JOURNAL OF
SCHOOL HEALTH

RESEARCH ARTICLE

How Healthy Is Homeschool? An Analysis of Body Composition and Cardiovascular Disease Risk

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ABSTRACT

BACKGROUND: Public school children regularly participate in school-based physical activity, physical education, and fitness testing. However, almost 2 million American children are homeschooled. The purpose of this research was to assess the body composition of elementary school-aged homeschool children and their corresponding cardiovascular disease (CVD) risk.

METHODS: This research explored the body composition and CVD risk of 145 homeschool children aged 5-11 years using body mass index (BMI), percent body fat, and waist circumference. Chi-square and Mann-Whitney *U* tests examined differences in CVD risk within the homeschool population.

RESULTS: Overall, homeschool children had average BMI z-scores (SD [range]) with a mean of −0.11 (0.97 [−3.47 to 2.53]). Unhealthy classifications were seen in 11.2% of the sample by BMI, 19.6% by percent body fat, and 49.7% by waist circumference. Statistical analysis revealed no difference in CVD risk between sexes ($\chi^2(1) = 0.062$, $p = .804$) or ethnicities ($\chi^2(1) = 0.927$, $p = .336$) but increased prevalence in children aged 5-9 years ($U = 1427$, $z = -4.559$, $p < .001$).

CONCLUSIONS: Almost half of elementary school-aged homeschool children showed increased risk for CVD and need regular assessment of central adiposity.

Keywords: child and adolescent health; community health; physical fitness and sport; special populations.

Citation: Kabiri LS, Mitchell K, Brewer W, Ortiz A. How healthy is homeschool? An analysis of body composition and cardiovascular disease risk. J Sch Health. 2018; 88: 132-138.

Received on January 27, 2017
Accepted on June 22, 2017

Data indicate that almost 2 million American children receive schooling outside of the public school system.[1] This number has almost doubled since 2003 and indicates an increasing trend in homeschool education.[1] Unlike public school children, homeschool children are not subject to state regulations including physical education classes, physical activity initiatives, or regular fitness testing.[2] Compared to their public school peers, homeschool children have been shown to have similar or lower levels of physical activity.[3-5] Due to decreased energy expenditure, homeschool children are at a potentially higher risk for poor body composition and corresponding deficits in cardiovascular health.

Poor body composition has been linked to cardiometabolic disease such as type 2 diabetes, hypertension, inflammatory markers, and cardiovascular disease (CVD) among children.[6-9] In addition to increased disease risk, childhood obesity has also been shown to affect a child's social and psychological health as well as his or her academic performance.[6] Socially, overweight and obese children are frequently teased, bullied, negatively stereotyped, and discriminated against by their peers.[6] Psychologically, body

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This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

composition issues can lead to depression, poor self-esteem, body dissatisfaction, and/or the development of eating disorders.[6] Academically, unhealthy body composition has been associated with poor cognitive test scores, academic achievement, and behavior.[10] More specifically, increased abdominal fat has been associated with significantly lower reading, spelling, and arithmetic standardized test scores in children aged 7-9 years.[11]

Body mass index (BMI) is commonly used to assess body composition in children. However, it does not directly assess body composition. Rather, it is an estimate of how appropriate an individual's weight is in relationship to his or her height. This can lead to inaccurate body composition classification, especially in individuals with high levels of muscle mass. Nevertheless, body mass is still widely used and is a good indicator of body composition in most of the population.[12] Bioelectrical impedance analysis measures percent body fat and can be used as a complement to BMI in children to distinguish between lean and fat mass.[13] The term ''overfat'' refers to individuals with fat mass above the normal levels while the term ''overweight'' refers to individuals with total body mass above normal levels. This is an important distinction as increased health risks are associated with higher levels of fat mass, not body mass. To further clarify a child's body composition, waist circumference is often used to assess central adiposity. Waist circumference may be a better indicator of CVD risk than BMI as a more direct measure of visceral fat.[14,15] In short, BMI, percent body fat, and waist circumference offer complementary perspectives on a child's overall body composition. BMI indicates a child's proportionality as body mass, percent body fat indicates adiposity as fat mass, and waist circumference indicates CVD risk as central adiposity.

