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Physical Activity and Sedentary Behavior in Adolescents With Type 1 Diabetes

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Abstract

The purpose of this study was to describe the associations between levels of physical activity measured by accelerometry and changes in fitness, body composition, lipids, and glucose control (i.e., glycosolated hemoglobin [A1C]) in a sample of 16 adolescents with type 1 diabetes participating in a personalized exercise program. More sedentary activity was associated with lower fitness and fat free mass and increased total cholesterol, low-density lipoprotein (LDL-c), and triglycerides ($p < .05$). Greater amounts of moderate to vigorous activity were associated with higher fitness and fat free mass, and decreased total cholesterol, LDL-c, triglycerides, and A1C ($p < .05$). Findings support the beneficial effects of increased moderate activity and decreased sedentary behavior to reduce cardiovascular risks and improve glucose control in adolescents with type 1 diabetes.

Keywords

type 1 diabetes; youth; exercise; sedentary; blood lipids; fitness

Regular physical activity is one of the most important regimens individuals can engage in to improve their overall health. Current physical activity guidelines advise youth to accumulate a minimum of 60 minutes of moderate physical activity on all days of the week (U.S. Department of Health and Human Services [DHHS], 2008). However, despite a compelling body of literature on the importance of promoting physical activity in youth, particularly for those with type 1 diabetes (Campaigne, Gilliam, Spencer, Lampman, & Schork, 1984; Michaliszyn, Shaibi, Quinn, Fritschi, & Faulkner, 2009; Ramalho et al., 2006), current research indicates that most adolescents lead sedentary lifestyles. Accelerometry data for youth from the National Health and Nutrition Examination Survey (NHANES) 2003–2004 showed remarkably high levels of sedentary behavior paralleled by low levels of moderate to vigorous physical activity (MVPA; Troiano et al., 2008; Whitt-Glover et al., 2009). In fact, only 8% of adolescents achieved the recommended level of 60 minutes/day.

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Furthermore, self-reports for attaining 60 minutes of MVPA per day have indicated significantly lower frequencies in youth with type 1 diabetes when compared to healthy controls (2.8 ± 2.5 vs. 3.6 ± 1.9 days, respectively, $p < .001$; Valerio et al., 2007).

In an effort to improve MVPA among youth with type 1 diabetes, we developed a 16-week personalized, community-based exercise program in which teens were asked to wear an accelerometer for the 16-week exercise duration to track levels of physical activity frequency, duration, and intensity (Faulkner, Michaliszyn, & Hepworth, 2010). Our personalized, community-based approach allowed teens to design their own exercise program in conjunction with an exercise physiologist. Other exercise interventions in youth with and without type 1 diabetes have included supervised activity programs ranging from weeks to months and have focused specifically on improving MVPA (Campaigne et al., 1984; Ramalho et al., 2006; Sideraviciute, Gailiuniene, Visagurskiene, & Vizbaraite, 2006); however, recent evidence suggests that focusing just on MVPA may not be enough to decrease cardiovascular (CV) risks (American Diabetes Association, 2010; Helmerhorst, Wijndaele, Brage, Wareham, & Ekelund, 2009; Martinez-Gomez, Tucker, Heelan, Welk, & Eisenmann, 2009). Focusing on simultaneously decreasing levels of sedentary activity is warranted, as high amounts of sedentary behavior have been linked to increases in adiposity and hypertension in youth without type 1 diabetes (Martinez-Gomez et al., 2009; Pratt et al., 2008; Treuth et al., 2009) and with poor glycemic control in those with diabetes (Aman et al., 2009).

The development of CV risk already has been observed in youth with type 1 diabetes (Kershnar et al., 2006), and CV risk remains the major contributor to morbidity and mortality in adults with type 1 diabetes (Soedamah-Muthu et al., 2006). Over 48% of youth with type 1 diabetes have low-density lipoprotein (LDL-c) levels over the recommended threshold of 100 mg/dL (Kershnar et al., 2006). The risk for CV disease in youth with type 1 diabetes may be further accentuated by the growing prevalence of overweight in this population. In a recent study, youth with type 1 diabetes versus healthy controls were significantly more overweight (24% vs. 10%, respectively, $p < .001$), and this finding was observed across all age groups and in both genders (Sandhu et al., 2008). Carrying the burden of excess weight and type 1 diabetes may have both medical and psychological consequences (e.g., low self esteem) for youth. Thus, reducing risk factors associated with CV disease is imperative for the health and quality of life of youth diagnosed with diabetes.

