Cardiovascular Health and Physical Activity Levels in Homeschooled Children

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***Objective*: The objective of this study was to establish a baseline of variables that potentially influence homeschooled children's health status. *Methods*: Children ages 8-16 were tested to determine indicators of cardiovascular health including, aerobic capacity (VO_2); body composition (body fat %); and weight status (BMI). Their activity levels were measured by wearing accelerometer devices for one week. Parents of the children also completed a survey identifying family routines and behaviors. *Results*: Significant relationships were found between cardiovascular health variables, activity levels, parental perceptions of family behaviors, and the sex of the children. *Conclusions*: The uniqueness of the homeschooling environment has a potentially positive influence on the physical activity levels and cardiovascular health of homeschooled children.**

Key words: accelerometer; physical activity; homeschooling; children; obesity
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The homeschooled population has seen a steady increase in the number of families choosing this form of education. It is believed that there are over 2 million children being educated in the home, up about 3% from 2007.[1] These numbers equate to around 2% of the entire school-age population in United States (US). Reasons for the increase include curricular and educational approaches; values and moral instruction; well-being and safety of the child; and family unity.[2]

Unlike the well-established public school setting that includes regular opportunities for physical activity (ie, recess, physical education, before/after school programs),[3] the homeschool environment is unique and differs from one family to another. Opportunities for these children to be physically active vary significantly, oftentimes based on parental influence, availability of resources, and family income.[4] Though most states require homeschoolers provide physical education instruction,[5] there is little government oversight on what must be reported, thereby leaving the families to decide what kind and how much physical activity their children receive.

With increased rates of childhood obesity and cardiovascular disease, there has been a push in the literature to improve understanding of what influences the behavior choices and health status of children.[6] However, most studies focus on public school children because of the easy access to this population. The political history of homeschooling has prevailed at keeping educational policies and requirements out of the home, constraining the data that can be collected at the state level.[7] Though a fundamental win for this group, it has lead to a lack of available information of homeschooled children's health status.[8] The little research that does exist on homeschooled children attempts to compare physical activity levels with their public school counterparts; suggesting that homeschoolers receive less physical activity by comparison.[4,8] These studies lack explanations into how the homeschool environment influences the health status of this particular group of children. Because little is known about the environmental impact homeschooling has on health status, it leaves these children at greater risk for inactivity and cardiovascular disease.[8]

This study sought to identify potential variables that might influence the cardiovascular health and physical activity patterns of this underrepresented group of children. Because it is well established that parents directly influence their children's physical activity and the physical environment available to

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their children,[9] the primary focus was on the parents as a variable to homeschooled children's health behaviors. Lastly, participants' sex, age, aerobic capacity, body composition, and accelerometer-based physical activity levels were compared to determine relationships among these variables.

METHODS

Correlates were grouped into 4 categories including: (1) demographic and physiological variables (age, sex, BMI, and body fat); (2) parental variables (parent activity levels and attitudes toward physical activity); (3) social variables (parent support, sibling measures, and family routines); and (4) behavioral variables (sedentary time, dietary habits, and family bedtime routines).

Participants

This study examined 14 homeschooling families, including 25 children ages 8-16, and each of the 14 family's parent-teacher. All participants were eligible to participate in the study because the children are educated fulltime in the home and the primary caregiver is the teacher. Most of the children in the sample were boys (53.3%) versus girls (46.7%), and were 11-12 years old (52%) compared to the 8-10 (32%), and 13-16 (16%) age groups. The parent-teacher participants included in this study were all mothers of the children. Both consent and assent forms were collected from participants, including consent forms from the parents and assent forms from all of the children.

Data Collection Procedures

This descriptive, comparative pilot study used a quantitative design involving 2 separate data sets – children and parents. The child data were collected on cardiovascular health (estimated VO_2, body composition, and weight status [BMI]) as well as accelerometer-based activity levels. The parent data were collected via a survey-questionnaire reporting perceived physical activity levels, attitudes towards physical activity, dietary habits, and family routines.

