Comparison of BMI and Physical Activity Between Old Order Amish Children and Non-Amish Children

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OBJECTIVE—The Old Order Amish (OOA) is a conservative Christian sect of European origin living in Pennsylvania. Diabetes is rare in adult OOA despite a mean BMI rivaling that in the general U.S. non-Hispanic white population. The current study examines childhood factors that may contribute to the low prevalence of diabetes in the OOA by comparing OOA children aged 8–19 years with National Health and Nutrition Examination Survey (NHANES) data and children from Maryland's Eastern Shore (ES), a nearby, non-Amish, rural community. We hypothesized that pediatric overweight is less common in OOA children, that physical activity (PA) and BMI are inversely correlated, and that OOA children are more physically active than ES children.

RESEARCH DESIGN AND METHODS—We obtained anthropometric data in 270 OOA children and 229 ES children (166 non-Hispanic white, 60 non-Hispanic black, 3 Hispanic). PA was measured by hip-worn accelerometers in all ES children and in 198 OOA children. Instrumentation in 43 OOA children was identical to ES children.

RESULTS—OOA children were approximately 3.3 times less likely than non-Hispanic white ES children and NHANES estimates to be overweight (BMI ≥85th percentile, Centers for Disease Control and Prevention). Time spent in moderate/vigorous PA (MVPA) was inversely correlated to BMI z-score ($r = -0.24$, $P = 0.0006$). PA levels did not differ by ethnicity within the ES group, but OOA children spent an additional 34 min/day in light activity (442 ± 56 vs. 408 ± 75, $P = 0.005$) and, impressively, an additional 53 min/day in MVPA (106 ± 54 vs. 53 ± 32, $P < 0.0001$) compared with ES children. In both groups, boys were more active than girls but OOA girls were easily more active than ES boys.

CONCLUSIONS—We confirmed all three hypotheses. Together with our previous data, the study implies that the OOA tend to gain their excess weight relatively late in life and that OOA children are very physically active, both of which may provide some long-term protection against diabetes.

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The Old Order Amish (OOA) is a conservative Christian sect of European origin living in rural areas of Lancaster County, Pennsylvania. We have previously reported (1) that the prevalence of diabetes in adult OOA is only approximately half of that in the general U.S. population of European ancestry. This is an intriguing finding because the mean BMI of adult OOA (26.9 kg/m^2) rivals that of the adult general U.S. population of European ancestry (26.5 kg/m^2) (1). By contrast, our anecdotal observations from the same Lancaster County Amish community suggest that OOA children are very rarely overweight compared with non-Amish U.S. children. If correct, our anecdotal observations imply that the OOA generally tend to gain their excess weight at a later stage in life than the general, non-Amish U.S. population. Gaining one's excess weight relatively late in life may be protective against diabetes, as several prospective studies of adults indicate that the number of years lived with obesity is a predictor of diabetes risk (2,3) independently of age and current BMI. Thus, to follow up on our report on OOA adults, we designed the OOA Childhood Obesity Study to collect data in OOA children and adolescents (in the following, children and adolescents will collectively be referred to as "children"). If OOA children are indeed much more rarely overweight than their non-OOA peers, this observation would pave the way for studies involving this population to better understand the role of weight-gain trajectory in the etiology of disease. The first aim was to compare the age- and sex-adjusted BMI of OOA children with estimates from the National Health and Nutrition Examination Survey (NHANES).

The second aim was to test the hypothesis that physical activity (PA) and BMI are correlated in the OOA. Although it is often taken for granted that PA and BMI are causally connected, the two are not always correlated on a population level. Reports indicate that PA has important BMI-independent effects on diabetes risk (4), and it has been argued (5) that PA is the most proximal behavioral factor influencing insulin resistance. PA was measured objectively by hip-worn PA monitors (accelerometers).

Another relevant question is whether PA levels in Amish children differ from those of their non-Amish peers. OOA life is guided by the *Ordnung*—rules that regulate many aspects of life to be consistent with OOA values, which are religious devotion, family, and community cohesion. Many modern technologies are banned, including electric power, telephones, self-powered farm equipment, and personal automobiles. These voluntary constraints result in a lifestyle resembling that of farming Americans or Europeans a century or two ago. Although one might

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think that these circumstances promote greater levels of PA in OOA children compared with non-Amish children, the null hypothesis is favored by studies (6,7) finding similar PA levels in other groups whose environments differ greatly (e.g., individuals residing in the U.S. and Nigeria).

