5-2019

Fitness vs Fatness and Cardiovascular Health in Adolescents

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A thesis submitted to the Honors College at the University of Arkansas in partial fulfillment of the requirements for the degree Bachelor of Science in Kinesiology with Honors

April 30, 2019

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Abstract

Background: Adolescent obesity has been on the rise with studies showing obesity tracks into adulthood. Obesity is an independent risk factor for cardiovascular disease (CVD); CVD is the leading cause of adult death in the U.S. Previous research shows a strong positive relationship between physical activity (PA) and cardiovascular (CV) health even in an obese adult population. Thus, the relationship between adolescent physical fitness and lifetime risk for CVD and all-cause mortality should be investigated. **Purpose:** The purpose of this study is to determine associations between PA and adiposity with cardiovascular health in obese and non-obese weight adolescents, with the hypothesis that physical activity will be positively associated with cardiovascular health independent of adiposity. **Methodology:** A convenience sample of 30 adolescents (ages 12-18) from the community completed assessments of height, weight, a dual x-ray absorptiometry (DXA) scan, resting blood pressure, and a flow-mediated dilation ultrasound (FMD) as a measure of endothelial function and cardiac health. Participants wore an accelerometer for one week to track PA. Participants were assigned to non-obese and obese categories from DXA, the gold standard, measure of body fat. Activity level was also grouped by minutes of moderate-to-vigorous PA (MVPA) per day based on a median split of 15 minutes per day. FMD value was calculated as (maximum diameter – baseline diameter)/ baseline diameter x 100. Comparisons in FMD (dependent variable) between body fat and MVPA groups (independent variables) were made using t-tests and associations between body fat and MVPA were tested using linear regression adjusted for sex. **Results:** FMD data was only available for 10 participants: average age=14.6 (SD 1.8), 50% female, BMI=20.9 (2.6), FMD%=11.9 (8.5). There were no differences (p=.943) in FMD between the obese (mean FMD% = 12.2, SE 4.1) and non-obese (11.8, SE 3.4) groups. Similarly, when percent body fat was examined as a continuous variable, percent body fat was not associated with FMD (coefficient =0.16 (SE 0.31), p=.612). Those with greater than 15 minutes of MVPA per day had a higher FMD (15.0, SE 3.3) compared to those with less than 15 minutes of MVPA per day (8.9, SE 3.3, p=.024). When MVPA was examined as a continuous variable, MVPA was positively associated with MVPA (coefficient =.32 (SE 15), p=.067, however, not statistically significant. **Discussion:** Despite the small sample size, there does appear to be a positive association between FMD and MVPA in adolescents but not an association between FMD and percent body fat. These results suggest an important correlation between PA and cardiac health and may also support the notion that PA may be more important in overall CV health when compared to body composition. Clinicians should emphasize promoting physical activity among adolescents, and not just focus solely on body fat.

Introduction

Adolescent obesity rates have been on the rise in the in the last two decades (Hales et. al, 2016). Longitudinal studies have shown a high rate of adolescent obesity tracking into adulthood (Gordon- Larsen et. al., 2004, Singh et. al., 2008). Obesity is an independent risk factor for cardiovascular disease (CVD) in addition to contributing to other leading risk factors of CVD such as hypertension, dyslipidemia, and an increased risk of developing type 2 diabetes (Burke et. al., 2008, Mokdad et. al., 2001). Cardiovascular health and CVD risk factors of adolescents have also been shown to correlate to the overall cardiovascular health in adult life, this is significant with CVD being the leading cause of adult death in the United States (Benjamin et. al., 2018, Freedman et. al., 1999, Wang and Shen, 2016).

Previous research has shown a strong positive relationship between physical fitness and cardiovascular health (Blair et. al., 1989). Further, research shows that even in a population of obese adults, cardiorespiratory fitness is a more important factor in CVD related and all-cause mortality rates when compared with BMI and body fatness. In addition, males whom belong to the obese population but are considered to be physically fit, exhibit more favorable outcomes (measured by instances of CVD and all- cause mortality) than the non- obese– unfit population (Lee et. al., 1999). Similar research has been done in adolescent populations that support the theory that cardiorespiratory fitness during adolescence will lead to lower instances of CVD risk factors and overall lower rates of CVD related and all-cause mortality over a significant period of time into adult life; (Carnethon et. al., 2003). Adolescence is defined as being 12-18 years of age; cardiorespiratory fitness was measured using a graded treadmill test, and CVD risk factors and outcomes were tracked by instances of type 2 diabetes, hypertension, hypercholesterolemia, and metabolic syndrome (Carnethon et. al., 2003).

