

Manuscript Number:

Title: Comparison of Physical Activity and Body Composition between Old Order Amish Children and non-Amish Children

Article Type: Article

Corresponding Author: Dr. Soren Snitker, M.D., Ph.D.

Corresponding Author's Institution: University of Maryland School of Medicine

First Author: Kristen G Hairston, MD, MPH

Order of Authors: Kristen G Hairston, MD, MPH; Julie D Ducharme, MD; Margarita S Treuth, PhD; Wen-Chi Hsueh, MPH, PhD; Kathy A Ryan, MS; Xiaolin Shi, MS; Braxton D Mitchell, PhD, MPH; Alan R Shuldiner, MD; Soren Snitker, M.D., Ph.D.

Abstract: Background: To assess the potential for increase of physical activity (PA) levels in children from current levels, it is important to know historical levels. To bypass the problem that methods to quantify PA accurately were only developed in the last few decades, we studied a contemporary, "historical control", the Old Order Amish (OOA), who subscribe to a non-mechanized lifestyle much like that of farmers centuries ago. We compared PA levels in OOA children age 8-19 yrs with those of non-Amish children living nearby in Maryland's Eastern Shore (ES). In addition, we determined to which extent PA levels statistically explained differences in body composition.

Methods: We obtained anthropometric data in 270 OOA children and 229 ES children. PA was measured by Actical accelerometers in 198 OOA, and by Actiwatch accelerometers in 43 OOA and all ES.

Findings: Mean age was 12.6 ± 2.9 yrs. OOA had lower mean body weight above CDC age- and sex-specific medians (1.7 ± 8.5 kg vs. 9.6 ± 15.0 kg) and recorded more mean total activity counts (338 ± 97 vs. 227 ± 67 thousand counts/d), largely attributable to spending more time in moderate or vigorous PA (MVPA) (106 ± 54 vs. 53 ± 32 min/d) (all $p < 0.0001$). Time spent in MVPA was inversely correlated with BMI z-score ($r = -0.24$, $p = 0.0006$) and body weight above CDC median ($r = -0.29$, $p < 0.0001$). OOA girls were less active than OOA boys but more active than ES boys.

Interpretation: OOA were less frequently overweight and spent twice as much time in MVPA. If one assumes a unidirectional causality from PA to body composition, 2.5 kg of the excess body weight in the ES was explained by their spending 53 min/d rather than 106 min/d in MVPA. The study suggests the potential for appropriate environmental modifications to increase physical activity in children.

Funding: NIH, CDC, American Diabetes Association.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34

**Comparison of Physical Activity and Body
Composition between Old Order Amish
Children and non-Amish Children**

**Kristen G. Hairston^{1,4}, Julie D. Ducharme^{1,4}, Margarita S. Treuth²,
Wen-Chi Hsueh³, Kathy A. Ryan¹, Xiaolian Shi¹,
Braxton D. Mitchell¹, Alan R. Shuldiner¹, Soren Snitker¹**

1. University of Maryland School of Medicine,
Baltimore, MD, USA
2. University of Maryland Eastern Shore, Department
of Physical Therapy, Princess Anne, MD, USA
3. University of California, San Francisco School of
Medicine, San Francisco, CA, USA
4. KGH and JDD contributed equally to the work

Running title: Physical activity in Old Order Amish children

Author for Correspondence:

Soren Snitker, M.D., Ph.D

Associate Professor

University of Maryland School of Medicine

Dept. of Medicine, Div. of Endocrinology, Diabetes, and Nutrition

660 W Redwood St. Rm. HH-598-B

Baltimore, MD 21201

ssnitker@medicine.umaryland.edu

ABSTRACT

Background: To assess the potential for increase of physical activity (PA) levels in children from current levels, it is important to know historical levels. To bypass the problem that methods to quantify PA accurately were only developed in the last few decades, we studied a contemporary, “historical control”, the Old Order Amish (OOA), who subscribe to a non-mechanized lifestyle much like that of farmers centuries ago. We compared PA levels in OOA children age 8-19 yrs with those of non-Amish children living nearby in Maryland’s Eastern Shore (ES). In addition, we determined to which extent PA levels statistically explained differences in body composition.

Methods: We obtained anthropometric data in 270 OOA children and 229 ES children. PA was measured by Actical accelerometers in 198 OOA, and by Actiwatch accelerometers in 43 OOA and all ES.

Findings: Mean age was 12.6 ± 2.9 yrs. OOA had lower mean body weight above CDC age- and sex- specific medians (1.7 ± 8.5 kg vs. 9.6 ± 15.0 kg) and recorded more mean total activity counts (338 ± 97 vs. $227 \pm 67 \times 10^3$ counts/d), largely attributable to spending more time in moderate or vigorous PA (MVPA) (106 ± 54 vs. 53 ± 32 min/d) (all $p < 0.0001$). Time spent in MVPA was inversely correlated with BMI z-score ($r = -0.24$, $p = 0.0006$) and body weight above CDC median ($r = -0.29$, $p < 0.0001$). OOA girls were less active than OOA boys but more active than ES boys.

1 **Interpretation:** OOA were less frequently overweight and spent twice as much time in MVPA. If
2 one assumes a unidirectional causality from PA to body composition, 2.5 kg of the excess body
3 weight in the ES was explained by their spending 53 min/d rather than 106 min/d in MVPA. The
4 study suggests the potential for appropriate environmental modifications to increase physical
5 activity in children.