A systematic review and meta-analysis found that 55% of obese children will become obese adolescents and 70% of obese adolescents will become obese adults beyond age 30.[16] Thus, it is critical to identify unhealthy body composition in children during elementary school. Early identification can prevent deficits from tracking into adulthood, decrease disease risk, and increase life expectancy. Recent data show that 19.4% of fourth graders are overweight and 22.4% are obese in public schools.[17] However, only 2 studies address body composition in homeschool children in the literature with conflicting results. In 2010, Long et al found no difference in body composition between 36 age-/sex-matched homeschool and public school children aged 7-11 years.[3] Four years later, Cardel et al found 7- to 12-year-old homeschool children to have lower BMI than their public school peers.[4] Thus, more research is needed examining body composition and resulting CVD risk within the homeschool population.

Therefore, the purpose of this research was to describe the body composition of elementary school-aged homeschool children, assess their corresponding risk of CVD, and determine any factors related to CVD risk among this population. It was hypothesized that homeschool children would show poor body composition and high CVD risk that was affected by socioeconomic status, primary caregiver education level, and organized sports participation but unaffected by age, sex, or ethnicity due to the use of age-, sex-, and ethnicity-specific reference scores.

METHODS

Participants

This cross-sectional study was completed as part of Fitness Assessment in the Homeschooled: The FAITH Study. Homeschool families with children aged 5-11 years who had completed at least 1 year of homeschool were recruited from emails listed on public websites, homeschool support groups, cooperatives, and by word of mouth among homeschool families in April and May of 2016. Homeschool children who were enrolled in online public school or other homeschool models which required physical education or fitness testing were excluded. Children who had mental or physical limitations by parental report that would prevent study participation were also excluded. An a priori power analysis for a 2-tailed Mann-Whitney *U* test (2 groups) indicated a minimum sample size of 126 children would be needed with a medium effect size ($d = 0.6$), an alpha level of 0.05, and a power of 0.9.

Instrumentation

Outcome variables included BMI, percent body fat, and waist circumference along with their respective classifications. BMI, BMI z-scores, as well as age- and sex-specific BMI percentiles were determined using Centers for Disease Control and Prevention (CDC) growth charts.[18] Height was measured using a portable stadiometer (Neewer® Stature Meter). Standard CDC cutoffs were used for BMI classification with <5th percentile indicating underweight, 5th to <85th percentile indicating healthy weight, ≥85th to <95th percentile indicating overweight, and ≥95th percentile indicating an obese classification. A BMI classification of overweight or obese was considered unhealthy.

Children's weight, percent body fat, and age-/sex-specific percent body fat classification were calculated using the Tanita BF-689 pediatric bioelectrical impedance analysis scale (Tanita Corporation, Tokyo, Japan) using preprogrammed indwelling normative data.[19] Body fat classifications included underfat, healthy, overfat, or obese. Children are generally considered to be underfat below the 2nd percentile, overfat above the 85th percentile, and obese above the 95th percentile.[20] A body fat classification of overfat or obese was considered unhealthy. Reliability and validity of the Tanita BF-689 has been confirmed in the literature with an intraclass correlation coefficient (ICC) of 0.99 for test-retest reliability and an ICC = 0.79 for absolute agreement with dual energy X-ray absorptiometry scans within this age range.[21]

The CVD risk was determined using age-, sex-, and ethnicity-specific waist circumference cut-off scores previously established by Katzmarzyk et al.[22] These cutoff scores were shown to predict clustered CVD risk as defined by low high-density lipoprotein cholesterol level, high low-density lipoprotein cholesterol level, high triglyceride level, high glucose level, high insulin level, and high blood pressure for American children from the same region as our sample population.[22] Waist circumference was assessed using a nonelastic measuring tape placed parallel to the floor midway between the iliac crest and lower ribs to mimic the measurement site used by Katzmarzyk et al.[22] Confounding variables known to affect body composition and resulting CVD risk including age, sex, ethnicity, socioeconomic status, primary caregiver education level, and organized sports participation were considered in final data analysis.[6,23]

Procedure

Full institutional review board approval was secured prior to any participant enrollment or data collection. Parental/guardian informed consent and child assent in children aged 8 and older was obtained for all participants prior to study enrollment. All data were collected during May 2016. Each child attended a single test session with no follow-up required. Test sessions were offered in a group setting at local parks or at participants' homes as per parental preference. While their child was being tested, parents filled out a demographic survey including household characteristics and organized sports participation information for each child.

Organized sports participation was considered current enrollment in any sport or physical activity in which they paid for participation. Parents also reported the average number of hours/week of organized sports participation. Children completed the entire test session with bare feet and 1 layer of light clothing over undergarments. Parents were asked to have their children observe a 2-hour fasting window and give them an opportunity to void their bladder prior to testing to optimize body composition assessment accuracy.

