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Research Article

Predictors of Physical Fitness among Southwestern Native American Adolescents at Risk for Diabetes

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Abstract

The prevalence of obesity is increasing among children nationally. Native American children from Zuni Pueblo appear to be at increased risk for obesity, which also increases the risk for the metabolic syndrome, diabetes, and cardiovascular disease. While exercise and physical fitness can prevent or forestall these developments, predictors of physical fitness in this population are unknown.

Forty-seven Native American adolescents completed four aspects of the Presidential Fitness Challenge (push-ups, sit-ups, step-ups, and timed walking) during screening for another study, and fitness was empirically summarized with a Presidential Fitness Index. Correlative analyses were subsequently performed to elucidate predictors of fitness. Age was the only independent predictor of the Presidential Fitness Index. Other variables that were not found to be independent predictors included BMI percentile, waist circumference, fat free mass, total body fat, and HDL cholesterol.

Among adolescent Southwest Native Americans, older children performed better on the Presidential Fitness Challenge. Additionally, BMI was not found to be an independent predictor of fitness.

Keywords: Physical fitness; Fitness testing; Native American; Adolescent; Metabolic syndrome; Pre-diabetes

Abbreviations

PFI: Presidential Fitness Index; MPH: Miles Per Hour; HR: Heart Rate; BIA: Bioelectrical Impedance Analysis; BMI: Body Mass Index

Introduction

The prevalence of obesity is increasing among Native American children. This increased obesity over the past few generations has been attributed to the easy accessibility of high calorie density food and a sedentary lifestyle [1]. In 2011, the NHANES (National Health and Nutritional Examination Survey) found that 34.5% of children aged 12-19 were overweight or obese (defined as BMI greater than the 85th percentile) [2]. This is greater among the Native American population [3,4], although recent epidemiological studies measuring this are lacking. In the early 1990s, the Navajo Health and Nutrition Survey found that 35% of boys and 40% of girls were overweight or obese [5]. These data suggest that the prevalence of obesity in the Native American adolescent population is at a critical level and needs to be addressed to safeguard the future of their rich, diverse, and unique cultures.

Because of the high prevalence of obesity, the pediatric Native American population is at risk for the metabolic syndrome, diabetes, and early cardiovascular disease. Both diet and exercise play a central role in prevention of these conditions and this has been well studied in the context of diabetes treatment in adults. Unlike these older adult populations, however, adolescents typically have few contraindications to exercise [6,7] and as such, exercise may be able to play a larger role in the treatment of metabolic syndrome and its associated diseases. Exercise testing among obese children has been increasing in recent years in response to the increased prevalence of obesity [8]. Maximal oxygen consumption (VO_2 max) and blood lactate determination using treadmills or bicycle ergometers are strategies used in adults, but are expensive and difficult to perform in an untrained and/or pediatric population [6]. Most pediatric studies have therefore employed a timed walk or run test with upper body and core strength testing [8-10].

Some conclusions have already been drawn regarding exercise testing in children. For example, it has been shown that baseline activity levels did not correlate with fitness levels in Native American youth [11] and that personal motivation to perform on exercise testing plays a large role in fitness test performance [6,12]. There are also data to suggest that physical fitness and performance on physical fitness test show a positive correlation with performance on standardized math and English testing [13]. As many Native American communities in New Mexico, including Zuni Pueblo, struggle with healthcare and educational disparities, exercise to improve physical fitness may be an inexpensive way to improve performance in both of these areas.

Obesity prevalence is increasing nationwide and is particularly threatening to Native American youth. Because the Native American population is at risk for multiple diseases and conditions enveloped within the metabolic syndrome, most notably obesity and diabetes, there has been an increase in physical fitness testing among Native American children. Unfortunately, predictors of relative physical fitness in the Native American adolescent population are not known. The objective of this study was to identify predictors of physical fitness

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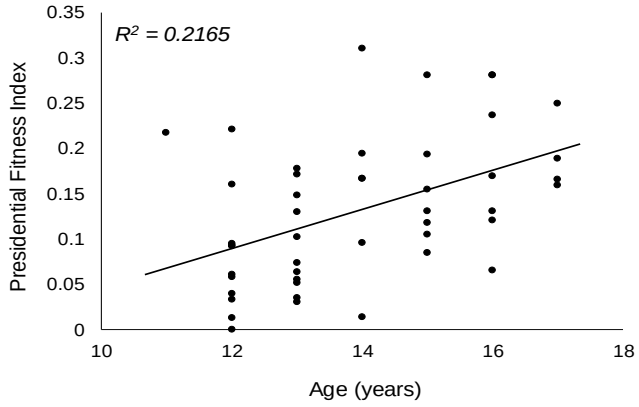

Figure 1: Univariate regression analysis of age as a predictor of the "Presidential Fitness Index" among adolescent Native Americans from Zuni Pueblo.

among Native American adolescents at risk for obesity, diabetes, and cardiovascular disease.