To our knowledge, longitudinal data on varying levels of daily physical activity have not been examined in youth with type 1 diabetes, a population with known vulnerabilities for future CV disease. Therefore, the purpose of this pilot study was to describe the amount of time spent by adolescents with type 1 diabetes in various levels of activity while engaged in a 16-week exercise program. We also determined associations between amounts of activity at various intensities and changes in known CV risk factors (i.e., fitness, body composition, lipid profile, and glycosylated hemoglobin).

The research questions were:

1. How much time do youth with type 1 diabetes spend participating in sedentary, light, moderate, vigorous, or a combination of moderate and vigorous activity (MVPA)?
2. What are the differences in these activity levels between males versus females?
3. How do the different levels of physical activity independently relate to CV risks?

METHODS

Sampling

This study was part of a larger investigation examining personalized exercise in adolescents with diabetes. A detailed explanation of the conceptual framework, intervention, and methods has been published elsewhere (Faulkner et al., 2010). Briefly, the personalized exercise program (PEP) intervention is based on an integration of social cognitive theory (Bandura, 2001), family systems theory (Broderick, 1993), and an individualized exercise plan for each adolescent. Previous research findings indicate that participation in physical activity is far more likely when there is a prescriptive program individualized to the specific needs of each person (Albright et al., 2000; Elley, Kerse, Arroll, & Robinson, 2003). According to social cognitive theory, intentional behaviors of adolescents are affected not only by personal choices and self-efficacy, but also by proxy, for example, by enlisting parental assistance to produce desired results. In families with an adolescent member who has diabetes, the daily regimen of glucose control through medication adherence, dietary choices, and exercise necessitates planning, organization, and dedication to a healthy lifestyle. Parental modeling to promote maturity assists in youth competency in interpersonal skills and healthy behaviors. The PEP framework focuses on the parent–adolescent dyad within the family as a point of intervention. It encourages developmentally appropriate transitions in the parent–adolescent family hierarchy for assuming responsibility for engaging in healthy behaviors. To guide the development of realistic goals specifically designed for each adolescent, the PEP framework incorporates individual characteristics (i.e., diagnosis with diabetes, current activity, and fitness level), behavior-specific cognitions (i.e., preferences to exercise, exercise self-efficacy), and family and community resources as necessary components in planning each PEP.

Adolescents with type 1 diabetes between the ages of 12 and 17 were recruited from a Pediatric Diabetes Clinic in the Southwestern United States. The University Institutional Review Committee approved the study, and both parental consent and child assent were obtained. Adolescents were required to have been diagnosed with type 1 diabetes for a minimum of 1 year to be included. Recruitment also included at least one parent (guardian) or family member willing to engage in physical activity (~30 minutes per day, 5 days per week). Adolescents were excluded if they had developed diabetes as a secondary condition; had a known cardiac abnormality; if their grade level was more than 2 years below age appropriateness; or if they were pregnant at the time of screening (confirmed via urine testing).

The Seven Day Physical Activity Recall (PAR), a valid and reliable self-report measure for adolescents (Sallis, Buono, Roby, Micale, & Nelson, 1993), was used to assure enrollment of adolescents not actively engaging in regular physical activity. The Seven Day Physical Activity Recall was administered in a 15- to 20-minute interview to determine the adolescent's duration, frequency, and intensity of moderate or vigorous physical activity over the 7 days preceding enrollment. Energy expenditure, calculated as metabolic equivalents (METS), was calculated using the intensity, frequency, and duration of a minimum of 10 minutes of moderate or vigorous physical activity per day. A METS value <36 was used to determine activity below current recommendations of 60 minutes of MVPA/day for youth who were included and to exclude those who were already physically active (DHHS, 2008). Baseline data obtained from the Seven Day Physical Activity Recall revealed adolescents had accumulated an average of only 9.2 ± 10.7 minutes per day of MVPA the week preceding enrollment.