Indicators of cardiovascular health. Fitness levels were established by calculating the aerobic capacity, or estimated VO_2 levels, of the children. The 20-meter PACER (Progressive Aerobic Cardiovascular Endurance Run) was administered to measure estimated VO_2 levels. A clinically validated formula that compares the PACER lap results with the children's height and weight was used to calculate aerobic capacity in the form of estimated VO_2 levels.[10]

Body mass index (BMI) was measured using the child's height and weight. Standing height was measured using a wall-fixed stadiometer. Body weight was measured using a calibrated scale. All children were measured in light-weight clothing containing no metal and without shoes. BMI is a reliable measurable way to identify risk factors for cardiovascular disease.[11]

To measure body composition, a handheld bioelectrical impedance method (BIA) was used. Bioelectrical impedance analysis (BIA) is a method of measuring body fat percentage by sending a low-level, safe, electrical current through the body. It has been shown to be an accurate method in estimating body fat percentage in children.[12]

Indicators of physical activity. The physical activity levels of the children were monitored by clinically validated SenseWear Mini® accelerometers.[13] Each child wore the device for a 7-day period, only removing them to shower or swim. The devices tracked time in physical activity, sedentary time, step count, and calories burned. The accelerometer-based data were collected during the fall season.

Results were organized by calculating daily averages for the aforementioned measures. Physical activity measures were categorized based on accelerometer results of light physical activity (LPA), moderate physical activity (MPA), and vigorous physical activity (VPA). The intensity of physical activity was determined based on the children's metabolic equivalent of task (MET) levels, or a physiological measure expressing the energy cost of physical activity.[14] MET can be thought of as an index of the intensity of activity. The accelerometer devices chosen for this study predetermined MET values as less than 2.0 for sedentary activity, 2.0 – 3.0 METs for light physical activity, 3.0 – 6.0 METs for moderate physical activity, and 6.0 – 9.0 METs for vigorous physical activity.

Parental behaviors and perceptions on child health habits. A questionnaire specifically designed for this study was completed by the parent-teacher to measure their perceived behaviors and

family health habits. The survey was designed using 18 Likert-style items made up of 5 subscales including: (1) parents' own physical activity levels (eg, during a typical week how often do you walk for exercise?); (2) their support of physical activity (eg, during a typical week how often do you tell your child(ren) that physical activity is good for his or her health); (3) their family's diet and nutritional habits (eg, during a typical week how often does your family eat mostly freshly prepared meals and regularly consume fruits and vegetables with meals or as snacks); (4) their family's television habits (eg, during a typical week how often does your family monitor the amount of TV, computer, or video game time and limit the access to these devices in the child(ren)'s bedroom); and (5) their family's routine and sleep schedules (eg, during a typical week how often does your family follow a daily routine or schedule for bedtime and your child(ren) typically get(s) at least 10 hours of sleep a night). The survey results were calculated by averaging the parent scores on all of the items that make up each subscale. These scores were than compared to their own children's indicators of physical activity and physiological factors. The overall internal consistency of the questionnaire was computed using Cronbach's alpha reliability (α = .613) and deemed to have adequate reliability.[15]

Data Analysis

Given the exploratory nature of this study, the analysis of data takes into account effect sizes. The small sample size used in this study was taken into account when developing analysis procedures. Descriptive statistics were used to explain the data results for the fitness levels, and body composition. Independent t-tests were used to determine mean differences between sex and the test variables. Spearman rho correlation tests were used to compare the age groups with the test variables, as well as comparing the parents' survey responses with their children's results. Spearman rho tests are more appropriate than Pearson's correlation or a one-way analysis of variance (ANOVA) due to the small sample size. To address the small sample size further and increase the power of the results, one-tailed tests were used.

Because some of the family groups enrolled more than one child in the study, linear mixed models were used to compare fitness levels and body composition between the siblings, thereby accounting for correlations in the data of more than one child per family.

RESULTS

Study compliance was high with the average duration that the participants wore the accelerometer devices being 22.67 hours (SD=1.88) per day, which is an impressive 94.5% tracking time over the entire 7-day period.

Demographic and Physiological Variables

The demographic (age and sex) and physiological (BMI, body fat percentage, and estimated VO_2 max) variables examined in this study were compared to the participants' light physical activity (LPA) levels, moderate physical activity (MPA) levels, and vigorous physical activity (VPA) levels. Demographic traits were compared to the physiological factors as well.

Demographic variables. The mean differences of physical activity levels and physiological factors based on participants' sex yielded significant differences (Table 1). In fact, girls took an average 3651 fewer steps and burned an average of 432 fewer calories per day than did boys.

The participants' age grouping (8-10; 11-12; 13-16) had an effect on the test variable results (Table 1). Specifically, it was determined that the 13-16 year-old group burned significantly ($p < .01$) more calories per day (679 calories) than the 8-10 year-old group. No other significant mean differences were found with respect to age as a dependent variable.