Increased physical activity correlates to higher levels of cardiorespiratory fitness with increased sedentary time correlating to poor cardiorespiratory health (Knaeps et. al., 2016). There is a clear correlation between levels of physical activity and the level cardiorespiratory fitness that predicts for risk of CVD and all- cause mortality. Although there is evidence that cardiorespiratory fitness is the most important factor in predicting cardiovascular health, the direct relationship between physical activity and cardiorespiratory fitness should be further investigated.

For example, the majority of research on fitness and cardiovascular health has been conducted on adult populations (Blair et. al., 1989, Lee et. al., 1999). With studies in adult populations showing a positive relationship with cardiorespiratory fitness and adolescent studies showing the relationship between cardiorespiratory fitness and the risk for developing CVD; physical activity could be a valuable measure for predicting early signs of CVD in adolescents (Carnethon et. al., 2003, Knaeps et. al., 2016). Often BMI is used as a predictor for the health of adolescents because of the convenient and inexpensive nature of the measurement, if research shows that physical activity is a strong predictor for the cardiovascular health, measures of physical activity could become the standard and very well offer a more accurate measure of health. In addition to offering a look at the current health of the subject, since physical activity can be easily and directly measured: tracking physical activity may offer a solution for monitoring those whom might be looking to improve their cardiovascular health by increasing physical activity.

Therefore, the purpose of this study is to determine how the level of physical activity relates to the cardiovascular health in both populations of obese and non- obese adolescents. Cardiovascular health was measured by a flow- mediated dilation ultrasounds. Physical activity was measured using an accelerometer worn by the participants. This population was selected because of the evidence that supports cardiovascular health in adolescent years will set the precedent for cardiovascular health in adult life (Wang and Shen, 2016). We hypothesized that a higher level of physical activity will correlate to better cardiovascular health independent of the obese or non-obese weight category of the participants.

Methods

Since the purpose of the study was to explore how different levels of physical activity affect the cardiovascular health in both obese and non- obese populations of adolescents we excluded the overweight population from this study. All subjects participating in this study signed an Informed Assent and their parent or guardian signed an Informed Consent on their behalf; both approved by the Institutional Review Board.

To investigate the relationship between cardiovascular health and physical activity we obtained basic body measurements and cardiovascular measures upon the participants first visit to the lab, with a week of physical activity monitoring following the visit. Participants returned to the lab one week after their first visit to return accelerometer, but no other measurements were taken on the participant upon their return.

Prior to visiting the lab, participants went through a screening process via phone call where they were asked basic questions to determine eligibility for the trial. To be eligible subjects had to be in either the non- obese or obese population according to BMI, 5^{th}- 85^{th} percentile and 95^{th} percentile or greater, respectively. No subjects in the overweight population, BMI 85^{th} -94^{th} percentile, will be admitted to the study. After participants had been deemed to fit the subject criteria they completed an online survey containing basic questions about lifestyle and family history. When participants arrived to the lab, we explained what would be asked of them throughout the trial. Informed Consent/ Assent were provided and once it has been signed we began with basic measurements. Measurements for this trial include height and weight, a DEXA scan, resting blood pressure, and a flow- mediated dilation ultrasound. These measures were used in part to assess the body composition of our participants along with their cardiovascular health.

Data Collection

Height and weight were measured first using Seca 216 stadiometer and a manual Detecto 437 scale. We informed the participant of the small risk of radiation exposure presented by the DEXA (Lunar Prodigy; General Electric, Madison, WI) scan prior to the scan being performed. For blood pressure measurements the participants were asked to lie quietly in the supine position for 15 minutes so that a true resting blood pressure can be measured. Blood pressure was measured on the right arm of the participant using the automatic monitor Omron bp761n.

Flow mediated dilation (FMD) will serve as a measure of cardiovascular health, directly measuring the arterial endothelial function in our participants (Raitakari and Celemajer, 2000). Artery diameter and blood velocity was measured using duplex-Doppler ultrasound. A validated software (FMD Studio, Quipu, Pisa, Italy) for beat-to-beat analysis vessel wall detection and quantification of shear rate was utilized to analyze the ultrasound videos. The reading took place after the resting blood pressure had been measured with the participant still in the supine position. The ultrasound was conducted on the left arm targeting the brachial artery. The artery was scanned and measured at baseline, then the cuff was inflated for 5 minutes to induce the dilation, and the artery was measured again after cuff deflation. FMD value was calculated as (maximum diameter – baseline diameter)/ baseline diameter x 100.

