associations between fitness and physical activity were found with adolescents who had type 2 DM, several clinical findings offer insight into target areas for primary care assessment and intervention. These include the routine evaluation of HDL-c, triglycerides, blood pressure, and activity levels for adolescents with type 2 who tend to have elevated BMI and obesity. Current evidence exists for engaging these adolescents in moderate to vigorous physical activity, along with dietary and cognitive-behavioral approaches (Barton, 2010). The *Physical Activity Guidelines for Americans* (U.S. Department of Health and Human Services, 2008) and the *Exercise in Medicine™* initiative of the American College of Sports Medicine (2010) emphasize at least 60 minutes of moderate to vigorous activity on most days for adolescents. Nurses practicing in primary care clinics, schools, pediatric endocrine clinics, and hospitals are key advocates for identifying strategies for motivating teens with either type 1 or type 2 DM to be more physically active and for adding exercise into treatment regimes for optimal metabolic and QoL outcomes.

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Table 1

Demographic and Clinical Characteristics of the Sample

	Type 1 Diabetes (<i>n</i> = 109)	Type 2 Diabetes (<i>n</i> = 42)	t value	df	<i>p</i>
Males	60 (55)	19 (45)			
African American	13 (22)	12 (27)			
Hispanic	2 (3)	7 (37)			
Caucasian	45 (75)	0			
Asian	0	0			
Females	49 (45)	23 (55)			
African American	17 (35)	18 (78)			
Hispanic	4 (8)	4 (17)			
Caucasian	28 (57)	0			
Asian	0	1 (4)			
Mean Age (<i>SD</i>) – yrs.	15.29 ± 1.87	15.86 ± 1.82			
Mean Onset Age (<i>SD</i>) yrs. **	9.11 ± 3.39	13.49 ± 2.25			
Mean Duration (<i>SD</i>) yrs. **	6.18 ± 3.69	2.40 ± 2.02			
Median Tanner Stage *	5	5			
BMI (kg/M ²) **	23.3 ± 4.0	33.7 ± 9.0	-7.18	47.4	.001
BMI Percentile **	.72 ± .23	.96 ± 0.06	-9.83	134.7	.001
Systolic BP at rest (mmHg) *	114 ± 11	118 ± 12	-2.15	139	.034
Diastolic BP at rest (mmHg) *	65 ± 9	69 ± 9	-2.34	139	.021
Total Cholesterol (mg/dl)	167 ± 31	170 ± 41	-.452	60.2	.653
LDL-c (mg/dl)	102 ± 25	104 ± 34	-.333	56.9	.740
HDL-c (mg/dl) **	52 ± 12	43 ± 15	4.133	148	.001
Triglycerides (mg/dl) **	60 ± 40	110 ± 79	-3.881	47.9	.001
Recent A1C (%)	8.7 ± 1.6	8.5 ± 2.5	.479	51.2	.634
Average A1C (%)	8.9 ± 1.7	8.5 ± 2.5	.810	41.7	.422
V _{O₂Peak} (ml/kg/min) **	34.7 ± 8.9	25.4 ± 5.9	6.979	88.6	.001
Physical activity (METS) *	34.9 ± 3.5	33.7 ± 1.6	2.854	145.7	.005

Note: Data are presented as means ± *SD* or *n* (%) for each group.

100' > d
**
50' > d
*

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Table 2

Relationships of Cardiovascular Fitness with Lipids and A1C

<u>VO_{2Peak} (ml/kg/min)</u>	<u>Total Cholesterol</u>	<u>LDL-c</u>	<u>HDL-c</u>	<u>Triglycerides</u>	<u>Recent A1C</u>	<u>Average A1C</u>
<i>Total sample</i>	-.165	-.178*	.158	-.303**	-.133	-.233**
<i>Type 1</i>	-.256**	-.242*	.018	-.295**	-.306**	-.420**
<i>Type 2</i>	.122	-.074	.048	.125	.190	.164

*
 $p < .05$ **
 $p < .001$

Table 3

Relationships of Physical Activity Expenditure with Lipids and A1C

	<u>Total Cholesterol</u>	<u>LDL-c</u>	<u>HDL-c</u>	<u>Triglycerides</u>	<u>Recent A1C</u>	<u>Average A1C</u>
Physical Activity Expenditure (METs/day)						
<i>Total sample</i>	-.110	-.075	.001	-.122	-.035	-.041
<i>Type 1</i>	-.110	-.092	.008	.088	-.065	.073
<i>Type 2</i>	-.131	-.015	.093	-.053	.006	-.025

Table 4

Relationships of Cardiovascular Fitness with Diabetes-Related & Generic QoL

	<u>Health</u>	<u>Worries</u>	<u>Impact</u>	<u>Life Satisfaction</u>	<u>Athletic Comp</u>	<u>Scholastic Comp</u>	<u>Global Self-Worth</u>
VO _{2Peak} (ml/kg/min)							
<i>Total sample</i>	.281**	-.058	-.114	.122	.178*	-.036	.101
<i>Type 1</i>	.223*	-.060	-.153	.127	.204*	-.084	.136
<i>Type 2</i>	.099	-.015	-.059	-.121	-.059	-.144	-.042

Note: QoL = Quality of Life, Comp = Competence

*
 $p < .05$

**
 $p < .001$

Table 5
Relationships of Physical Activity Expenditure with Diabetes-Related & Generic QoL

	<u>Health</u>	<u>Worries</u>	<u>Impact</u>	<u>Life Satisfaction</u>	<u>Athletic Comp</u>	<u>Scholastic Comp</u>	<u>Global Self-Worth</u>
Physical Activity Expenditure (METs/day)							
<i>Total sample</i>	.130	-.087	-.112	.158	.144	.191*	.180*
<i>Type 1</i>	.227*	-.070	-.160	.131	.142	.219*	.195*
<i>Type 2</i>	.099	.011	-.032	-.135	.169	-.067	.099

Note: QoL = Quality of Life, Comp = Competence

*
 $p < .05$