6

7 **Funding:** NIH, CDC, American Diabetes Association.

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

23

24

25

26 **Key Words:** Actigraphy, population study, United States, Children, obesity, public health

1 Recent public health statements from expert committees (1), national governments (2,
2 3), and the World Health Organization (4) include a call to promote greater physical activity
3 among children and adults. To assess the potential for increase of physical activity (PA) in
4 children from current levels, it is important to know historical levels. However, gathering such
5 information is very difficult because methods to quantify physical activity accurately were not
6 developed until the last decades. To bypass this problem, we studied children belonging to a
7 contemporary, “historical control”, the Old Order Amish (OOA), a conservative Christian sect
8 living in rural areas of Lancaster County, Pennsylvania. The OOA have maintained a virtually
9 unchanged lifestyle since their ancestors immigrated to the United States in the 18th century.
10 Amish society is guided by the *Ordnung*, rules that regulate many aspects of life to be
11 consistent with Amish values, which are religious devotion, family, and community cohesion.
12 Many modern technologies are banned, including electric power, telephones, self-powered farm
13 equipment, and personal automobiles. These voluntary constraints result in a non-mechanized
14 lifestyle not much different from that of farming Americans or Europeans a century or two ago.
15 This lifestyle affects the whole family as OOA children attend their own schools and are
16 frequently seen playing outside or engaged in physical chores.

17 The purpose of this study is to objectively measure and compare physical activity levels
18 and body composition in OOA children and a group of non-Amish children from Maryland’s
19 Eastern Shore (ES), a rural environment not far from Lancaster County having similar climate
20 and topography. In addition, we determine the correlation between physical activity and BMI-for-
21 age.

22
23
24
25
26

METHODS

Study Populations

OOA children aged 8-19 years from Lancaster County, Pennsylvania were recruited for the study between 2005-2007. Requirements for participation were willingness to wear an accelerometer around the waist for a period of 9 days and have height, weight, and body composition measured. The recruitment team consisted of a research nurse and an Amish liaison, who visited the homes of children to inquire about interest in the study. To ensure that the sample was as representative as possible, homes to visit were selected without prejudice regarding the body composition or presumed physical activity level of the children living there. To minimize the possibility of self-selection bias on the basis of body composition or PA level, our recruitment narrative described the studies in a way that did not imply judgment regarding body type or activity level. Informed parental consent and minor assent were obtained prior to any study procedure. The study was approved by the University of Maryland Baltimore Institutional Review Board.

The ES children were recruited in 2002 as part of a school-based physical activity assessment study (5). Boys and girls aged 7-19 years old attending one elementary and a combined middle and high school, residing on the Eastern Shore of Maryland participated. That study was approved by the Institutional Review Board of the Johns Hopkins Bloomberg School of Public Health, as well as the county school board of education. The methods and consent/assent procedures of this study have been published previously (5), and are largely similar to those of the OOA study.

As an additional contemporaneous comparison to the OOA and ES samples, we used previously published data from the Third National Health and Nutrition Survey Examination (NHANES) 2003-2004 (6).

1 *Measurements*

2 All children underwent a brief physical exam including measurements of height
3 (Shorrboard ICA stadiometer; Olney, MD, USA), weight (calibrated electronic scale), and
4 percent body fat by bioelectrical impedance analysis (TANITA Model # BF682; Tanita Corp.,
5 Tokyo, Japan). BMI was calculated as the ratio of weight to height² (kg/m²). BMI values were
6 converted to z-scores (z-BMI) and percentiles based on the 2000 Centers for Disease Control
7 and Prevention (CDC) age- and sex-specific tables using algorithms and parameters provided
8 on the CDC website (7). In addition, we calculated individual body weight above the age- and
9 sex- specific median (50th percentile), using the same CDC norms, by subtraction of the median
10 from the body weight.

11

12 *Physical Activity by Accelerometry*

13 OOA children wore the Actical accelerometer (Mini Mitter Co., Inc.; Bend, OR, USA) on
14 the lateral aspect of the hip, held in place by a neoprene belt around the body, for at least 9
15 consecutive days, 24 hours a day, except when showering or bathing. The Actical device has
16 been validated by Heil (8) against gas exchange in children and adolescents aged 8-17 years.
17 All Actical monitors were of version 8.4. Epoch length was set for 15 sec and version 2.04
18 software was used for programming. The analysis incorporated the first 7 complete days of
19 wear (from midnight to midnight), i.e., data was ignored from the first day, which was always
20 incomplete, and any subsequent incomplete days. Days were considered incomplete due to
21 non-wear when more than 1 hour of zero daytime activity counts was recorded. Lack of
22 compliance was rare. Data from subjects with fewer than 5 days of observation and those not
23 wearing the Actical for long periods during the day were excluded from analysis (n = 11). Four
24 recordings were excluded due to obvious device malfunction. Usable Actical recordings were
25 available in 198 children (97 boys and 101 girls). In addition to total daily counts, activity energy
26 expenditure was calculated on a per-minute basis, using Heil's equations (8) as implemented in

1 the Actical software, to derive time spent at defined levels of physical activity intensity
2 (sedentary, light, moderate, and vigorous). Using a cutoff point between light and moderate
3 activity of $\geq 0.05 \text{ kcal}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ as proposed by Puyau, et al. (9) for children and adolescents,
4 we report time spent in a collapsed category of moderate and vigorous activity (MVPA).
5 Sedentary activity was defined as periods with an activity count of less than 50 counts/minute
6 for 10 consecutive minutes. The activity measures were expressed as daily means.