Participants were also issued an accelerometer, Actigraph GT9x to be worn on their right hip for the following week. They were also given a log to record their wear time, activities, and sleep. After the participants had completed their week of physical activity monitoring, they returned to the lab with the accelerometer wear log and accelerometer.

Analysis

We analyzed the physical activity of each participant using the data from the accelerometers and the Actilife software. Activity level was grouped by minutes of moderate-to-vigorous physical activity (MVPA) per day based on a median split of 15 minutes per day (less than 15 minutes of MVPA, and greater than 15 minutes of MVPA per day). Participants were assigned to non-obese and obese categories from results of the DXA scans, the gold standard, measure of body fat, obese was defined by 25% body fat for males and 35% for females. The primary focus was to compare the findings of the FMD readings as a measure of cardiovascular health status between both the obese and non- obese populations and between the MVPA groups. Comparisons in FMD (dependent variable) between body fat and MVPA groups (independent variables) were made using t-tests and associations between body fat and MVPA were tested using linear regression adjusted for sex, an alpha level of <0.05 indicated a significant finding.

Results

There were 18 participants belonging to the non- obese population as defined by their BMI (5th percentile to less than the 85th percentile for adolescents the same age) and 13 participants belonging to the obese population as defined by their BMI (95th percentile or greater); the population of males and females was approximately equal.

FMD data was only available for 10 participants: average age=14.6 (SD 1.8), 50% female, BMI=20.9 (2.6), FMD%=11.9 (8.5). (Table 1).

FMD and Adiposity

There were no differences (p=.943) in FMD values between the obese (mean FMD% = 12.2, SE 4.1) and non-obese (11.8, SE 3.4) groups (Figure 1). Similarly, when percent body fat was examined as a continuous variable, percent body fat was not associated with FMD (coefficient =0.16 (SE 0.31), p=.612) (Figure 2).

FMD and Physical Activity

Participants getting greater than 15 minutes of MVPA per day had a higher FMD (15.0, SE 3.3) compared to those with less than 15 minutes of MVPA per day (8.9, SE 3.3, p=.024) (Figure 1). When MVPA was examined as a continuous variable, MVPA was positively associated with FMD (coefficient =.32 (SE 15), p=.067, however, not statistically significant (Figure 3).

FMD, Adiposity and Physical Activity

When both adiposity and physical activity were both included in the model physical activity was more strongly associated with FMD (0.32, SE 0.15, p=.083), though not statistically significant, compared to adiposity (0.16, 0.25, p=.539).

Table 1: Group Descriptives Compared Between Obesity and Physical Activity Groups

	Obesity Groups		Physical Activity groups	
Group Average	Obese	Non Obese	>15 Min MVPA	<15 Min MVPA
Age	13.78 (SD 1.1)	15.15(SD 1.9)	14.83 (SD 1.7)	14.38(SD 2.8)
Gender	50% Female	50% Female	60% Female	40% Female
FMD	12.18(SD 11.1)	11.76(SD 6.8)	15.74 (SD 10.9)	8.144 (SD2.8)
MVPA	11.34(SD 10.4)	21.96 SD15.2)	27.53 (SD 14.7)	7.9 (SD 6.3)
%Body Fat	32.68(SD 5.4)	18.78 (SD 7.3)	28.24 (SD 5.4)	20.44 (SD12.2)

Figure 1: Comparison of FMD Values (dependent variable) Between Obesity and Physical Activity Groups

