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Exercise Adherence in Hispanic Adolescents with Obesity or Type 2 Diabetes

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ABSTRACT

Purpose: Hispanic adolescents experience high rates of obesity and type 2 diabetes. The purpose of this study was to examine adherence to a 16-week personalized exercise intervention and the perception of family support for exercise, benefits and barriers to exercise and overall health in Hispanic adolescents diagnosed with obesity or type 2 diabetes.
Design and methods: Using a secondary analysis of a larger feasibility trial, data from 21 Hispanic adolescents, 13 with T2D and 8 who were obese and 14 that completed the entire 16-week study (7 T2D; 7 obese) were analyzed. Adolescents wore an Actigraph™ accelerometer for tracking exercise throughout the 16-week intervention.
Results: The adherence rate for the intervention was 59% for those with T2D and was 88% for those with obesity. Overall perceptions of health improved for those completing the 16-week intervention. Barriers to exercise were negatively associated with moderate-to-vigorous physical activity and were higher in those with T2D.
Conclusions: Adolescents with T2D were less adherent to their personalized exercise program than those who were obese.
Practice implications: Strategies that address cultural preferences and family engagement are needed to address barriers to exercise for Hispanic youth, particularly those already diagnosed with T2D that have high risks for early onset of disease complications.

Childhood overweight and obesity prevalence continues to be a major public health concern (Hales, Carroll, Fryar, & Ogden, 2017). The most recent National Health and Nutrition Exam Survey (NHANES) data from 2015 to 2016 revealed the combined overweight and obesity prevalence rate of Hispanic children and adolescents from 2 to 19 years of age to be 45.9% (Skinner, Ravanbakht, Skelton, Perrin, & Armstrong, 2018). During the same time period and across all age cohorts, obesity rates (body mass index ≥ the age and sex-specific 95th percentile of the US Centers for Disease Control and Prevention (CDC) growth charts for Hispanic males was 28.0%, the highest for any racial or ethnic group. The rate for Hispanic females was 23.6%, slightly less than the highest rate of 25.1% for non-Hispanic Black females (Hales et al., 2017).

Increased rates of obesity are associated with prediabetes, defined as having a higher than normal fasting blood glucose level ranging from 100 to 125 mg/dL, but not high enough to be diabetes (Arslanian et al., 2018). Although there are few studies on the total prevalence of prediabetes in children and adolescents, an analysis of 2005–2014 NHANES data indicated the prevalence of prediabetes of Hispanic adolescents to be 22.9% (Menke, Casagrande, & Cowie, 2016). Further evidence of the combined prevalence of prediabetes and type 2 diabetes is reported in the Study of Latino Youth, population-based research of youth aged 8 to 16 years that revealed a rate of 20.9 versus 11.8% respectively, for males compared to females (Isasi et al., 2016).

A major public health issue is the risk and diagnosis of type 2 diabetes in Hispanic populations that are significantly higher than in non-HispanicWhites (Aviles-Santa et al., 2017). Despite these trends, studies addressing interventions specifically targeting exercise for Hispanic adolescents with type 2 diabetes or those with obesity that predisposes them for developing diabetes are limited. Using global positioning receiving devices (GPS, QStarz 1300s) over 7 days, Carrell et al. reported in a study of Hispanic youth that 98% of their waking time was sedentary (Carrel, Sledge, Ventura, Eickhoff, & Allen, 2014). However, more recent data based upon 2013–2016 NHANES data from adolescents 16 to 19 years, 50.8% of Hispanics adolescents compared to 33.1% non-Hispanic White and 31.8% non-Hispanic Black adolescents were trying to lose weight during this time period, mostly through exercise (McDow et al., 2019).

Although exercise interventions for the general population of adolescents who are overweight or obese are available, success rates for improving and sustaining outcomes such as weight loss have been less than optimal (Shaibi, Ryder, Kim, & Barraza, 2015). Some evidence

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does support exercise in obese youth for improving insulin action independent of changes in weight or body composition (Kim & Park, 2013). Studies have shown positive results in insulin sensitivity and/or body composition. For example, in a randomized, controlled lifestyle intervention of nutrition and exercise over 3 months, Soltero et al. (2018) found improvements in insulin sensitivity, body mass index (BMI) percentile, percent body fat and waist circumference in 14 to 16 year old Hispanic adolescents with obesity compared to controls. In a slightly younger sample of overweight Hispanic youth (mean age 11.7 ± 1.4 years) participating in a nutrition and exercise intervention case series study over a similar time period, participants also experienced improvement in BMI percentile and waist circumference (Yli-Piipari et al., 2018).