Participants

For this pilot study, the sample consisted of 16 adolescents with a mean age of 14.4 ± 1.6 years and diabetes duration of 5.6 ± 3.1 years. There were 10 males (2 Hispanic; 8 Non-Hispanic white) and 6 females (3 Hispanic; 3 Non-Hispanic white). Using the PASS© program (Hintze, 2008), an estimated sample size of 20 with alpha of .05 was projected to provide 76% power to detect a difference between a null hypothesis correlation of .00 and an alternative hypothesis correlation of .50. As this was a preliminary analysis, we considered our sample adequate.

The participants mean glycosolated hemoglobin (A1C) was slightly higher (9.2 ± 1.7%) than values commonly reported in youth with type 1 diabetes (Aman et al., 2009; de Beaufort et al., 2007; Vanelli, Chiarelli, Chiari, & Tumini, 2003), although international investigations report substantial variations in A1C (range 7.4–9.2%) between diabetes centers (de Beaufort et al., 2007). Participants reported that they were healthy, and baseline blood lipid profiles and mean gender and age-adjusted BMI percentiles were within normal range (Table 1). Males were taller and had higher relative measures of VO_{2peak} and percent fat free mass, whereas females had higher percent body fat, as expected. No other significant sex differences were observed.

Measures

Procedures—All baseline and follow-up clinical measurements were conducted in the Research Suite of the College of Nursing. Participants arrived for their appointment following an overnight fast. Laboratory assays via finger-stick were completed, a light breakfast was served, and cardiovascular fitness (i.e., VO_{2peak}), and body composition were assessed. Standing height and weight were determined to the nearest centimeter and kilogram, respectively. Replicate height (within ± 1.0 cm) and weight (within ± .5 kg) were accepted, and repeat trials were conducted if necessary to meet this standard. Averages of the two closest measures were used. Weight was measured using a balance beam scale with stadiometer (Seca model 700, Seca, Hamburg, Germany). Body mass index was calculated as weight in kilograms divided by the square of height in meters. Gender and age-adjusted BMI percentile was then calculated based upon syntax files provided by the United States Centers for Disease Control (http://www.cdc.gov/nchs/about/major/nhanes/growthcharts/datafiles.htm).

Laboratory assays—A1C was determined using the DCA2000® assay method for quantitative measurement of whole blood (Bayer HealthCare LLC©, Elkart, IN). Total cholesterol, LDL-c, high-density lipoprotein (HDL-c), and triglyceride levels were assessed via a clinical Cardio-Check P·A analyzer (Polymer Technology Systems, Indianapolis, IN).

Cardiovascular fitness—Cardiovascular fitness (VO_{2peak}) was determined using graded exercise testing on a cycle ergometer (Ergoselect 100®, Ergoline, Bitz, Germany). After a 2-minute warm-up, the McMaster protocol was administered. The McMaster protocol uses 2-minute stages at predetermined work rates based on sex and height. The test is complete when the participant is no longer capable at pedaling at 60 rpm, despite encouragement. Expired gases were collected and analyzed using a Viasys Oxycon Pro metabolic cart (Jaeger-Viasys Healthcare, Hoechberg, Germany). Calibration was performed each day before testing, and VO_{2peak} was determined by averaging the last 15 seconds of oxygen consumption obtained with a respiratory exchange ratio above 1.0.

Body composition—Body composition (i.e., percent total body fat, fat mass [FM], and fat free mass [FFM]) was assessed using bioelectrical impedance analyses (BIA). The BIA measurements were performed using the RJL Quantum X Body Composition Analyzer (RJL Systems, Clinton Township, MI). Participants were in the supine position and instructed to lie with their arms at 30° from the body and legs not touching one another. Two electrodes were placed on the dorsal surface of the right hand and two on the dorsal surface of the right foot. Resistance and reactance values were recorded to the nearest tenth. All calibration and measurement procedures were performed as indicated in the manufacturer's operation manual.