7 The ES children wore the Actiwatch (Mini Mitter Co., Inc.) accelerometer on the hip for at
8 least 6 consecutive days, including 2 weekend days. The Actiwatch is physically similar to the
9 Actical but has a slightly different electronics and software. Thus, to ensure the highest degree
10 of accuracy in comparisons between the ES and the OOA children, the last 43 OOA children
11 were assigned to wear Actiwatch accelerometers concomitantly with the Actical accelerometers.
12 The OOA Actiwatch wear and data handling protocol was identical to the ES Actiwatch protocol
13 (5). Specifically, Actiware Rhythm software (v. 3.03) was used to program the devices for an
14 epoch length of 1 min and upload data. Six consecutive days were used, including two weekend
15 days. All Actiwatch devices used for the OOA had either been used in the ES study or were of
16 the same version as determined by a serial number starting with "V63". As in the ES study (5),
17 an Excel spreadsheet macro, developed in the laboratory of Dr. Nancy Butte, was used to
18 calculate amount of time spent at defined levels of physical activity according to the definitions
19 of Puyau, et al., (9). Body composition was assessed in the ES study using the same TANITA
20 bioelectrical impedance analysis method as in the OOA study.

21

22 *Statistical Analysis*

23 Analyses were performed with SAS for Windows version 9.1 (SAS Institute Inc., Cary,
24 NC, USA). We compared levels of PA and other factors between OOA and ES children using
25 analysis of variance to adjust for age and sex. Prevalence of high-BMI-for-age (defined as BMI
26 at or above the 85th percentile for age and sex) was compared between groups using logistic

1 regression. To assess the relation of PA levels to body composition, a mixed model was used,
2 adjusting for family as a random effect, to account for the fact that multiple OOA subjects were
3 recruited from the same household. Adjusted point estimates are given as least squares means
4 using the LSMEANS statement in PROC GLM.

5

6 *Role of the funding sources*

7 The funding sources had no involvement beyond approval of the studies prior to
8 recruitment.

9

10

RESULTS

11

12 *Physical activity and body composition in OOA and ES children*

13 **Table 1** shows the characteristics of the 270 OOA children and 229 ES children. The
14 age range was 8–19 yrs in the OOA sample and 7–19 yrs in the ES sample, as the latter
15 included 2 children of age 7 yrs. The 270 OOA children belonged to 80 nuclear families (mean
16 number of siblings per family (\pm SD) 3.4 ± 1.0 , range 1-8). Mean age was 12.4 ± 3.1 and $12.0 \pm$
17 2.8 yrs in the OOA and ES children, respectively ($p = 0.13$). ES children had higher mean BMI
18 (22.1 ± 5.4 vs. 19.5 ± 3.4), z-BMI (0.68 ± 1.1 vs. 0.11 ± 0.82), body weight above the age- and
19 sex- specific CDC median (9.6 ± 15.0 vs. 1.7 ± 8.5 kg), and percentage of body fat (23.7 ± 11.5
20 vs. 18.4 ± 7.4) (all $p < 0.0001$). Likewise, ES children were more likely to be have a BMI at or
21 above the 85th percentile as evidenced by the fact that the age- and sex-adjusted odds ratio of a
22 BMI at or above the 85th percentile in the OOA relative to the ES was 0.25 (95% CI [0.16, 0.39])
23 ($p < 0.0001$). By age group, it was 0.19 [0.09, 0.38] ($p < 0.0001$) in the 7-11 year-olds and 0.28
24 [0.16-0.53] ($p < 0.0001$) in the 12-19 year-olds.

1 **Figure 1** extends the above comparison with national estimates for non-Hispanic White
2 children originating from NHANES, showing that the prevalence of a BMI at or above the 85th
3 percentile is much lower in the OOA children than in the ES children and NHANES.

4 In preparation for our comparison of Actiwatch counts in the OOA and the ES, to assure
5 that the activity levels of the 43 OOA children that had been assigned to wear Actiwatch
6 monitors were representative of the background population, we compared the observed Actical
7 counts for the 43 children to their values predicted from the greater (n = 198) OOA sample
8 based on age, sex, and z-BMI. We found no difference between observed and predicted Actical
9 counts (409 ± 129 vs. $386 \pm 71 \times 10^3$ counts/d, $p = 0.22$) leading us to conclude that the 43
10 Actiwatch-wearing children were indeed representative of the greater sample.

11 **Figure 2** shows Actiwatch counts by sex and age group in the ES and the OOA. Total
12 activity counts were higher in the OOA than in the ES (338 ± 97 vs. $227 \pm 67 \times 10^3$ counts/d, $p <$
13 0.0001 by t -test). A multivariate regression analysis adjusting for age and sex produced least
14 squares means that deviated minimally from the crude means (LS means [95% CI] $333 [312,$
15 $351]$ vs. $228 [219, 236] \times 10^3$ counts/d, $p < 0.0001$). Moreover, the age x group interaction was
16 significant ($p = 0.01$), such that the amount by which the OOA counts exceeded the ES counts
17 diminished with increasing age. Compared to the ES, the OOA spent more time in both light
18 activity (442 ± 56 vs. 408 ± 75 min/d, $p = 0.005$) and MVPA (106 ± 54 vs. 53 ± 32 min/d, $p <$
19 0.0001) (**Figures 3 and 4**).