For adolescents already diagnosed with type 2 diabetes who have increased cardiometabolic risks, there is limited research addressing exercise in this population, particularly for those that are Hispanic. Studies of adolescents with type 2 diabetes have examined the effects of 12 weeks of supervised, exercise training on vascular and biometric outcomes. (Lee, Yoo, & So, 2015; Naylor et al., 2016) Results show that those engaged in high-intensity aerobic exercise (≥ 80% of heart rate reserve) versus low-intensity aerobic exercise (≤ 45% heart rate reserve) to achieve 1200 kcal/week of energy expenditure experienced a significant reduction in body fat, fasting glucose and insulin resistance (Lee et al., 2015). In a personalized, gym-based, randomized exercise training intervention compared to a usual care control group, improvement occurred in flow mediated dilatation (a measure of endothelial function and vascular elasticity), total lean body mass and muscle strength; however, there were no changes in BMI, cardiorespiratory fitness or insulin sensitivity (Naylor et al., 2016).

In addition to the variation in study design and outcomes measured in intervention studies of adolescents with type 2 diabetes, other descriptive studies of this population have noted physiologic alterations that may affect exercise capacity (Nadeau et al., 2009; Pinto et al., 2014). For example, cardiac MRI scans conducted during rest and submaximal exercise, comparing adolescents with type 2 diabetes to overweight/obese or normal weight non-diabetic controls revealed 20% lower indexed cardiac output in those with type 2 diabetes due to reduced stroke volume (Pinto et al., 2014). The smaller increase in cardiac output and greater increase in mean arterial blood pressure resulted in increased total peripheral resistance during exercise in those with type 2 diabetes, so that it was greater than in the overweight/obese and non-diabetic control groups (Pinto et al., 2014). Cardiorespiratory fitness, a known biomarker for increased mortality, was found to be significantly lower in adolescents with type 2 diabetes compared to similar obese adolescents and is particularly concerning that early impaired cardiac function may already exist for these adolescents (Nadeau et al., 2009). The studies completed by Lee et al., Naylor et al. and Pinto et al. did not include Hispanic adolescents with type 2 diabetes, reflecting a major gap in what is known regarding exercise in Hispanic adolescents with type 2 diabetes. None of the current studies tracked longitudinal adherence to the interventions using accelerometry throughout the intervention period and that was conducted in a community versus supervised setting. With up to 40% of Hispanics undiagnosed (Aviles-Santa et al., 2017), there also is a need to better understand exercise approaches and adherence for obese Hispanic youth that have a high risk for developing type 2 diabetes and that may be unaware of their risk.

Purpose

The primary aim of this secondary analysis of an original feasibility trial was to examine exercise adherence over a 16-week personalized exercise intervention in Hispanic adolescents already diagnosed with type 2 diabetes and those who were obese. A secondary aim was to examine any changes in key biometric measures of BMI, waist circumference, cardiorespiratory fitness, blood pressure or perception of overall health for those that completed the intervention compared to baseline measures. A third aim explored associations of the adolescents' perceptions of benefits and barriers for exercise at the beginning of the intervention on adherence to moderate-to-vigorous levels of activity in those completing the intervention. The potential relationship of family support as perceived by the adolescents with benefits and barriers to exercise and exercise adherence were also explored.

Methods

We conducted the parent study that was a feasibility trial of a community-based, personalized exercise intervention for adolescents with diabetes (type 1 or type 2) or obesity. Details of the parent study intervention and composite findings have been published previously Fa, (Faulkner, Michaliszyn, Hepworth, & Wheeler, 2014). The intervention consisted of designing a personal exercise program for each adolescent based upon their current fitness level, personal interests in exercise behaviors, and resource availability in their community. The exercise program was developed by an exercise physiologist based upon the goal of achieving 60 min of moderate-to vigorous activity per day. Prior to starting the intervention, adolescents received a review of diabetes education safety information regarding exercise. Home visits were conducted by study personnel every 2 weeks to check fidelity of the exercise program and provide feedback to the adolescent and key family member.