Physiological factors. As Table 2 presents, there were moderate correlations between the participants' body fat percentage and aerobic threshold (VO_2) with nearly every indicator of physical activity tested. As predicted, the physiological variables also were related to each other, with a moderate correlation found between aerobic threshold (VO_2) and their (1) body fat percentage ($r = .542$, $p < .01$), and (2) BMI ($r = -.505$, $p < .01$).

Family Influence on Physical Activity and Physiological Factors

Family influence was tested by looking at the

Table 1
Comparison of Sex and Age Mean Scores

	Boys (N = 14) M (SD)	Girls (N = 11) M (SD)	t	p value	Ages 8-10 (N = 13) M (SD)	Ages 11-12 (N = 8) M (SD)	Ages 13-16 (N = 4) M (SD)	r value	p value
BMI	17.82 (3.13)	18.96 (1.85)	1.05	.308	17.32 (2.48)	18.53 (3.52)	18.59 (.81)	.644	.535
Body Fat	15.8 (5.48)	29.78 (5.46)	5.68*	.001	25.05 (8.97)	20.99 (7.67)	17.38 (9.40)	1.39	.270
VO_2	46.22 (4.82)	41.60 (1.87)	3.1*	.01	43.25 (3.65)	45.35 (4.80)	47.30 (3.63)	1.76	.196
Average Daily Calories Burned	1,857 (422.58)	1,433 (302.62)	2.92*	.01	1,452 (322.71)	1,795 (340.15)	2,131 (480.01)	6.37*	.007
MPA (minutes)	193.15 (96.75)	130 (84.21)	1.58	.134	157.23 (94.25)	166.75 (96.95)	158.5 (84.47)	.027	.974
VPA (minutes)	16.31 (10.11)	9.50 (5.97)	1.94	.068	9.85 (7.73)	17.75 (12.71)	17.75 (12.71)	1.32	.288

Note.
***Correlation is significant at the p < .01 (1-tailed)**

parent-reported physical activity levels and their support of physical activity levels in their children. To analyze family influence further, sibling weight status (BMI and body fat), and aerobic thresholds (VO_2) were compared within each family group.

Parent's support of physical activity. A moderate relationship was found between parents' support of physical activity and their children's body fat percentage ($r = -.415$, $p < .05$), suggesting that higher levels of parent support towards physical activity was associated with lower body fat percentage of the children.

Parents' physical activity levels. Moderate relationships were found between each parent's reported physical activity level and several test variables, suggesting that each parent physical activity levels were moderately associated with their children's moderate physical activity ($r = .474$, $p < .01$) and body fat percentage ($r = -.499$, $p < .01$).

Nutritional habits. The parents' perceived nutritional habits of their families were moderately correlated to their children's amount of light physical activity ($r = .628$, $p < .01$), and moderate physical activity ($r = .636$, $p < .01$) levels. Furthermore, dietary habits also were moderately correlated to the children's VO_2 levels ($r = .481$, $p < .01$). These results suggest that parents who reported having healthier family diets had more active children.

Television viewing and gaming time. There was a moderate negative correlation ($r = -.485$, $p < .01$) between family TV and gaming time and the children's VO_2 levels, suggesting that the parent-reported limited TV and gaming time was moderately associated with higher aerobic capacity levels in their children.

Sleep patterns and family routines. When comparing the results with the parent-reported family bedtime routines, moderate correlation were found between both the children's light ($r = 408$, $p < .05$) and moderate ($r = .403$, $p < .05$) physical activity levels, suggesting that families who reported following a daily bedtime routine had more active children. Interestingly, none of the physiological characteristics (BMI, body fat, or VO_2) were significantly correlated to the family bedtime routines.

Sibling comparison of physical activity levels and weight status. Because homeschooled siblings spend a great amount of time together, they were considered a social variable for the purpose of this study. One family was excluded from this analysis due to having only one child participate in the study. When comparing sibling results to the multiple variables examined, 2 moderate correlations were found between sibling body composition ($r = .460$, $p < .05$) and aerobic thresholds (VO_2) ($r = .452$, $p < .01$).