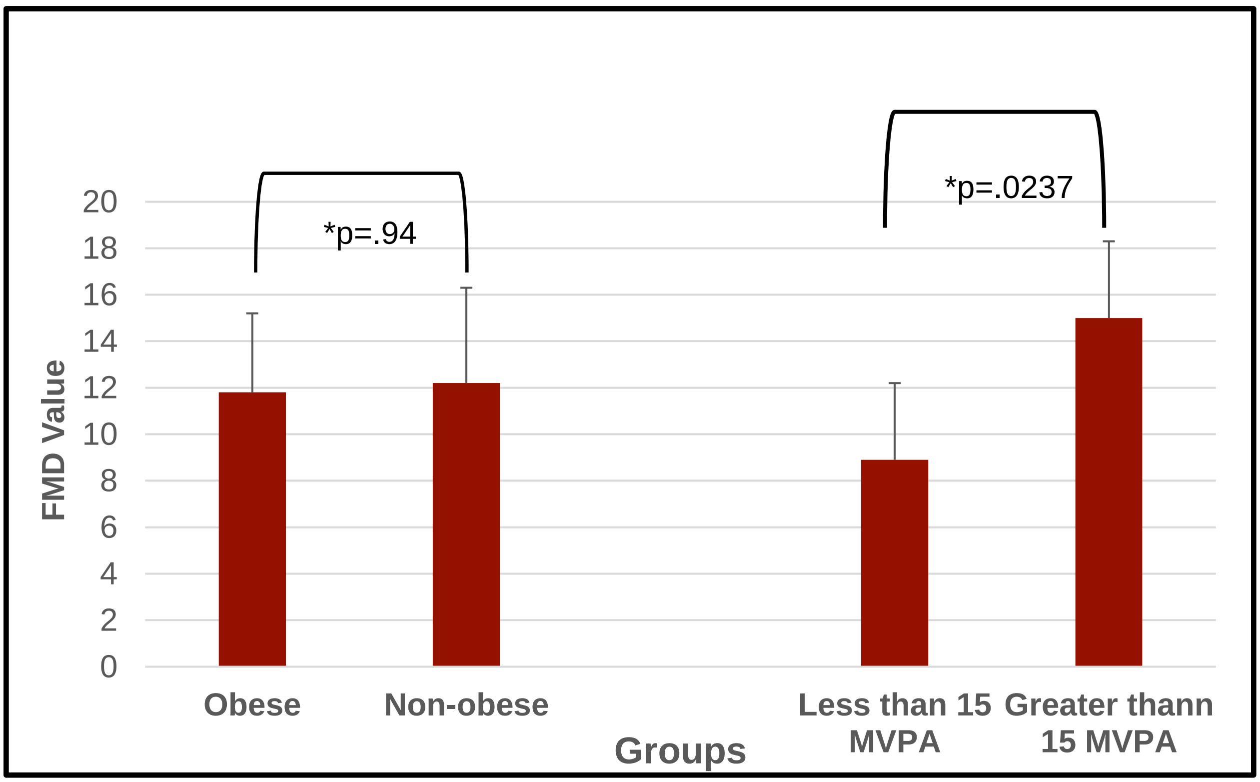


Figure 2: Linear Regression of FMD (dependent variable) vs % Body Fat

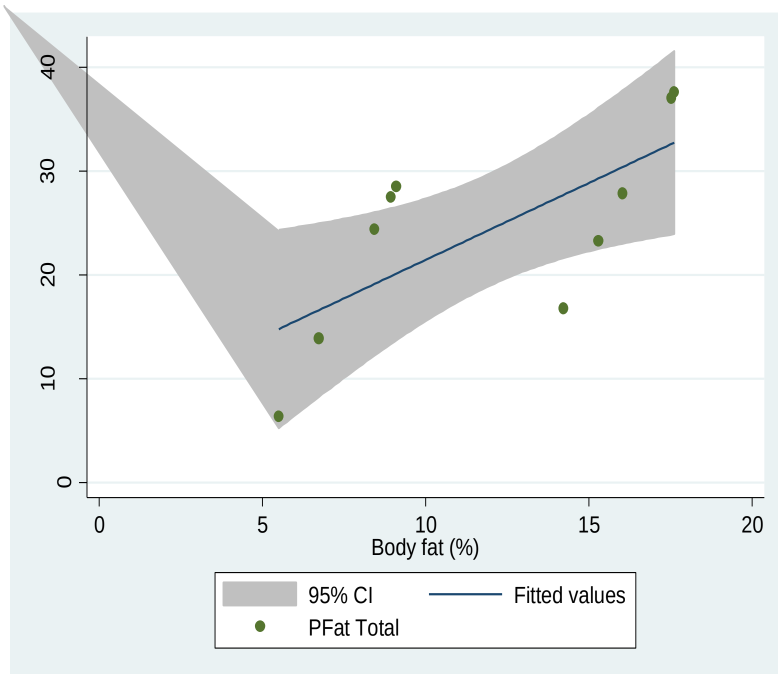
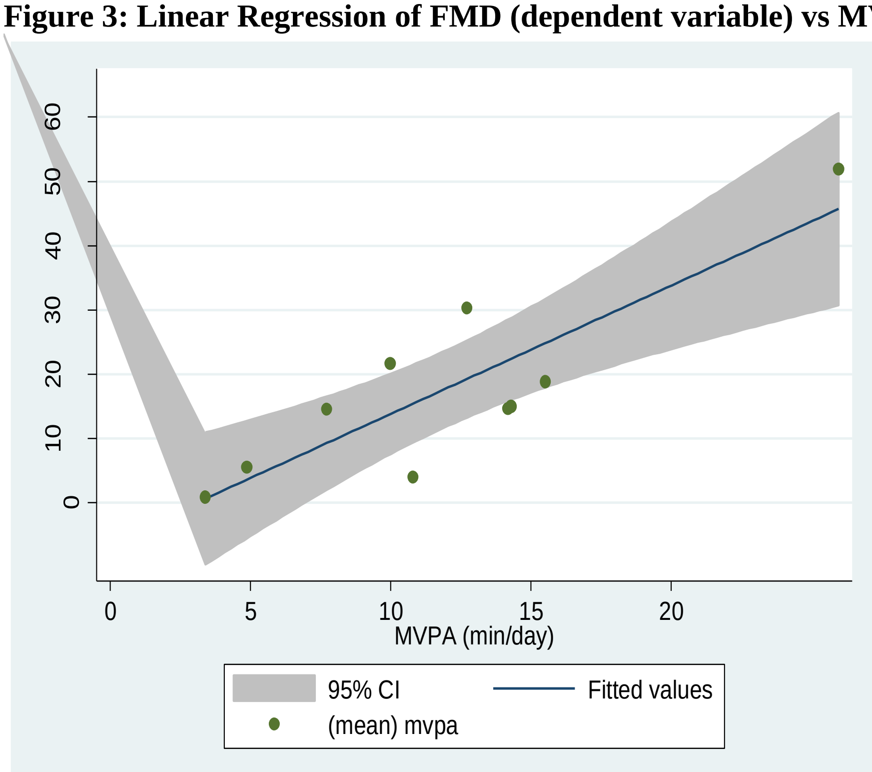