21 ***Relation between physical activity and body composition***

22 The relation between physical activity and body composition was examined in the 198
23 OOA children who had valid Actical data. Compared to girls, boys collected significantly more
24 total average daily Actical counts (427 ± 114 vs. $311 \pm 109 \times 10^3$ counts/d, $p < 0.0001$), spent
25 more time in MVPA (117 ± 42 min/d vs. 74 ± 40 min/d, $p < 0.0001$), and spent less time in
26 sedentary activity (835 ± 83 min/d vs. 867 ± 94 min/d, $p = 0.009$). In separate mixed models,

1 adjusting for family membership as a random variable, z-BMI ($\beta = -4.93 \times 10^{-3}$, $p = 0.0009$), and
2 body weight above the age- and sex- specific median ($\beta = -46.2 \times 10^{-3}$, $p = 0.003$) were both
3 inversely correlated with time spent in MVPA (**Figures 5 and 6**), but not with time spent in
4 sedentary activity ($p = 0.48 - 0.62$). There was no significant moderating (interaction) effect of
5 sex on the relationships between body composition and MVPA ($p = 0.24 - 0.36$). According to
6 the effect sizes (β -coefficients) of these relationships, an increment of MVPA by 53 min/d is
7 associated with a decrement of BMI by 0.26 SD, or body weight by 2.45 kg.

8

9

DISCUSSION

10

11 In this study there were three major findings: First, OOA children differ minimally from
12 CDC prescriptive norms with regard to BMI, whereas ES children are more frequently
13 overweight, in agreement with mainstream NHANES trends. Second, OOA children are more
14 physically active than ES children, spending twice as much time in MVPA. Third, within the OOA
15 group, we found that differences in MVPA statistically may explain up to 2.5 kg of the difference
16 in mean body weight between the two groups.

17 The first two findings are in agreement with Bassett, et al., (10), who found high levels of
18 PA and a low prevalence of overweight in Amish children residing in Canada. The third finding
19 expands previous work by providing evidence, in a cross-sectional fashion, that suggests a
20 causal connection between PA and overweight, and quantifying the potential effect size.

21 The finding of such great differences in PA between the Amish and the ES is intriguing
22 because studies (11, 12), comparing other groups whose environments were thought to differ
23 crucially, found that the groups had similar levels of PA. The origins of the OOA/ES differences
24 are unclear. In addition to chores and outside play, the prominence of active transportation in
25 the OOA may play a role. Bicycles are not allowed but walking and foot-propelled scooters
26 (which are less energy-efficient than bicycles) are used for local travel. By contrast, the ES

1 almost universally travel to school and other destinations by bus or car. Future studies, mapping
2 the nature of activities undertaken by OOA youths may provide ideas for the design of
3 interventions to reduce weight gain in mainstream youths through an increase in PA, as
4 previously no such interventions have been clearly successful (13).

5 Some (5, 14, 15), but not all, studies in children have found a relation between PA and
6 body composition, either in the whole sample or a subgroup. Treuth, et al. (5) found an inverse
7 association between body fatness and PA as measured by accelerometry in the ES children,
8 but only in girls. Compared to the existing literature, we suspect that the relatively wide range of
9 PA levels in the OOA, the use of an objective measure of PA, and limited variability in other
10 environmental factors may have enhanced our ability to demonstrate a true correlation between
11 PA and body composition.

12 The inverse correlation between PA and BMI found in the OOA, the ES and a number of
13 other populations is supportive of the hypothesis that differences in PA explain differences in
14 body composition. However, the opposite causality is also possible (i.e., lack of obesity may
15 facilitate PA), there could be bidirectional causal relationships, or finally, no relationship other
16 than a shared influence of an antecedent cause.

17 Under the assumption that causality runs from activity to body composition, the effect
18 size (β -coefficient) of this relation indicates that the ES would have been, on average, about 2.5
19 kg lighter if they had spent as much time in MVPA as the OOA, 106 min/d, instead of their
20 actual 53 min/d. Even in this “best-case-scenario”, however, differences in MVPA explain only
21 about one-third of the difference in body weight between the groups, meaning that other factors,
22 such as diet, must also play a role.

23 In agreement with other studies (16, 17) we found that OOA children become less
24 physically active with increasing age, and within each group, girls tend to be less physically
25 active than boys. While this gender dimorphism could suggest biological sex differences, it is

1 likely that cultural norms also play a large role, as evidenced by the fact that OOA girls were
2 easily more active than ES boys.

3 Data from the Youth Risk Behavior Survey (18, 19) suggest that PA declined among US
4 adolescents from 1993-2003. A recent development that may help to explain a decline in PA in
5 the mainstream population is the proliferation of electronic devices. Although OOA businesses
6 are permitted to have computers, they are never used in homes, nor are televisions or electronic
7 games.

8 In contrast to children, the BMI of adult OOA adults is similar to that of the general, non-
9 Amish, Caucasian population (20). Nevertheless, adult OOA have approximately half the
10 prevalence of diabetes compared to the general United States population of European ancestry
11 (20, 21). The present study suggests that the OOA preferentially gain their excess weight in
12 adulthood rather than as children and adolescents. Thus one could hypothesize that adult OOA
13 may be relatively protected against diabetes in adulthood because of a shorter lifetime exposure
14 to obesity (i.e., fewer “fat-years” in analogy to the health risks from “pack-years” of cigarette
15 smoking).