Personalized exercise prescription—Adolescents and participating family members received a review of nutrition and physical activity safety prior to beginning the exercise intervention. The exercise intervention consisted of individually prescribed aerobic exercises (between 60% and 75% peak heart rate) that accumulated up to 60 minutes per day 5 days per week. All exercises took place in a home or community setting and varied from teen to teen (e.g., kickboxing, Dance Dance Revolution [Konami, Japan], walking). Equipment support and community resources (dance videos and gym memberships) were provided to participants if needed. Teens were allowed to divide the 60 minutes into smaller exercise bouts with a minimum goal of 10 minutes each.

Time spent in daily physical activity—Adolescents were instructed to wear an Actigraph Accelerometer (model GT1M, Pensacola, FL) located on the right hip during waking hours for the 16-week intervention to obtain physical activity measurements. The Actigraph GT1M is a valid and reliable estimate of daily physical activity in youth (Welk, Schaben, & Morrow, 2004). Epoch duration was set for 60 seconds, and data were downloaded approximately every 2 weeks. Raw accelerometer counts per epoch were used to determine age specific energy expenditure, expressed in METS, which were calculated using a prediction equation for youth developed by Freedson, Pober, and Janz, (2005).

The U.S. Department of Health and Human Services (DHHS, 2008) stated that "most of the 60 or more minutes a day should be *either* moderate or vigorous-intensity aerobic physical activity" (p. 16). To date, data are nonexistent for associations between independent intensity levels and health outcomes in youth with type 1 diabetes. To determine these associations, time spent in daily physical activity over the 16-week exercise period was grouped and averaged into five categories: sedentary (<2.0 METS), light (≥ 2.0 to <3.0 METS), moderate (≥ 3.0 to 5.99 METS), vigorous (≥ 6.0 METS), and the combined categories of both moderate and vigorous activity referred to as MVPA (≥ 3.0 METS). The total time spent in each category was calculated as the sum of minutes spent in each category per day divided by total minutes the accelerometer was worn per day, and expressed as a percentage of time.

Statistical Analyses

Statistical analyses were performed using SPSS 14.0 (Chicago, IL) using $\alpha < .05$. All data are expressed as mean ± *SD*. Descriptive statistics were used for variables examined in research question 1. Research question 2 was addressed using Student's *t*-tests to determine sex differences in time spent in varying physical activity intensities per day. Research question 3 was addressed using Pearson correlation coefficients to determine the associations among time spent in differing intensities of daily physical activity and the percent change in body composition, VO_{2peak}, blood lipid profile and A1C from baseline to completion of the exercise intervention.

RESULTS

Average Time Spent in Differing Intensities

Overall, youth wore the accelerometer for a total of 74.3 ± 30.7 days with 55.9 ± 32.5 days ≥ 10 hours. Average wear time was 12.0 ± 2.1 hours/day. Table 2 depicts average time spent in differing intensities throughout the exercise intervention. Based upon the average accelerometer wear time, youth spent 10 hours of the time in sedentary activities and only 1.3 hours in light activity, 39 minutes in moderate activity, 2.7 minutes in vigorous activity and 42 minutes in the combined measure of MVPA.

Associations Between Daily Physical Activity and Outcome Variables

All associations between times spent in daily activity with percent changes in body composition, VO_{2peak}, lipid profile, and A1C are presented in Table 3. Times spent in moderate, vigorous, and MVPA were positively associated with increases in fat free mass ($p \leq .01$), whereas time spent in sedentary activity was associated with decreases in fat free mass ($p = .04$). Increased VO_{2peak} was associated with more moderate physical activity and MVPA ($p = .02$) and less sedentary behavior ($p = .03$).

Time spent in sedentary activity was associated with increases in total cholesterol, LDL-c, HDL-c, and triglycerides ($p < .05$). Times spent in light, moderate, and MVPA were associated with decreases in total cholesterol, LDL-c, triglycerides, and A1C ($p < .05$). Moderate and MVPA were associated with decreases in HDL-c ($p = .05$). In summary, youth who engaged in the least amount of sedentary activity and in more MVPA throughout the day showed more positive changes in fat free mass and VO_{2peak}, and greater reductions in total cholesterol, LDL-c, triglycerides, and A1C, but unexpectedly, a decrease in HDL-c.