Figure 3: Linear Regression of FMD (dependent variable) vs MVPA



Discussion

The major finding of this study is the positive relationship between physical activity and cardiovascular health in adolescents. Even considering the small sample size, there was a significant positive association between MVPA and FMD in adolescents. There does not appear to be an association between percent body fat and FMD in this population. The chohort study at the Cooper clinic in the 90s demonstrated the significant relationship that fitness played in lowering the risk of CVD related and all cause mortality rates among both the lean and obese population of adult men (Lee et. al., 1999). With physical activity being a direct factor on fitness, I wanted to further investigate this relationship between physical activity and cardiovascular health. The results of this study were consistent with my proposed hypothesis that physical activity may be a better indicator of cardiovascular health than body composition in an adolescent population.

In an adult population a direct relationship has been shown between body fatness and all cause and CVD related mortality; however, the same study showed that the mortality rate for fit obese men and fit lean men was not significantly different, again these findings suggest fitness is a more important indicator of cardiovascular health than body composition (Lee et. al., 1999). Although obesity is an independent risk factor for CVD, the results of this study do not show a significant difference in the cardiovascular measures between the obese and non- obese populations; again suggesting physical activity may have a more direct effect on cardiovascular health in an adolescent population.

It is important to take note that the median split for MVPA was 15 minutes, while the US Department of Health and Human Services of recommends 60 minutes of moderate to vigorous physical activity per day. No participant averaged an hour of exercise per day, with only two participants averaging more than 30 minutes a day, yet we still see a significant difference in the endothelial function of the participants who were participating in more physical activity. This suggests that even small volumes of daily physical activity level could potentially have a positive effect on cardiovascular health.

This study highlights the importance of physical activity on cardiovascular health and may also support the claim that physical activity has a greater effect on cardiovascular health when compared to body composition. Limitations of this study include small sample size and limited data for that sample size due to human error during data collection. An additional limitation may be the short tracking period for physical activity of the participants; extending the length of days the accelerometer was worn by participants could potentially provide a more accurate representation of average physical activity of each participant and be beneficial in future studies. There is more research to be done both about adolescent adiposity and physical activity and how they both relate to cardiovascular health in adolescence as well as how it tracks into adulthood. Going forward there is more to be learned about how an exercise intervention program would benefit cardiovascular health in an adolescent population. Additional research questions should include at what level of physical activity will we see benefits, and if cardiovascular improvements track similarly in a population of sedentary obese and non-obese individuals. This study does suggest that in an adolescent population, clinicians should emphasize promoting physical activity and not just focus solely on body composition to measure the relative health of an individual or population. Increasing physical activity in the adolescent population may improve cardiovascular health and lower the risk for CVD as that same population ages.

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