To compare OOA children with a relevant control, we amended the protocol of the OOA Childhood Obesity Study by adding, as a third aim, a comparison of PA levels in the OOA children with non-Amish children residing in Maryland's Eastern Shore (ES). The ES is a nearby, rural community with similar topography and climate. One of the investigators, who had collected PA data in the ES a few years prior (8), provided the protocol, instrumentation, and data to allow a direct comparison. The final 43 OOA participants were enrolled in the amended protocol.

RESEARCH DESIGN AND METHODS

Study populations

The study enrolled 270 OOA children aged 8–19 years from Lancaster County, Pennsylvania from 2005 to 2007. Requirements for participation were willingness to wear an accelerometer around the waist for 9 days and to undergo a physical examination. 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 PA 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 PA level. Informed parental consent and minor assent were obtained before any study procedure. The study was approved by the Institutional Review Board of the University of Maryland Baltimore.

The ES children were recruited in 2002 as part of a school-based PA assessment study (8). Participants were girls and boys residing on the ES of Maryland and attending one elementary and one combined middle and high school. Of 234 enrolled children, 5 were excluded because of incomplete accelerometry data. The final ES sample (n = 229) included 130 girls and 99 boys aged 7–19 years. The ES children were 72% non-Hispanic white (n = 166), 26% non-Hispanic black (n = 60), and 1% Hispanic (n = 3). The methods and consent and assent procedures of the ES study have been published previously (8) and are largely similar to those of the OOA study. The ES study was approved by the Institutional Review Board of the Johns Hopkins Bloomberg School of Public Health and by the county school board of education.

The OOA and ES samples were compared with contemporaneous national estimates in a published summary (9) of data from the NHANES 2003–2004 cycle. NHANES is a complex, multistage probability sample of the U.S. civilian, noninstitutionalized population, conducted by the National Center for Health Statistics of the Centers for Disease Control and Prevention (CDC). Its 2003–2004 cycle included 3,958 children.

Measurements

The OOA children underwent a brief physical examination, including measurements of height (Shorrboard ICA stadiometer; Olney, MD) and weight (calibrated electronic scale). The ES children were examined according to an essentially identical protocol (8). BMI was calculated as weight/height in meters squared (kg/m^2). BMI values were converted to z-scores (z-BMI) and percentiles based on the 2000 CDC age- and sex-specific tables using algorithms and parameters provided on the CDC Web site (10). Because it is difficult to visualize the physical manifestation of a given z-BMI value, we also calculated the variable *body weight above the CDC age- and sex-specific median* by subtraction of the CDC age- and sex-specific 50th percentile from individual body weight.

PA by Actical

The Actical PA monitor (version 8.4; Mini Mitter Co., Inc., Bend, OR) was used throughout the study in OOA children. The Actical device has been validated by Heil (11) against gas exchange in children and adolescents aged 8–17 years. Epoch length was set for 15 s and software version 2.04 was used for programming. The device was worn on the lateral aspect of the hip, held in place by a neoprene belt around the body, recording for at least 7 consecutive days, 24 h a day. To keep the belt dry, participants were permitted to remove it (and thus the monitor) for showering or bathing. The Actical analysis incorporated the first 7 complete days of wear (from midnight to midnight). Noncompliance with the 24 h-a-day wear requirement was detected by the presence of extended periods of zero counts. A day was considered incomplete due to nonwear if an incident of subsequent zero counts lasted for more than 1 h. However, up to three nights of nonwear was tolerated (in this context, "night" was defined by the child's habitual sleep and wake times). Noncompliance was rare; only 11 children had more than 2 incomplete days and were excluded from analysis. Four recordings were excluded as a result of obvious device malfunction. Fifty-seven children did not have Actical recordings because of temporary device shortages. During these times of high demand, Actical devices were assigned randomly to participating children. Usable Actical recordings were available in 198 children (97 boys and 101 girls). In addition to total daily counts, activity energy expenditure was calculated on a per-minute basis, using Heil's equations (11), as implemented in the Actical software, to derive time spent at defined levels of PA intensity (sedentary, light, moderate, and vigorous). Using a cutoff point between light and moderate activity of $\geq$0.05 kcal $\cdot$ kg^{-1} $\cdot$ min^{-1} as proposed by Puyau et al. (12) for children and adolescents, we report time spent in a collapsed category of moderate and vigorous PA (MVPA). Sedentary activity was defined as periods with an activity count of less than 50 counts/min for 10 consecutive min. The activity measures were expressed as daily means.