The theoretical framework for this study was based upon the integration of social cognitive theory (Bandura, 2001), family systems theory (Broderick, 1993), and a personalized exercise prescription (PEP) intervention model (Faulkner, Michaiszyn, & Hepworth, 2010). Social cognitive theory purports that human beings are their own agents who accomplish tasks and goals that give meaning and satisfaction to their lives through cognitive and sensorimotor processes. These processes heavily depend on one's social and physical environments. In families, intentional behavior often involves other participating members. Thus, activities require a commitment to a shared intention and negotiation of family members to carry out plans of action. Intentional behaviors of adolescents are affected not only by personal choices, but also by proxy, enlisting parental assistance and sharing family beliefs to produce desired results. Thus, this study included the adolescents' perceptions of family support for exercise adherence, as well as benefits and barriers to exercise.

Adolescents who were included in the study were screened by administering the Seven-Day Physical Activity Recall instrument (Sallis et al., 1993) to determine that they were sedentary and not already physically active. The parent study was approved by the Institutional Review Board of the University of Arizona. Both parental approval (consent) and child assent were obtained. The protocol for the personalized exercise intervention was based upon the baseline cardiorespiratory fitness level of each adolescent, an assessment of their perceived benefits and barriers to exercise, and their personal preferences and resources for engaging in a community-based exercise program. Each adolescent's exercise prescription was based upon 60%–75% of predicted peak heart rate derived from fitness testing and included activities in which the adolescents had expressed an interest. These activities could be conducted at a gym facility, a park, a school, or the participant's home. Examples of activities included calisthenics, kick boxing, basketball, dancing, cycling and walking. Parents were asked to engage in moderate activity, such as walking 30 min daily, to provide social support to their adolescent.

Baseline biometric measures of BMI, waist circumference, Hemoglobin A_{1c}, homeostasis model for insulin resistance (HOMA-IR), cardiorespiratory fitness (VO_{2peak}), blood pressure and measures of benefits of barriers to exercise, health perception and family support for exercise were examined to identify differences by group, either for those with type 2 diabetes or that were obese. Changes in the biometric measures of Hemoglobin A_{1c} or HOMA-IR post-intervention were measured within group due to differences at baseline, which were expected related to having a diagnosis of type 2 di[...] biometric

and behavioral measures and perception of health were evaluated for changes in the entire sample completing the intervention.

Adherence to exercise

As a measure of adherence to the exercise intervention, 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 s and data were downloaded approximately every 2 weeks. Raw accelerometer counts per epoch were used to determine age specific energy expenditure, expressed in metabolic equivalents (METS), which were calculated using a prediction equation for youth developed by Freedson et al. (Freedson, Pober, & Janz, 2005). Time spent in minutes of daily physical activity that met the criterion of intensity at a level of moderate to vigorous activity (MVPA) was at least ≥3.0 METS and was averaged over the 16-week intervention. The average level of intensity in METS over the intervention was also calculated.

Cardiorespiratory fitness

Cardiorespiratory fitness (VO_{2peak}) was determined using graded exercise testing on a cycle ergometer (Ergoselect 100®, Ergoline, Bitz, Germany). Upon a few minutes warm up period to adjust to cycling cadence, the McMaster protocol was administered. The McMaster protocol uses 2-min stages at predetermined work rates based on gender and height of the participant. 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. Cardiorespiratory fitness (VO_{2peak}) was determined by averaging the last 15 s of oxygen consumption obtained with a respiratory exchange ratio above 1.0, which indicates aerobic threshold.

Biometric measures

Gender and age-adjusted body mass index (BMI) percentiles and z-scores were computed using the Children's BMI Percentile-for-Age Calculator (Children's Nutrition Research Center, Houston, TX), https://www.bcm.edu/cnrc-apps/bodycomp/bmiz2.html. Waist circumference was obtained by using a Gulick II Plus tape measure at the level of the adolescent's umbilicus and recorded at the nearest value to 0.1 cm. Measurement was recorded twice and the mean value recorded. The protocol for using the Gulick tape measure is noted in the National Center for Health Statistics Waist Circumference Measurement and Methodology Study (Ostchega et al., 2019). Systolic and diastolic blood pressure was obtained using the right arm with the adolescent in the sitting position following at least 10 min at rest.