16 Some limitations of our findings deserve mention. The study was an observational,
17 cross-sectional study, unable to establish causality. We could not assure representativeness in
18 our sample by any means other than our efforts to recruit randomly and present the study to
19 prospective subjects in ways that would not introduce bias in enrollment. However, we believe
20 the ascertainment was as unbiased as possible. Data from NHANES was obtained from a
21 published summary which meant that we could not perform statistical tests against our own
22 data. However, we find it unlikely that statistical testing would provide additional insights.

23 It is a strength of the study that the measurement of PA was performed with the exact
24 same instrumentation and procedures in the OOA and the ES. Although the number of OOA
25 who wore the Actiwatch was limited to 43, we could use the data collected by their

1 simultaneously worn Actical monitors to ensure that they were representative of the larger OOA
2 sample.

3 Thus, our results indicate that in comparison to a group of non-Amish children living
4 nearby, OOA children spend twice as much time in MVPA, which may in part explain why they
5 are less frequently overweight.

ACKNOWLEDGEMENTS

Support was provided by the Clinical Nutrition Research Unit of Maryland (P30 DK072488), the Geriatric Research and Education Clinical Center, Baltimore Veterans Administration Medical Center, a postdoctoral NIH/NIA training grant T32 AG000219 (JDD), a postdoctoral award from the American Diabetes Association (KGH), and K01 AG22782 (WCH). The ES study was supported by the CDC Agency for Toxic Substances and Disease Registry Project S1906-21.

The authors would like to extend their gratitude to the Amish study participants and to the extraordinary efforts of our Amish Research Clinic staff.

REFERENCES

1. Lynn Parker, Annina Catherine Burns, and Eduardo Sanchez, Editors; Committee on Childhood Obesity Prevention Actions for Local Governments; Institute of Medicine; National Research Council. National Academies Press, Washington, DC, 2008. Available for download at <http://www.iom.edu/Reports/2009/ChildhoodObesityPreventionLocalGovernments.aspx>
2. U.S. Department of Health and Human Services. 2008 Physical Activity Guidelines for Americans. Government printing office, 2008. Available for download at <http://www.health.gov/paguidelines/guidelines/summary.aspx>
3. At Least Five a Week. Department of Health, Physical Activity, Health Improvement and Prevention. Available for download at http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_4080981.pdf
4. World Health Organization. Global Strategy on Diet, Physical Activity, and Health. Available for download at http://www.who.int/dietphysicalactivity/strategy/eb11344/strategy_english_web.pdf
5. Treuth MS, Hou N, Young DR, Maynard LM. Accelerometry-measured activity or sedentary time and overweight in rural boys and girls. *Obes Res* 2005; 13:1606-1614.
6. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999-2004. *JAMA* 2006; 295:1549-1555.
7. Available for download at <http://www.cdc.gov/growthcharts>
8. Heil DP. Predicting activity energy expenditure using the Actical activity monitor. *Res Q Exerc Sport*. 2006;77:64-80.
9. Puyau MR, Adolph AL, Vohra FA, Butte NF. Validation and calibration of physical activity monitors in children. *Obes Res*. 2002;10:150-7.

10. Esliger DW, Tremblay MS, Copeland JL, Barnes JD, Huntington GE, Bassett DR Jr. Physical activity profile of Old Order Amish, Mennonite, and contemporary children. *Med Sci Sports Exerc.* 2010;42:296-303.
11. Wilkin TJ, Mallam KM, Metcalf BS, Jeffery AN, Voss LD. Variation in physical activity lies with the child, not his environment: evidence for an 'activitystat' in young children (EarlyBird 16). *Int J Obes (Lond).* 2006;30:1050-5.
12. Ebersole KE, Dugas LR, Durazo-Arvizut RA, Adeyemo AA, Tayo BO, Omotade OO, Brieger WR, Schoeller DA, Cooper RS, Luke AH. Energy expenditure and adiposity in Nigerian and African-American women. *Obesity* 2008;16:2148-54.
13. Wareham NJ, van Sluijs EM, Ekelund U. Physical activity and obesity prevention: a review of the current evidence. *Proc Nutr Soc.* 2005;64:229-47.
14. Ness AR, Leary SD, Mattocks C et al. Objectively measured physical activity and fat mass in a large cohort of children. *PLoS Med* 2007;4:e97. doi:10.1371/journal.pmed.0040097
15. Hughes AR, Henderson A, Ortiz-Rodriguez V, Artinou ML, Reilly JJ. Habitual physical activity and sedentary behavior in a clinical sample of obese children. *Int J Obes (Lond)* 2006;30:1494-500.
16. Nader PR, Bradley RH, Houts RM, McRitchie SL, O'Brien M. Moderate-to-vigorous physical activity from ages 9 to 15 years. *JAMA.* 2008;300:295-305.
17. Kimm SYS, Glynn NW, Kriska AM et al. Decline in physical activity in black girls and white girls during adolescence. *New Engl J Med* 2002; 156:1075-1080.
18. Brownson RC, Boehmer TK, Luke DA. Declining rates of physical activity in the United States: what are the contributors? *Annu Rev Public Health.*2005; 26 :421–443

19. Adams J. Trends in physical activity and inactivity amongst US 14–18 year olds by gender, school grade and race, 1993–2003: evidence from the Youth Risk Behavior Survey. *BMC Public Health*.2006; 6 :57

20. Hsueh WC, Mitchell BD, Aburomia R, Pollin T, Sakul H, Gelder Ehm M, Michelsen BK, Wagner MJ, St Jean PL, Knowler WC, Burns DK, Bell CJ, Shuldiner AR. Diabetes in the Old Order Amish: characterization and heritability analysis of the Amish Family Diabetes Study. *Diabetes Care*. 2000;23:595-601.