Height was measured with children facing away from the device and heels together. Child weight, percent body fat, and age-/sex-specific percent body fat classification were then determined using the Tanita BF-689. Children's feet were guided onto the bioelectrical impedance analysis foot sensors by the raters to ensure optimal contact and centralized heel placement. Waist circumference was taken on bare skin after normal participant exhalation without compressing subcutaneous tissue.

Data Analysis

Descriptive statistics including means, standard deviations (SDs), and range were calculated for continuous variables as well as counts and percentages for discrete variables. Chi-square tests were utilized to examine differences between dichotomous predictors including sex (male/female), ethnicity (white, nonwhite), or organized sports participation (yes/no) and CVD risk groups (risk/no risk). Mann-Whitney *U* tests were used to determine differences in the distribution of child age, primary caregiver education level (high school graduate or some college, trade school or associate degree, undergraduate degree, graduate degree), socioeconomic status (gross annual household income of <\$60 K, \$60 K to <\$100 K, or ≥\$100 K), or average hours per week of organized sports between CVD risk groups. Uneven distributions were followed up with chi-square tests to determine if there was a significant difference in CVD risk classification between groups. All statistical analyses were completed using SPSS software (v. 23.0; Chicago, IL).

RESULTS

Overall, 145 children enrolled in the study with 1 child declining to participate in testing. The final sample included 144 homeschool children aged 5-11 years (52% male, 48% female). One child with a BMI z-score of −16.64 was excluded from final data analysis as an extreme outlier resulting in a final sample size of 143 children. Three families declined to disclose their total annual gross household income. Socioeconomic differences between CVD risk groups were determined from a sample of 140. All other analyses, including sample descriptive characteristics, were calculated from the total sample of 143.

Table 1 presents the demographic characteristics of the sample. The sample was predominantly of white ethnicity, higher socioeconomic status, and had college-educated primary caregivers. Overall, the sample had a mean age (SD [range]) of 8.34 years (1.85 [5.00-11.75]). All children were in households with at least 2 adults, an average of 3.94 children (1.45 [1-8]), and 66.4% had primary caregivers who did not work outside the home. Average weekly organized sports participation was 3.27 hours (2.90 [0-13]) per child.

As a group, homeschool children had a BMI z-score of −0.11 (0.97 [−3.47-2.53]), BMI of 16.31

Table 1. **Participant Characteristics for the Total Sample**

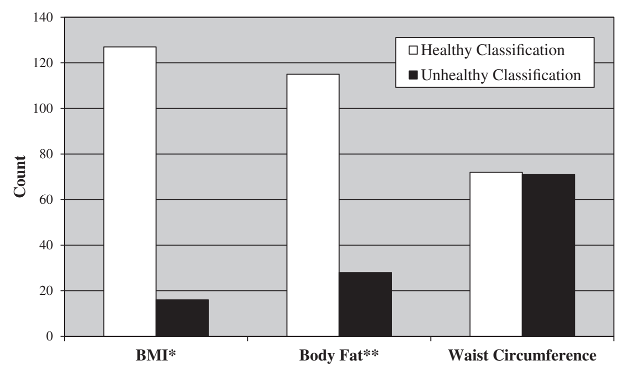
Characteristic	Number of Participants (Total N = 143)	Sample Percentage (%)
Sex		
Male	74	51.7
Female	69	48.3
Ethnicity		
White	121	84.6
Hispanic	3	2.1
African American	5	3.5
Asian	5	3.5
Biracial	8	5.6
Other	1	0.7
Gross annual household income		
<$60 K	19	13.3
$60 K to <$100 K	47	32.9
≥$100 K	74	51.7
Undisclosed	3	2.1
Primary caregiver education level		
High school graduate or some college	14	9.8
Trade school or associate degree	14	9.8
Bachelor's degree	80	55.9
Graduate degree	35	24.5
Organized sports participation		
Yes	107	74.8
No	36	25.2

Table 2. **Participant Classifications by BMI, Percent Body Fat, and Waist Circumference**

Characteristic	Number of Participants (Total N = 143)	Sample Percentage (%)
BMI (kg/m^2)		
Underweight	9	6.3
Healthy	118	82.5
Overweight	10	7.0
Obese	6	4.2
Percent body fat		
Underfat	28	19.6
Healthy	87	60.8
Overfat	21	14.7
Obese	7	4.9
Waist circumference		
No increased cardiovascular disease risk	72	50.3
Increased cardiovascular disease risk	71	49.7

BMI, body mass index.