DISCUSSION AND CONCLUSIONS

Prior research findings indicate that high amounts of sedentary behavior increase CV risk, whereas MVPA decreases CV risk (Aman et al., 2009; Martinez-Gomez et al., 2009; Pratt et al., 2008; Treuth et al., 2009). Most investigators conducting exercise interventions have focused specifically on improving MVPA, but MVPA unaccompanied by decreases in sedentary activity may not be efficacious in improving CV risks alone. Therefore, in youth currently engaged in our ongoing 16-week exercise program we examined the amount of time spent during various levels of activity. The main finding was that adolescents with type 1 diabetes who participated in a 16-week aerobic exercise program spent approximately 80% of the recorded accelerometer time quite sedentary while engaging in only 42 minutes in MVPA per day.

We anticipated that individuals actively participating in an intervention focused on increasing levels of MVPA would have lower levels of sedentary activity. However, the findings suggest that sedentary activity and MVPA may not be in opposition. Our results support that an individual can spend the majority of the day engaged in sedentary behavior but still achieve moderate amounts of MVPA. Compared to youth without diabetes of a similar age range, our sample engaged in slightly greater amounts of sedentary activity: Whitt-Glover et al. (2009; 10 hours vs. 8.3 hours/day) and Treuth et al. (2009; 10 hours vs. 8.5 hours/day). This difference in results may be attributed to the amount of time the accelerometer was worn. Our participants were instructed to wear the accelerometer daily for a total of 16 weeks, whereas Whitt-Glover et al. and Trueth et al. required less than 7 days. A longitudinal time frame may be more representative of a participant's true level of activity because it diminishes the initial effects of wearing a device that may directly influence them to be more active, merely because they are being studied.

Cross-sectional investigations document a high prevalence for sedentary activity among female youth compared to males (Martinez-Gomez et al., 2009; Treuth et al., 2009; Whitt-Glover et al., 2009). In our longitudinal study we did not find a sex difference in sedentary activity, but did find that females participated in significantly greater amounts of *light* activity compared to males, which may relate to less time in behaviors such as watching television and computer usage and more time spent doing indoor chores.

One limitation to our study is that we did not collect levels of physical activity using accelerometry prior to initiating the intervention, and thus were unable to make comparisons between baseline physical activity levels and levels obtained during the 16-week intervention. However, using the baseline Physical Activity Recall we were able to evaluate the effects of the intervention on increasing MVPA. Youth engaged in significantly more MVPA during the intervention compared to self-reported levels of physical activity obtained during baseline screening (42.0 ± 19.9 minutes/day vs. 9.2 ± 10.7 minutes/day, respectively, $p = .001$). However, these results should be interpreted cautiously because the correlation between self-report instruments and accelerometry data among youth is low (Slootmaker, Schuit, Chinapaw, Seidell, & van Mechelen, 2009).

Our research addressed associations among time spent per day in differing intensities of daily physical activity and changes in health outcomes. The main finding was that those who spent more time being at least moderately active had the greatest decreases in total cholesterol, LDL-c, and triglycerides. This is encouraging, as diabetes is a known CV risk with established linkages to abnormal lipid concentrations and the prevalence rates for elevated lipoprotein levels among youth with type 1 diabetes have increased in recent years (Kershnar et al., 2006). Although the cause of abnormal lipoprotein levels is multifactorial, our investigation is the first to our knowledge to report that youth who engaged in higher amounts of sedentary activity displayed increases in total cholesterol, LDL-c, and triglycerides, whereas increased time spent in light, moderate, and total MVPA was associated with decreases in total cholesterol, LDL-c, and triglycerides. Results of previous studies of the effects of physical activity on lipoprotein levels among adolescents without type 1 diabetes have been inconclusive (Kelly et al., 2004; Suter & Hawes, 1993). However, in youth with type 1 diabetes, physical fitness (i.e., VO_{2peak}) rather than physical activity, has been associated with lower total cholesterol, LDL-c, and triglycerides (Michaliszyn et al., 2009).