Table 2
Physiological Correlates of Physical Activity Levels

		Calories Burned	Daily Steps	PA (3 METs)	MPA (3-6 METs)	VPA (6-9 METs)
BMI	Spearman rho	-.515**	.237	-.227	-.232	-.118
	p value	(.008)	(.254)	(.276)	(.265)	(.574)
BF%	Spearman rho	-.489*	-.432*	-.491*	-.466*	-.597**
	p value	(.013)	(.031)	(.013)	(.019)	(.002)
VO_2	Spearman rho	.262	.564**	.617**	.604**	.579**
	p value	(.205)	(.003)	(.001)	(.001)	(.002)

Note.
*** Correlation is significant at p < .05 (1-tailed)**
**** Correlation is significant at p < .01 (1-tailed)**

DISCUSSION

The results of this pilot study provide comparisons of body fat percentage, BMI, aerobic capacity, physical activity levels, and daily routines of homeschooling children, as well as parental and environmental influence. To date, this combination of health-related data has never been published on this particular population of children. Only 2 published studies have reported on the homeschool population's physical activity levels.[4,8] Though both studies compared homeschooled children's physical activity patterns to public school children, some of the results can be compared to the current study. For example, Long et al[4] found that homeschooled children's physical activity patterns (defined as accelerometer-based activity counts) appeared to follow their parent's activity patterns. These findings are supported by the results of this study which suggest there is a moderate relationship between parent-reported activity levels and their children's objectively-measured physical activity levels.

When looking at sex, Welk et al[8] also found similar results to the current study in that aerobic capacity and physical activity levels of homeschooled boys were consistently higher than the girls. These comparisons begin to demonstrate a trend with the homeschool population that boys are more physically active and have higher aerobic capacities than girls, similar to comparisons made with public school children.[3,16-18]

Overall activity levels of homeschooled children reflect positive results. According to the National Association of Sport and Physical Education (NASPE), school-aged children should be receiving at least 60 minutes per day of moderate-to-vigorous physical activity. In this current study, 88% of the children's daily averages were above the recommended 60 minutes per day of MPA over the one-week of accelerometer collected data. They also averaged 12.32 minutes of vigorous (6.0 – 9.0 MET) per day. Furthermore, their patterns of MPA were consistent between weekday (160.2 minutes per day), and weekend (161.5 minutes per day) averages. This differs from the research on public school children that suggest public school children consistently engage in more moderate physical activity during the week than during the weekend.[17,19-21] The differences between homeschooled and public school children's physical activity patterns may be attributed to the established routines (recess and physical education) of the public school setting, explaining why they engage in more MPA during the week.

The results gathered from this small pilot study cannot be generalized to all homeschooled children and was focused in rural western Pennsylvania. Besides the small sample size, another limitation is the lack of information on the types of physical activity in which children participated. Lastly, this study failed to identify any equipment, space, and resources that were availability to the families, all of which influence activity levels.

The purpose was to begin reporting on this underrepresented population of children and to begin identifying possible variables that might merit further investigation. Researchers should begin to ex-

plore the potential effects that might be conducive to child health behaviors found within the homeschool culture.

IMPLICATIONS FOR HEALTH BEHAVIOR OR POLICY

Identifying environmental factors that impact the health of homeschooled children is critical to ensuring that this population is represented in health initiatives. With the number of homeschooled children increasing,[1] and a growing number of health policies and programs being geared towards public schools, the potential for a gap exists.

Several major health initiatives have a direct focus on public school children with no mention of homeschooling. For instance, the *Healthy People 2020* objectives recommend increasing health and physical education in the public schools.[22] The World Health Organization (WHO) recommendations are supportive of an increased emphasis on health education in schools.[23] Lastly, federal US law now requires public schools to establish a local wellness policy that has resulted in districts incorporating obesity prevention programs emphasizing nutrition and physical activity.[24]

Although these programs provide funding and support to help communities combat obesity and other health-related diseases, the scope of these programs should be reevaluated to ensure that all children are being impacted. Researchers should start exploring factors that influence child health behaviors in alternative school settings to help policymakers broaden their focus and outreach efforts.

For example, future studies could establish homeschooling schedules and what, if any, opportunities (eg, weekend and evening programs, homeschool co-op group activities, athletics, etc) are available for these children to be physically active. The participants in this study engaged in a high amount of physical activity throughout the week; however, the quality of that time is undetermined. Researchers also should explore skill-related fitness abilities of homeschoolers to determine if they differ from public school children who receive structured physical education where these skills are formally developed. Lastly, the dietary habits of homeschoolers should be examined to identify what extent this environment has on children's nutritional intake.

Human Subjects Approval Statement

This research study was approved by the Indiana University of Pennsylvania's Institutional Review Board for the Protection of Human Subjects (Log No. 13-141).

Conflict of Interest Disclosure Statement

The author has no conflicts of interest to declare.

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