Figure 1. **Dichotomized Classification by BMI, Percent Body Fat, and Waist Circumference. *Healthy = underweight or healthy weight; unhealthy = overweight or obese; **Healthy = underfat or healthy; unhealthy = overfat or obese.**



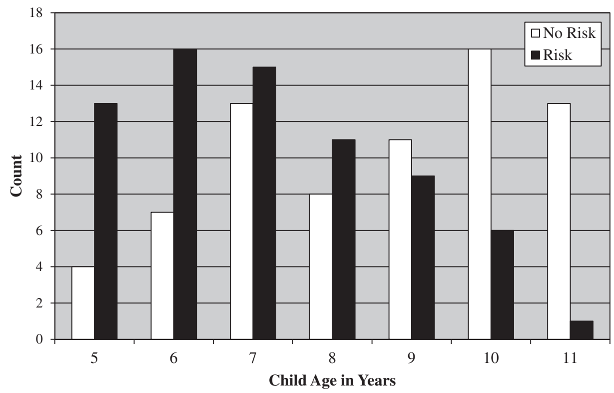
(2.42 [12.73-27.96]), percent body fat of 18.41 (5.61 [5.00-39.70]), and waist circumference of 58.63 cm (6.95 [47.00-82.50]). Age- and sex-specific classifications by BMI, percent body fat, and waist circumference can be seen in Table 2. Overall, 11.2% of the sample had an unhealthy body composition classification by body mass (overweight or obese), which increased to 19.6% when classified by fat mass (overfat or obese), and 49.7% when classified by central adiposity. Figure 1 shows the change in unhealthy classification by assessment technique.

Chi-square tests revealed no significant differences in CVD risk between sexes ($\chi^2(1) = 0.062$, $p = .804$), ethnicity groups ($\chi^2(1) = 0.927$, $p = .336$), or organized sports participants ($\chi^2(1) = 0.002$, $p = .961$). Mann-Whitney *U* tests showed an uneven distribution of age between CVD risk groups ($U = 1427$, $z = -4.559$, $p < .001$) with more young children in the risk group (mean age = 7.62 years) versus no risk group (mean age = 9.04) and a large effect size ($d = 0.83$). The distribution of CVD risk classification by age is shown in Figure 2. A follow-up chi-square test also revealed significantly higher CVD risk among younger (5- to 8-year-olds) versus older (9- to 11-year-olds) children ($\chi^2(1) = 16.360$, $p < .001$) with a medium effect size ($\phi = 0.34$). However, there were no significantly uneven distributions of primary caregiver education ($U = 2568$, $z = 0.056$, $p = .955$), total annual gross household income ($U = 2369$, $z = -0.336$, $p = .737$), or average hours per week of organized sports activity ($U = 2539$, $z = -0.069$, $p = .945$) between CVD risk groups.

DISCUSSION

The purpose of this research was to describe the body composition of elementary school-aged homeschool children, assess their corresponding risk of CVD, and determine any factors related to CVD risk among this population. It was hypothesized that homeschool children would show poor body composition and high CVD risk that was affected by socioeconomic status, primary caregiver education level, and organized sports participation but unaffected by age, sex, or ethnicity. This study found elementary school-aged homeschool children to predominantly

Figure 2. **Central Adiposity-Related Clustered Cardiovascular Disease Risk Prevalence by Age Among Homeschool Children**



have healthy body mass and fat mass levels but elevated levels of central adiposity. This increased central adiposity resulted in almost half of the sample being classified as increased risk for CVD. As shown in Figure 1, levels of unhealthy body composition classification sequentially increased from body mass to fat mass to central adiposity.

It is often assumed that a healthy BMI or percent body fat indicates healthy body composition. However, this study clearly shows that high levels of abdominal fat can coexist with both normal BMI and percent body fat. This combination of low BMI and high waist circumference along with increased CVD risk in children has also been seen in other pediatric populations.[15] As BMI does not indicate fat mass and percent body fat does not account for fat distribution, it is possible for children with low BMI and low percent body fat to still have increased levels of central adiposity. Central adiposity can be quickly and easily assessed in a noninvasive manner using waist circumference measurements. Accordingly, waist circumference should be included in routine body composition assessments regardless of BMI or percent body fat to better screen for cardiovascular risk in elementary school-aged homeschool children.