Methods

This study enrolled adolescent participants in a larger cohort study designed to investigate the effectiveness of exercise and nutritional interventions among Native Americans in Zuni Pueblo, NM, between 2012 and 2014. Outcomes from these interventions have been published separately [14]. The current study uses baseline measurements taken before the exercise program was initiated to investigate possible predictors of physical fitness in an untrained Native American adolescent population. The 47 participants, aged 12-17, were recruited from middle and high schools on Zuni Pueblo through school health classes, handbills, or by peer invitation.

Physical fitness assessment

The Presidential Fitness Challenge is an exercise test designed to motivate children to exercise and improve their fitness. The test included aerobic, strength, and flexibility activities. Participants in this study completed four components of the Presidential Fitness Challenge at baseline: number of partial curl-ups to exhaustion, number of full push-ups to exhaustion, heart rate after completing as many 4-inch step-ups as possible in one minute, and heart rate after walking one mile on a flat treadmill at 3.5 MPH. Fitness was determined using a prospectively identified fitness score, the "Presidential Fitness Index" (PFI), defined as (Curl-ups+Push-ups)/(Step HR+Walk HR).

Metabolic profile

Fasting blood samples were obtained from all participating children to assess metabolic risk, including fasting lipids, A1C, liver function tests, uric acid, and urinary albumin to creatinine ratio. The samples were obtained by certified community health representatives, who processed and sent the samples for analysis to the Clinical Laboratory Improvement Amendments (CLIA) certified Tricore Reference Laboratory (Albuquerque, NM) using standard clinical assays.

Anthropometric measurements

Participants underwent blood pressure, height and weight measurements, as well as body composition analysis. Body composition was measured using Bioelectrical Impedance Analysis (BIA) (Quantum III, RJL Systems, Clinton Township and MI) and included total body fat and fat free mass. Participants' Body-Mass Index (BMI) and BMI-percentile were calculated using the CDC Children's BMI Tool for Schools. Previous studies have shown that BMI is a poor estimator of body fat in the pediatric Native American population, but BIA has been validated [4,15,16]. Nevertheless, BMI was still reported and analyzed here given its widespread use as a comparative measure against ideal body weight and its negative correlation with fitness in other studies.

Statistical analysis

To assess potential predictors of fitness as measured by the PFI, univariate Pearson's correlation and multiple regression analyses were performed against the following attributes: age, BMI percentile, waist circumference, blood pressure, fasting plasma glucose, A1C, fasting lipid concentrations, urinary albumin to creatinine ratio, total body fat, and fat free mass. Analysis was performed using SAS Version 9.4 (Cary, NC).

The University of New Mexico Health Sciences Center Human Research Review Committee and the Indian Health Service Institutional Review Board approved this study and all participants rendered written informed assent and consent prior to study. All participants received $25 for their participation.

Results

Subjects were aged 13.9±1.7 years, were 38% female, and had a mean BMI percentile of 87.6±18.1 and a mean A1C of 5.9±1.4%. The mean PFI score was 0.13±0.08. Univariate analyses were significant for age ($r=0.47$, $p<0.001$), BMI percentile ($r=-0.49$, $p<0.001$), waist circumference ($r=-0.45$, $p=0.002$), total body fat ($r=-0.37$, $p=0.013$), fat free mass ($r=0.37$, $p=0.016$), and HDL cholesterol ($r=0.49$, $p<0.001$), as shown in (Figure 1). For multiple regression that incorporated all of the above attributes, only age was an independent predictor of PFI performance (parameter estimate=0.016, $p=0.04$). The multiple correlation coefficient for the entire model was 0.7, thus describing 49% of the variability in this analysis (Table 1).