Insulin resistance was calculated by the Homeostasis Model Assessment (HOMA-IR) method (Matthews et al., 1985). The HOMA-IR was derived from the following formula: fasting insulin (μIU/mL) X fasting glucose (mg/dL)/405. Insulin was measured using the electrochemiluminescence immunoassay (Roche Diagnostics, Indianapolis, IN). Glucose control over the past 2–3 months was determined by glycosylated hemoglobin (HbA_{1c}) using the DCA2000® monoclonal antibody assay method for quantitative measurement of whole blood (Bayer HealthCare LLC©, Elkart, IN). Both HOMA-IR and HbA_{1c} are outcomes that are examined in response to exercise interventions for individuals with obesity and prediabetes or type 2 diabetes (Bird and Hawlley, 2017; Grace et al., 2017).

Personal and behavioral measures

The *Perceived Benefits of Action Instrument* and the *Perceived Barriers to Action Instrument* are adolescent versions of measures to assess exercise-specific perceptions. The *Perceived Benefits of Action Instrument* measures reasons for exercising, using 9 items on a Likert scale from "not at all true" (1) to "very true" (5). Scores are added across all items, and a mean benefits score is calculated. The *Perceived Barriers to Action Instrument* measures reasons why one might not exercise, using 10 items on a Likert scale from "not at all true" (1) to "very true" (5). Scores are also added across all items, and a mean barriers score is calculated. In a large multiracial sample of preadolescents, Cronbach's alphas are reported as 0.80 for the benefits scale and 0.77 for the barriers scale (Garcia, Broda, Frenn, Coviak, & Pender, 1995).

The *Diabetes Social Support Questionnaire-Family Version* (La Greca & Bearman, 2002) measures adolescents' perceptions of diabetes-specific family support in the areas of insulin administration, blood glucose testing, meals, exercise, and emotional support and has established reliability and validity. For this study, the 9-item subscale on family support for exercise was used. The Cronbach alpha reliability coefficient for the exercise subscale was reported as 0.85. Adolescents rate the frequency of each behavior, "how often does a family member…?" with 0 = never, 1 = fewer than 2 times per month, 2 = twice a month, 3 = once a week, 4 = several times a week, or 5 = at least once a day. Examples of items include: "suggest ways you can get exercise" or "exercise with you." Adolescents also provide ratings of supportiveness, "how does this make you feel?" with −1 = not supportive, 0 = neutral, 1 = a little supportive, 2 = supportive, and 3 = very supportive. Using an individualized approach, the frequency score for each item is multiplied by the corresponding supportiveness score. Average frequency scores for the family support for exercise subscale were computed across the 9 items.

The adolescents' perception of personal health was measured by a single item taken from the *Diabetes Quality of Life Instrument* (Ingersoll & Marrero, 1991) that asked, "compared to others your age, would you say that your health is" excellent (4), good (3), fair (2) or poor (1). Adolescents are adept and able to report their personal view of their own health. Evidence supports the use of a single item for obtaining one's individual view of personal health (Bowling, 2005).

Data analysis

Data analysis was completed using SPSS version 24.0. Independent *t*-tests were computed to examine differences in those with type 2 diabetes compared to those who were overweight or obese on the pre-test variables of age, BMI, waist circumference, HbA_{1c}, HOMA-IR, cardiorespiratory fitness, benefits and barriers to exercise, and family support and adherence to exercise over the intervention period. Both average minutes of MVPA and level of activity intensity were used to reflect adherence.

Paired t-tests were computed comparing pre-test to post-test values for those completing the intervention. Changes on BMI, WC, cardiorespiratory fitness, BP and perception of health were examined for the entire sample that completed the study. Due to the expected and noted higher levels of HbA_{1c} and HOMA-IR in those with type 2 diabetes versus those who were overweight or obese, differences in these variables were explored separately for each group. Associations between benefits and barriers to exercise and family support to exercise with exercise adherence using accelerometry were also computed for the entire group completing the intervention using Pearson correlation coefficients.

Results

There were 23 Hispanic adolescents initially enrolled in the study, 14 with type 2 diabetes (4 males, 10 females) and 9 who were obese (4 males, 5 females). One male with type 2 diabetes and one obese male

Table 1
Sample characteristics and baseline measures.