We also observed a negative association between higher moderate physical activity and decreases in HDL-c. The decline in HDL-c was counterintuitive. In contrast to our findings, Suter and Hawes (1993) reported a significant positive association between HDL-c and level of physical activity in adolescents without diabetes. The difference in our study results may be related to a combination of factors: (a) the use of a more objective measure of physical activity to assess levels of physical activity during the intervention, (b) a greater male to female ratio, and (c) a smaller sample size. Suter and Hawes determined levels of physical activity using self-report. Adolescents frequently report higher levels of MVPA than what is collected objectively using accelerometry (Slootmaker et al., 2009). Furthermore, in the study by Suter and Hawes, the sample was larger and there was a higher proportion of females to males (N = 97; 58 females, 39 males). Upon pubertal development females tend to have higher HDL-c concentrations compared to males (Hickman et al., 1998), which is consistent with our current findings (46.8 ± 13.2 mg/dL vs. 42.7 ± 8.6 mg/dL for females vs. males), and may have contributed to the significant positive association with MVPA reported by Suter and Hawes.

We also report decreases in A1C with time spent in moderate and MVPA suggesting that both the amount and intensity of physical activity affect improvement in glucose control. These results are in agreement with previous exercise interventions in youth with type 1 diabetes that resulted in better glucose control (Campaigne et al., 1984; Sideraviciute et al., 2006). Although an investigation of a 1-week exercise program by Huttenen et al. (1989) did not find a positive effect on glucose control, the investigators did find that when adolescents in the exercise group were stratified by increasing amounts of physical activity performed, A1C was significantly lower.

There are a number of limitations and strengths that should be considered when interpreting the results of this study and planning future investigations. First, our outcomes are representative of adolescents who had poor glycemic control (A1C = 9.2 ± 1.7%) at the inception of the program and were all recruited from the same pediatric diabetes clinic.

Although convenience versus random sampling is characteristic of almost all exercise interventions, it limits the generalizability of findings. Second, the small sample size of 16 reduces statistical power; however, our significant correlations between the different levels of physical activity and the outcome variables minimize this limitation. Third, accelerometry is an objective measure used to determine the time spent in various intensities of activity, but involves both strengths and weaknesses. The technology used with accelerometry allows investigators to assemble all forms of activity into sedentary, light, moderate, or vigorous intensity and is very useful in determining total amount of activity. However, accelerometry does not record what types of behaviors are occurring during those intensities. Lastly, the strength of our personalized, community-based exercise intervention was that each participant’s specific program was designed based upon individual preferences and fitness level. The few exercise interventions previously conducted with youth diagnosed with type 1 diabetes also included small samples (*N* = 9–14), and determined efficacy, but were not personalized (Campaigne et al., 1984; Dahl-Jorgensen, Meen, Hanssen, & Aagenaes, 1980; Landt, Campaigne, James, & Sperling, 1985; Ramalho et al., 2006). We examined both adherence and efficacy, showing that a personalized exercise intervention elicited at least 42 minutes of MVPA per day and also improved overall metabolic control (i.e., blood lipids and A1C).

SUMMARY

Adolescents with type 1 diabetes undergoing a 16-week PEP spent approximately 84% of the recorded daily activity engaged in sedentary activities. Adolescents who engaged in high sedentary behavior experienced greater increases in total cholesterol, LDL-c, and triglycerides, whereas those who participated in more MVPA experienced decreases in overall lipoprotein and A1C levels. Future research should focus on exercise interventions that have the goal of achieving the recommendation of at least 60 minutes of MVPA per day in combination with less sedentary activity, including conquering barriers for attaining these goals, in order to optimize reductions in cardiovascular risks among adolescents with type 1 diabetes. Future research on the determinants for developing and sustaining increased levels of MVPA as well as reducing sedentary behaviors is also warranted in order to develop effective intervention strategies that are integral to diabetes self-management education for these adolescents.