21. Snitker S, Mitchell BD, Shuldiner AR. Physical activity and prevention of type 2 diabetes. *Lancet*. 2003;361:87-8.

Table 1. Characteristics and physical activity measures for Old Order Amish (OOA) and Eastern Shore (ES) children.

Age (y)		Group		P (OOA vs. ES)
		OOA	ES	
8-11*		57 girls/45 boys	53 girls/48 boys	
	Age (years)	9.5 ± 1.1	9.8 ± 1.1	0.15
	Body weight (kg)	34.0 ± 8.6	41.4 ± 13.2	<.0001
	Weight above CDC age and sex median (kg)	1.3 ± 6.7	7.4 ± 12.1	0.0003
	BMI (kg/m ²)	17.4 ± 2.7	20.5 ± 4.5	<.0001
	z-BMI	0.08 ± 0.84	0.77 ± 1.12	<.0001
	Percent body fat	17.7 ± 5.8	23.5 ± 11.0	<.0001
	N weight ≥ 85 th percentile for age and sex	15 (18%)	45 (80%)	<.0001
	Actiwatch counts (10 ³ /d)	378 ± 84 [¶]	248 ± 67	<.0001
	Time spent in light activity (min/d)	434 ± 40 [¶]	430 ± 73	0.82
	Time spent in moderate/vigorous activity (min/d)	128 ± 45 [¶]	61 ± 34	<.0001
OOA				
ES				
12-19		72 girls/96 boys	51 girls/77 boys	
	Age (years)	14.7 ± 2.1	14.4 ± 1.8	0.06
	Body weight (kg)	54.7 ± 12.3	63.8 ± 17.3	<.0001
	Weight above CDC age and sex median (kg)	2.0 ± 9.4	11.2 ± 17.3	<.0001
	BMI (kg/m ²)	20.7 ± 3.1	23.5 ± 5.7	<.0001
	z-BMI	0.13 ± 0.82	0.62 ± 1.08	<.0001
	Percent body fat	18.8 ± 8.1	23.7 ± 11.9	<.0001
	N weight ≥ 85 th percentile for age and sex	21 (14%)	45 (54%)	<.0001
	Actiwatch counts (10 ³ /d)	297 ± 94 [§]	210 ± 62	<.0001
	Time spent in light activity (min/d)	450 ± 68 [§]	391 ± 72	0.001
	Time spent in moderate/vigorous activity (min/d)	83 ± 54 [§]	47 ± 29	<.0001

Values are means ± SD or N (percent). z-BMI, Body Mass Index z-score. CDC, Centers for Disease Control and Prevention. *Youngest children in ES group were 7 yrs. old (n=2). [¶]N = 9 girls/13 boys. [§]N = 10 girls/11 boys.

Figure 1. Prevalence of BMI at or above the 85th percentile in NHANES non-Hispanic White (NHW) children, ES, and OOA, by age stratum as used in (5); youngest children in ES and OOA cohorts were 7 and 8 years, respectively. * $p < 0.0001$ for ES vs. OOA.