	Type 2 DM n = 13	Obese n = 8	P Values
Age (years)	15.4 ± 2.2	14.8 ± 1.8	0.546
Sex			
Male	3 (23%)	3 (37%)	
Female	10 (77%)	5 (63%)	
BMI	37.1 ± 8.3	35.5 ± 4.9	0.582
BMI z-score	2.3 ± 0.4	2.3 ± 0.3	0.990
Waist circumference (cm)	118 ± 18	114 ± 11	0.547
Hemoglobin A_{1c}	8.9 ± 2.3	5.3 ± 0.2	0.000**
HOMA-IR	13.3 ± 9.9	7.7 ± 4.3	0.149
VO_{2peak} (ml/Kg/min.)	22.6 ± 4.5	22.3 ± 5.1	0.894
Benefits to Exercise	3.8 ± 0.6	4.0 ± 0.6	0.561
Systolic BP (mmHg)	119 ± 11	121 ± 8	0.602
Diastolic BP (mmHg)	75 ± 8	72 ± 6	0.337
Barriers to Exercise	3.5 ± 0.8	2.6 ± 0.8	0.012*
Family Support for Exercise	2.7 ± 1.2	3.2 ± 0.7	0.290
Health Perception	2.1 ± 0.9	2.1 ± 0.6	0.893

Note: Data are presented as means ± SD or (n) %.
** $p < 0.001$.
* $p < 0.05$.

withdrew after parental consent and youth assent. Table 1 depicts the demographics of the adolescents who were enrolled and pretested ($n = 21$). The only significant differences included a higher HbA_{1c} ($p < 0.001$) and greater perceptions of barriers to exercise ($p < 0.05$) in those with type 2 diabetes. The higher HbA_1 was expected due to a diagnosis of diabetes and the levels verified those with and without diabetes.

The overall completion rate for the Hispanic adolescents in the 16-week intervention was 67%. For those with type 2 diabetes, the rate was 59% and for those who were obese, the rate was 88%. Table 2 displays the changes in measures from baseline to post-test in measures for those that *completed* the study ($n = 14$; 7 with type 2 diabetes and 7 obese).

The only significant improvement was perception in health status following the intervention ($p < 0.05$), indicating a change in baseline perception of fair health to good heath after participating in the exercise intervention. Cohen's d for the change in perception of health reflected a strong effect size of 0.782.

Although there were no significant differences in adherence to the personalized exercise program based upon MVPA duration ($t = -1.479$, df = 12, $p = 0.165$) or intensity ($t = -0.196$, df = 12, $p = 0.848$) between adolescents with type 2 diabetes versus those that were obese, the obese adolescents had mean duration values for daily minutes of MVPA that were greater than those with type 2 diabetes (mean 51.9 ± 32.4 vs. 31.9 ± 15.4 min/day; Cohen's d = 0.788). The intensity level for MVPA was similar for both groups (4.03 ± 0.20 for type 2 diabetes vs. 4.05 ± 0.31 METS for obese; Cohen's d = 0.076).

For either group that *completed* the intervention ($n = 7$ type 2 diabetes; $n = 7$ obese), there was no improvement in HbA_{1c} or HOMA-IR from baseline to post-intervention. For those with type 2 diabetes completing the intervention, the baseline to post-intervention HbA_{1c} values were 9.0 ± 1.5% vs. 9.0 ± 1.9% and the HOMA-IR values were 15.6 ± 10.8 vs. 15.6 ± 6.1. For those with obesity completing the intervention, the baseline to post-intervention HbA_{1c} values were 5.33 ± 0.26% vs. 5.34 ± 0.25% and the HOMA-IR values were 7.8 ± 4.5 vs. 8.8 ± 3.1.

In terms of the assessment of correlations among baseline perceptions of benefits or barriers to exercise, or family support with adherence to the exercise program (average MVPA or average intensity in METS over the study period) for the total sample that completed the intervention ($n = 14$), barriers to exercise were associated with less daily MVPA duration.