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Table 1

Participant Characteristics at Baseline

	All (N = 16)		Females (N = 6)		Males (N =10)				
	M	***SD***	***M***	***SD***	***M***	***SD***	***t***	**df**	***p***
Height (cm)	166.2	7.0	160.6	3.8	169.5	6.3	1.424	14	.01
Weight (kg)	61.8	11.7	56.4	7.7	65.0	12.7	3.096	14	.16
BMI percentile	67.9	28.2	72.6	17.7	65.0	33.5	−.509	14	.62
VO_{2peak} (mL/kg/minute)	33.8	6.9	28.9	6.7	36.8	5.4	2.594	14	.02
Total cholesterol (mg/dL)	165.4	36.2	181.5	31.5	155.7	36.8	−1.427	14	.18
Low-density lipoprotein (mg/dL)	104.7	27.7	112.9	21.2	99.8	30.9	−.911	14	.38
High-density lipoprotein (mg/dL)	44.3	10.3	46.8	13.2	42.7	8.6	−.766	14	.46
Triglycerides (mg/dl)	81.7	51.6	109.8	71.8	64.8	26.8	−1.475	5.8	.19
A1C (%)	9.2	1.7	9.4	2.2	9.0	1.4	−1.816	14	.67
Body fat (%)	24.5	9.0	30.7	4.9	20.8	9.0	−2.476	14	.03
Fat free mass (%)	75.5	9.0	69.3	4.9	79.2	9.0	2.476	14	.03
Fat mass (kg)	15.5	7.7	17.6	5.1	14.3	9.0	−.825	14	.42
Fat free mass (kg)	45.9	8.4	38.0	3.7	50.7	6.6	4.279	14	.01

VO_{2peak} = cardiovascular fitness; A1C = glycosylated hemoglobin.

Table 2

Time Spent in Daily Activity

	Percent Time					Minutes				
	Mean	***SD***	***t***	**df**	***p***	**Mean**	***SD***	***t***	**df**	***p***
Sedentary time										
All	83.5	7.5				599.6	130.0			
Males	86.0	5.7				598.9	98.7			
Females	79.2	8.7	1.902	14	.08	601.0	181.4	−.026	6.8	.98
Light time										
All	10.8	5.3				80.4	37.8			
Males	8.5	3.5				64.1	28.9			
Females	14.7	5.8	−2.658	14	.02	107.6	37.1	−2.624	14	.02
Moderate time										
All	5.2	2.5				39.3	18.5			
Males	4.9	2.5				38.0	18.9			
Females	5.8	2.8	−.615	14	.55	41.4	19.4	−.345	14	.74
Vigorous time										
All	.4	.3				2.7	1.9			
Males	.3	.2				2.4	1.4			
Females	.5	.4	−1.001	14	.33	3.3	2.6	−.932	14	.37
Moderate vigorous time										
All	5.6	2.7				42.0	19.9			
Males	5.3	2.6				40.4	19.9			
Females	6.2	3.1	−.674	14	.51	44.7	21.4	−.410	14	.69

Table 3

Pearson Correlations Between Time Spent in Daily Activity and Change in Outcome Variables

	Sedentary		Light		Moderate		Vigorous		Mod-Vigorous	
Outcome Variables	***r***	***p***	***r***	***p***	***r***	***p***	***r***	***p***	***r***	***p***
BMI percentile	.05	.86	−.09	.73	.04	.87	.11	.68	.05	.85
VO_{2peak} (mL/kg/minute^{-1})	−.56	.03	.49	.06	.59	.02	.19	.49	.57	.02
Percent fat mass	.13	.62	−.11	.68	−.15	.58	−.03	.91	−.14	.60
Percent fat free mass	−.11	.69	.05	.86	.20	.45	.12	.67	.20	.45
Fat mass (kg)	−.02	.94	.03	.92	.02	.95	.07	.80	.02	.93
Fat free mass (kg)	−.52	.04	.42	.11	.61	.01	.70	.01	.64	.01
Cholesterol (mg/dL)	.61	.01	−.58	.02	−.61	.01	−.25	.36	−.60	.02
Low-density lipoprotein (mg/dL)	.62	.01	−.59	.02	−.61	.01	−.25	.36	−.60	.02
High-density lipoprotein (mg/dL)	.51	.04	−.47	.06	−.54	.03	−.25	.34	−.52	.04
Triglycerides (mg/dL)	.55	.03	−.55	.03	−.56	.02	−.30	.25	−.56	.03
A1C (%)	.36	.17	−.29	.28	−.56	.02	−.44	.08	−.57	.02

BMI = body mass index; VO_{2peak} = cardiovascular fitness; A1C = glycosylated hemoglobin; positive correlations = increase in outcome variable; negative correlations = decrease in outcome variable.