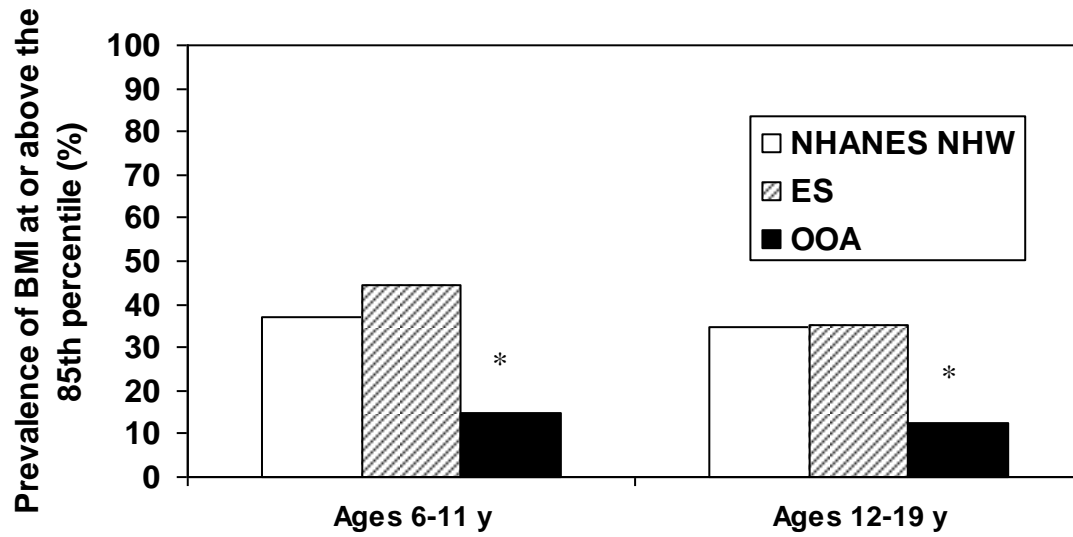
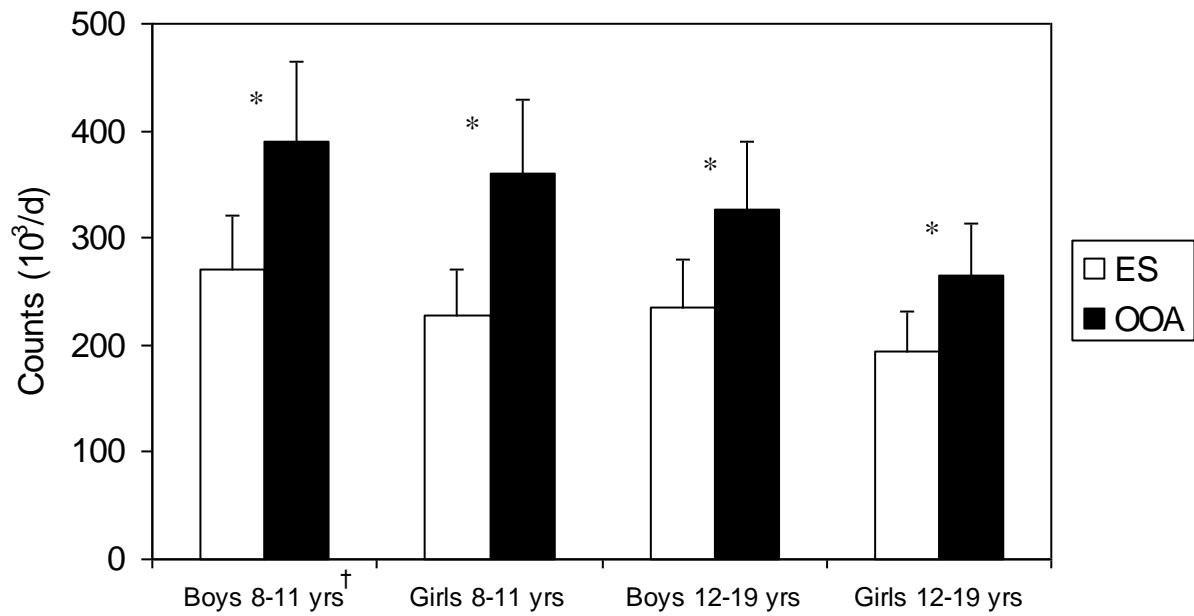
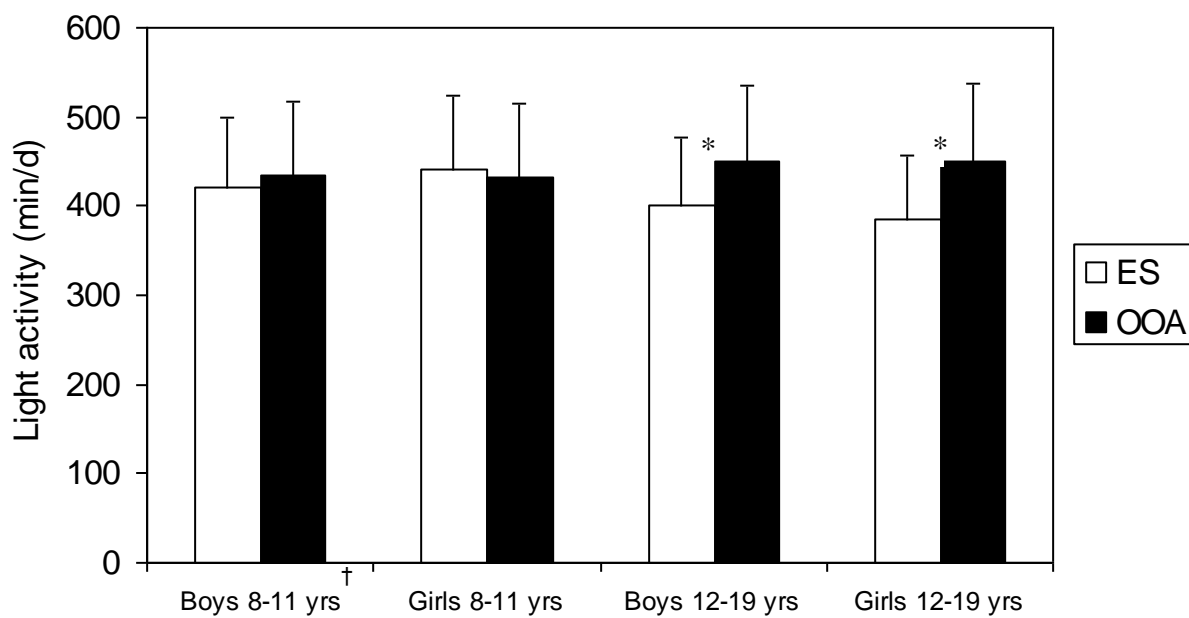


Figure 2. Physical activity levels (accelerometer counts) in OOA and ES children by age group and sex.