The low BMI and fat mass levels shown in our sample agrees with the single study available in the literature examining body composition in homeschool children by Cardel et al.[4] After assessing BMI and percent body fat by dual energy X-ray absorptiometry, they also found homeschool children to have significantly lower BMI percentile, total fat mass, percent body fat, and trunk fat compared to their public school peers.[4] Our research supports this thin, lean body composition profile among homeschool children. However, it refutes our hypothesis that they would have poorer body composition secondary to similar or decreased levels of physical activity compared to public school children.[3-5] Cardel et al also found homeschool children to consume on average 120 total fewer kilocalories per day, significantly less trans fat and total sugar, and significantly more fiber, fruits, and vegetables.[4] Thus, while physical activity may not explain the differences in body composition found in homeschool children, dietary intake might. However, it should be noted that this significantly less healthy diet among public school students is in direct conflict with research by Long et al which found no significant difference in dietary intake in public school children.[3] Regardless of the cause for body composition differences, our study supports findings of lower BMI and fat mass among homeschool children.

Unlike Cardel et al's research which showed significantly lower levels of trunk fat in homeschool children, the results of this study showed almost half of homeschool children had increased central adiposity. However, Cardel et al completed their study using 47 children in an older age range (7-12 years) while the present study was completed using 143 children in a younger age range (5-11 years).[4] Notably, our research found age was the only significant difference between CVD risk groups and that age had a large effect size. As seen in Figure 2, elevated levels of CVD risk prevail until after the age of 8 when healthy levels begin to outnumber unhealthy levels. If central adiposity is more prevalent in homeschool children under the age of 9, the younger and larger sample used in our study could explain the difference in findings. The dominance of unhealthy CVD risk classification in children aged 5-8 years also highlights the increased importance of measuring waist circumference in homeschool children within this younger age range.

No difference in central adiposity was noted due to sex, ethnicity, socioeconomic status, primary caregiver education level, or organized sports participation. These results agree with work done by Barriuso et al who concluded that in rich countries, the positive relationship between socioeconomic status and unhealthy child/adolescent weight classification has almost disappeared.[23] However, this study's findings disagree with the same research which found parental education level, with a stronger association with maternal education level, to have a significantly inverse relationship with child body composition. In other words, Barriuso et al found healthier children among more educated mothers.[23] Nonetheless, it should be noted that primary caregivers in our sample were predominantly college educated (91.2%) with almost 25% holding a graduate degree. This homogeneity in advanced primary caregiver education within our sample population could explain the discrepancy in findings. Finally, while physical activity levels can affect body composition, sports participation in our sample may not have been of sufficient duration or intensity to result in body composition change.

Limitations

Study limitations include possible bias through self-selection and a lack of ethnic or socioeconomic diversity among participants. However, the predominantly white sample with high socioeconomic status seen in our study matches the homeschool population demographics seen in other studies.[3-5] Thus, generalizability of our findings among homeschool children should not be affected. Additional limitations include the lack of a directly measured public school reference population which would allow for higher level statistical analyses. Future studies should determine the same risk for CVD as measured by waist circumference in the public school population as well.

Conclusions

In short, homeschool children show increased risk of CVD secondary to high levels of central adiposity regardless of BMI or fat mass. Due to the increased prevalence of CVD risk as measured by waist circumference among this population, homeschool children, especially under the age of 9, should have waist circumference regularly assessed to screen for CVD risk. As the first study to examine waist circumference in this population and age range, further research is needed to support these initial findings.

IMPLICATIONS FOR SCHOOL HEALTH

Homeschooling is a growing trend in the United States with highly varied structure and curriculum compared to public or private school. However, there are occasions when homeschool and public school overlap. Often, children in homeschool are allowed to participate in sports and extracurricular activities offered through the public school system. Also, tuition-free online public school is a viable homeschool option in many areas. When this overlapping occurs, public schools can help improve the health of homeschool children by:

1. Requiring online public school students to participate in on-site fitness testing (FitnessGram®) alongside traditional public school children to encourage regular interaction with school healthcare professionals
2. Offering local homeschool groups body composition and fitness screening, including waist circumference, for a nominal fee
3. Partnering with local gyms, universities, or pediatric healthcare clinics to offer health and wellness screening booths at school carnivals and events where both homeschool and public school may be in attendance

Finally, the high level of central adiposity accompanied by normal BMI among the elementary school-aged homeschool population also suggests the need to include waist circumference assessment in public school children. It is possible that the 58.2% of public school children from the same region classified as having a normal BMI may still be at risk for CVD.[17] While BMI is typically assessed as part of regular fitness screening in public schools, the addition of waist circumference may be needed to more accurately identify CVD risk in public school children as well.

Human Subjects Approval Statement

Full approval for this study was granted by Texas Woman's University - Houston Institutional Review Board as protocol #18919.

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