($R = -0.684$, $p = 0.007$). Further examination of the individual items on the *Barriers to Action Instrument* revealed that the top five reasons to not exercise were not having a good place to exercise, if the weather was too bad, if there was too much homework, not enough time or not having anyone with whom to exercise. There were no additional significant associations among other perceptual and behavioral study variables. Therefore, additional review of individual items on the *Benefits to Action Instrument* or the exercise subscale of the *Diabetes Social Support Questionnaire-Family Version* were not considered. Please see Table 3 for the correlational analyses.

Discussion

This study is the first to our knowledge that examined the feasibility of a personalized approach to exercise adherence in Hispanic adolescents with obesity or type 2 diabetes and compared variation in longitudinal, objective measures of adherence over time between the groups. Although the adolescents were allowed their own, individual selections of activities with a goal of achieving 60 min of MVPA per day, those with type 2 diabetes were less adherent to completing the intervention and obtained fewer average minutes of MVPA per day. Interestingly, the adolescents with type 2 diabetes reported significantly higher levels of barriers to exercise at the initiation of the intervention than those who were obese. This perception of potential deterrents to exercise may have been a factor in their ability to adhere to the intervention. Overall, for the combined group of adolescents with type 2 diabetes or obesity completing the intervention, barriers to exercise were associated with fewer minutes of MVPA per day.

Both groups had only moderate levels of exercise intensity, so were not participating in more vigorous levels of activity that would be warranted to affect improvements in cardiorespiratory fitness or other biometric measures. A particular concern is the finding of systolic blood pressure values that surpassed the new standard normal of <120 mmHg for the adolescents over 13 years (Flynn et al., 2017). This finding is a key warning of the importance for clinical vigilance in tracking blood pressure elevation in adolescents with existing risks for cardiometabolic disease.

Additionally, those with type 2 diabetes or obesity had elevated levels of HOMA-IR at baseline and post-intervention. An elevated level is expected with type 2 diabetes and is common in those with obesity. A systematic review of insulin resistance cut-off values using HOMA-IR in adolescents has recommended a level > 2.5 as an index value for determining insulin resistance for both males and females (de Andrade et al., 2016). Although no changes were noted in the

Table 2
Pre-intervention to post-intervention measures for completers ($n = 14$).

	BMI	Waist circumference (cm)	VO_{2peak} (ml/Kg/min)	Systolic BP (mmHg)	Diastolic BP (mmHg)	Health*
Pre-intervention	37.2 ± 6.7	119 ± 14	22.3 ± 4.2	120 ± 11	72 ± 7	2.3 ± 0.8
Post-intervention	37.2 ± 6.4	115 ± 14	22.8 ± 6.1	122 ± 13	72 ± 7	3.0 ± 0.8
p value	0.945	0.148	0.725	0.334	0.947	0.012*
Cohen' d	0.019	0.411	0.100	0.268	0.018	0.782

Note: Data are presented as means ± SD.
* p < 0.05.

Journal of Pediatric Nursing 56 (2021) 7–12

Table 3
Correlations of benefits and barriers to exercise, family support and exercise adherence for completers (n = 14).

	Benefits of Exercise	Barriers to Exercise	Family Support for Exercise	Daily Average MVPA Intensity (METS	Daily Average MVPA Duration
Benefits of Exercise					
r		0.419	0.378	−0.333	- 0.184
p		0.136	0.183	0.245	0.528
Barriers to Exercise					
r	0.419		−0.160	−0.207	−0.684**
p	0.136		0.584	0.479	0.007
Family Support for Exercise					
r	0.378	−0.160		0.311	0.287
p	0.183	0.584		0.280	0.320
Daily Average MVPA Intensity (METS)					
r	−0.333	−0.207	0.311		0.266
p	0.245	0.479	0.280		0.358
Daily Average MVPA Duration					
r	−0.184	−0.684**	0.287	0.266	
p	0.528	0.007	0.320	0.358	

Note: ** $p < 0.01$.

HOMA-IR values for either group, it is noteworthy that both groups had levels considerably higher than the index value and those with type 2 diabetes were taking Metformin, commonly prescribed to improve insulin resistance and to aid in minimizing future cardiometabolic disease.