Discussion

Over the past 10 years, there have been an increasing number of studies focusing on exercise testing in children to explore the rising prevalence of obesity and insulin resistance. Most of these studies focus on the population as a whole and therefore do not explicitly address health-disparate populations, such as those in the rural Native American Pueblos in the southwestern United States. This cross-sectional study explored predictors of physical fitness in one such at-risk adolescent population. It addresses a gap in the literature, as it explores possible predictors of physical fitness specifically in Native American children at risk for obesity and type 2 diabetes. We found that age alone, in contradistinction to other indicators and risk factors associated with the metabolic syndrome, was the only independent predictor of PFI. The Presidential Fitness Index, our empirically derived estimator of physical fitness, may prove to be a novel and utilitarian tool for summarizing performance on this ubiquitous test. The PFI combines strength and muscular fatigability (number of push ups and curl ups to exhaustion) as well as the body's

Table 1: Multivariate regression analysis of potential predictors of physical fitness among adolescent Native Americans from Zuni Pueblo. R^2 for the entire model was 0.492.

Dependent Parameter	Parameter Estimate	Lower 95% CI	Upper 95% CI	Std. Error	*t*-Value	p-Value
Age	0.016	0.001	0.030	0.007	2.170	0.037
BMI	-0.000	-0.003	0.002	0.001	-0.486	0.630
Waist Circumference	-0.004	-0.01	0.001	0.003	-1.581	0.123
HDL Cholesterol	0.003	-0.000	0.006	0.002	1.837	0.075
Total Fat Mass	-0.024	-0.066	0.018	0.021	-1.139	0.263
Fat Free Mass	-0.024	-0.067	0.018	0.021	-1.160	0.254

physiologic response to aerobic and anaerobic exercise (heart rate following standardized exertion). We believe the combination of these factors makes PFI a pragmatic and holistic assessment of physical fitness. Further studies will need to confirm our findings and explore why age alone correlated with baseline physical fitness and the PFI will need to be validated as a reproducible and accurate measure of physical fitness. Finally, the current study needs to be expanded to other Native and non-Native American populations to demonstrate the generalizability of the PFI.

The Presidential Fitness Challenge was a national exercise initiative begun in 1966 that encouraged school aged children to exercise and to improve their physical performance. Traditionally, this involved doing the fitness test twice yearly in physical education classes in elementary school. Improving on one's result combined aspects of hard work, exercise, short-term and long-term goal setting, and periodic assessment. All five of these elements are important tools for children to develop in attempt to optimize success in the prevention and treatment of insulin resistance. However, it is unclear if the Presidential Fitness Challenge actually motivated children to improve or merely served as a required physical education class activity. Further, the fitness test had the possibility of negatively affecting a child's desire to exercise by highlighting a student's weaknesses in physical fitness and causing embarrassment and a lack of motivation to perform well on the test. The Presidential Fitness Challenge was phased out and replaced by the Presidential Youth Fitness Program by President Barack Obama in 2012. The Presidential Youth Fitness Program focuses more on encouraging participants to engage in regular exercise and a long-term active lifestyle. It also minimizes comparisons between participants with no overt testing and it has the option of including the use of pedometers or other fitness trackers [16]. The Presidential Fitness Index employed in our study combined four elements of the Presidential Fitness Challenge to estimate the physical fitness of the study participant using validated aspects of the test. Since the goal of this study was overt testing of physical fitness in school aged children, the Presidential Fitness Challenge fitness test was appropriate for drawing fitness comparisons between study participants.

This study has some limitations. First, the use of the Presidential Fitness Index as a convenient proxy for physical fitness has not been validated. A maximal-effort stress test with VO_2 max and serum lactate measurement would provide a more comprehensive assessment of physical fitness, but such a test is difficult to perform in an untrained population [6]. Second, the Presidential Fitness Index uses heart rate response to activity to estimate fitness. Heart rate is used frequently in athletic training and testing to measure physical effort. However, this is typically used in conjunction with a maximum heart rate measurement. In the current study, it was not feasible to perform a maximum effort exercise test to obtain a maximum heart rate for safety reasons [6]. Third, our results contrast with other studies where BMI correlates negatively with fitness. This may reflect the broad age range of children enrolled in the current study, with the differential effects of sexual maturation potentially masking the effects of more commonly identified predictors of fitness [9,10]. Additionally, while BMI is a poor predictor of adiposity in the target population [4,15,16] neither of the other validated anthropometric measures of body makeup (body fat percentage and fat free mass) were independently associated with physical fitness in this study. Finally, these data were taken from a relatively small cohort of Native American adolescents from one pueblo in western New Mexico. Given the diversity of Native American tribes throughout New Mexico and the rest of the United States, it is unclear if our results can be generalized to a national Native American population.

Conclusion

Among untrained adolescent Native Americans in the Southwestern United States, older children performed better on the Presidential Fitness Challenge regardless of BMI percentile, body composition, gender, glucose homeostasis status, blood pressure, or fasting lipid profile.

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