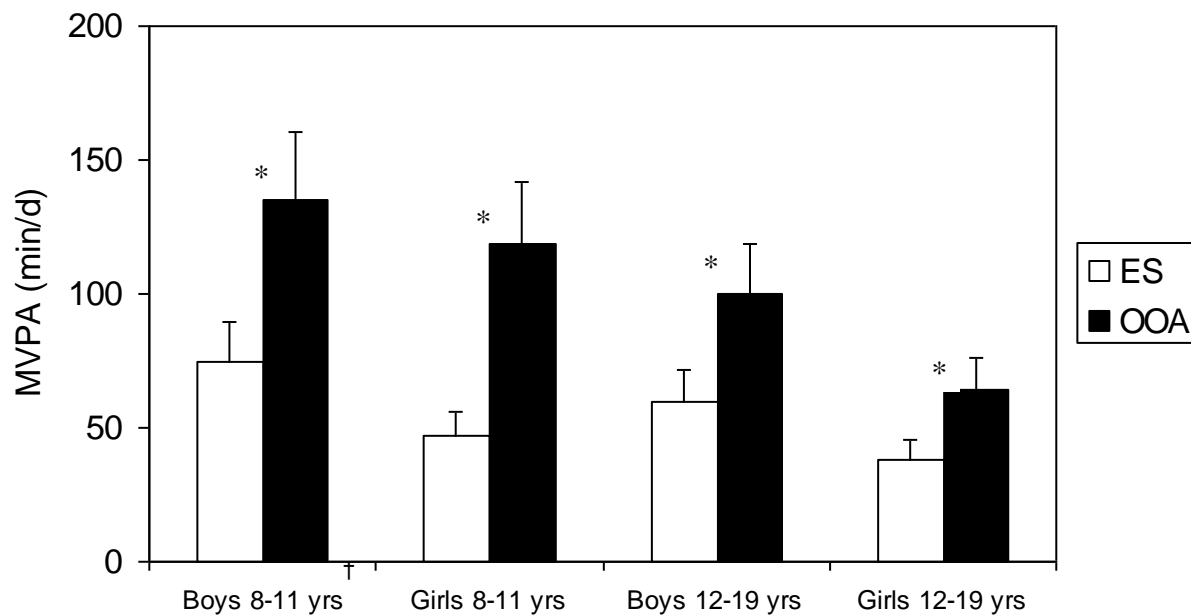
[†]The ES group included 2 boys aged 7 yrs. *ES < OOA, $p < 0.005$ or better.

Figure 3. Time spent in light activity in ES and OOA children by age group and sex.



†The ES group included 2 boys aged 7 yrs. *ES < OOA, $p < 0.05$ or better.

Figure 4. Time spent in MVPA (moderate/vigorous physical activity) in OOA and ES children by age group and sex.



†The ES group included 2 boys aged 7 yrs. *ES < OOA, $p < 0.05$ or better.

Figure 5

Figure 5. BMI z-score as a function of time spent in MVPA (moderate/vigorous physical activity) in OOA children ($r = -0.24$, $p = 0.0006$). The correlation was robust to adjustment for age by partial correlation ($r = -0.24$, $p = 0.0007$)

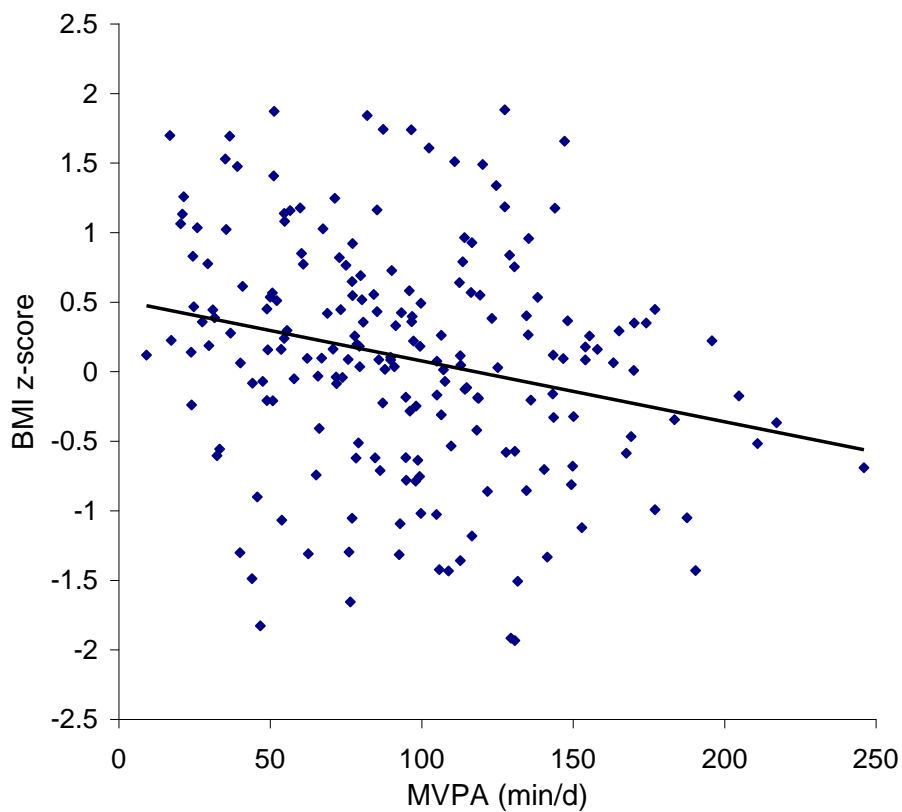


Figure 6

Figure 6. Body weight above the age- and sex- specific CDC median as a function of time spent in MVPA (moderate/vigorous physical activity) in OOA children ($r = -0.29$, $p < 0.0001$). The correlation was robust to adjustment for age by partial correlation ($r = -0.28$, $p < 0.0001$).