The values for HbA_{1c} for those with type 2 diabetes were less than favorable and higher than the recommendation to be <7.0%, unless there are problems with hypoglycemia, then values <7.5% are appropriate (American Diabetes Association, 2020). While the values of HbA_{1c} for those with obesity were not at a level indicative of prediabetes (5.7–6.4%), maintenance of lifestyle modification is warranted and recommended for primary care follow up for ongoing evaluation and initiation of treatment of prediabetes in youth if indicated (Magge, Silverstein, Elder, Nadeau, & Hannon, 2020).

The low level of activity revealed in this study is consistent with recent findings reported by researchers from the World Health Organization on the global trends of insufficient physical activity noted in 80% of 1.6 million adolescents worldwide that are not meeting the daily recommendation of one hour of MVPA per day (Guthold et al., 2020). Other evidence supports that physical activity trends may have become stagnant in the United States, adversely affecting the development and management of chronic diseases across the lifespan (Stevens et al., 2017). The independent effect of regular, physical activity on improving insulin sensitivity in the liver and skeletal muscle is well-known as a means for averting the onset of type 2 diabetes and managing glucose in those already diagnosed with the disease (Clamp et al., 2017). Although non-significant, the adolescents with obesity versus those with type 2 diabetes had a higher average daily duration of MVPA, which was supported by the large effect size noted by.

Cohen's d of 0.788. However, despite increasing their activity levels over their previous sedentary behaviors, adolescents were not meeting the recommended level of 60 min of MVPA per day.

A positive outcome of the intervention was an increased perception of a higher level of overall health by adolescents, since all too often those participating in physical activity programs become discouraged by not experiencing anticipated results. Studies of Latino families have found that mothers acknowledge that fathers are considered the head of the household and are primarily responsibility for influencing child behavior related to physical activity (Lora, Cheney, & Branscum, 2017; Tovar, Mena, Risica, Gorham, & Gans, 2015). Such gender characteristics align with male *machismo*, a sign of physical strength in Latino culture. Latino fathers have indicated that physical activity for their youth are affected by the more formal sports culture in the United States and necessity to pay for youth involvement rather than the more casual outdoor play activities in Mexico (Zhang, Hurtado, Flores, Alba-Meraz, & Reicks, 2018), which may be seen as barriers to exercise. The adolescents in this study were all Mexican American residing in the Southwestern United States. Although the intervention was a community-based, personalized approach to exercise that allowed the adolescents to select the activities that they most desired and supportive equipment or a gym membership was provided, challenges occurred at times due to family responsibilities and problems with transportation. The intervention included consent of one parent to provide support throughout the intervention. However, more than one key family member for support may be necessary for sustainability of exercise practices in daily routines.

Conclusions and practice implications

This study is not without limitations. The investigation is small and includes a subset of adolescent participants that were Hispanic and part of a larger, feasibility study on personalized exercise. Therefore, findings are not generalizable but provide initial insights into the challenges experienced by Hispanic adolescents that identify barriers to a more active lifestyle. Although the adolescents were able to select activities that they chose, no specific aspect of the intervention design targeted cultural preferences or assessment of ongoing barriers to exercise throughout the longitudinal investigation. To further promote a physically active lifestyle for Hispanic adolescents who either have type 2 diabetes or have risks for developing the disease, input from key family members, particularly with input and possibly role modeling of fathers, should be considered with subsequent evaluation in a larger investigation. In summary, culturally appropriate strategies for engaging Hispanic youth with high risks for metabolic disease in regular physical activity are greatly needed.

Adolescents with type 2 diabetes or obesity have risks for the development of future cardiometabolic disease. Both the Treatment Options for Type 2 Diabetes in Adolescents and Youth study (TODAY Study Group, 2012) and the Restoring Insulin Secretion (RISE) study (Buse, D'Alessio, & Riddle, 2018) revealed a more aggressive and worsening trajectory of disease onset and progression in adolescents compared to adults. While more is needed to understand the differences in β-cell function in youth, early lifestyle intervention remains a priority for pediatric nurses and health professionals to address barriers that are unique for each adolescent and their family, considering cultural preferences and strategies for engaging exercise into daily life to avert future cardiovascular disease.

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Author Statement on Data Sharing

Due to data retrieved from minor participants and assurance of confidentiality, sharing of the data is not available.

Declaration of Competing Interest

Melissa Spezia Faulkner and Sara Fleet Michaliszyn have no financial interests or potential conflicts with regards to this investigation, authorship and publication of this manuscript.

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