PA by Actiwatch

All ES children and the final 43 OOA children wore the Actiwatch PA monitor (Mini Mitter Co., Inc.), which is physically similar to the Actical but has slightly different electronics and software. All Actiwatch devices used for the OOA had been used in the ES study (provided by M.S.T.) or had a serial number in the same range (i.e., starting with "V63"). All OOA children who wore an Actiwatch also simultaneously wore an Actical according to the protocol used before the Actiwatch was added. The simultaneous use of Actiwatch and Actical monitors allowed us to examine whether PA levels in the final 43 children were representative of the entire OOA cohort. The OOA Actiwatch protocol was developed in collaboration with M.S.T. to be identical to that used in the

ES protocol (8). The following applies to Actiwatch studies in both ES and OOA: The device was worn on the lateral aspect of the hip and held in place by a neoprene belt around the body. Actiware Rhythm 3.03 software was used to program the devices for an epoch length of 1 min and upload data. These data were considered to be complete if ~70% of the day (1,000 min) was recorded for at least 4 of the 6 days with 2 of the days on a weekend. An Excel spreadsheet macro, developed in the laboratory of Dr. Nancy Butte (U.S. Department of Agriculture Children's Nutrition Research Center, Baylor College of Medicine, Houston, TX), was used to calculate amount of time spent at defined levels of PA. We used the Actiwatch cutoff points proposed by Puyau et al. (12), which are based on a threshold between light and moderate activity of $\geq$0.05 kcal $\cdot$ $kg^{-1} \cdot min^{-1}$ for children and adolescents and report time spent in a collapsed category of MVPA.

Statistical analysis

Analyses were performed with SAS 9.1 software (SAS Institute Inc., Cary, NC). We compared continuous variables between OOA and ES children using ANOVA to adjust for age and sex. Prevalence of high BMI-for-age (defined as BMI $\geq$85th percentile for age and sex) was compared between groups using logistic regression. Actical data from 198 OOA children were used to assess the relation of PA levels to BMI in this group; this question has previously been examined in the ES children (8). To account for multiple OOA subjects who were recruited from the same household, a mixed model was used, adjusting for family as a random effect. Each of the 80 families was numbered from 1 to 80. The family number was defined as a class variable in an SAS PROC MIXED model with the BMI measure of interest as the dependent variable and the PA measure of interest and the family number as the independent variables. The family number was specified as a random effect. Actiwatch data from 43 OOA and 229 ES children were used to compare PA levels between groups. A *t* test was used to examine whether the 43 dual-device (i.e., simultaneously wearing Actical and Actiwatch) OOA children were representative of the greater (n = 198) OOA sample. Adjusted point estimates are given as least-squares means using the LSMEANS statement in PROC GLM.

RESULTS

Physical characteristics of OOA and ES children

The age range was 8–19 years in the OOA sample and 7–19 years in the ES sample, as the latter included 2 children aged 7 years. Mean age was 12.4 ± 3.1 and 12.0 ± 2.8 years in the OOA and ES children, respectively (P = 0.13). ES children had higher mean BMI (22.1 ± 5.4 vs. 19.5 ± 3.4 kg/m^2), z-BMI (0.68 ± 1.1 vs. 0.11 ± 0.82), and *body weight above the age- and sex-specific CDC median* (9.6 ± 15.0 vs. 1.7 ± 8.5 kg; all $P <$ 0.0001). Table 1 reports the characteristics of the 270 OOA children and 229 ES children according to age-group.

Within the ES, mean body weight was 7.0 kg higher in non-Hispanic black participants than in non-Hispanic white participants after adjustment for age and sex (P = 0.002). Thus, to produce the most conservative estimate of the effect of the OOA/ES environmental differences on BMI, we performed an analysis limited to the ES non-Hispanic white subgroup (n = 166). The prevalence of a BMI $\geq$85th percentile was 13.3% in the OOA and 34.3% in ES non-Hispanic whites ($P <$ 0.0001); age- and sex- adjusted odds ratio of 0.30 (95% CI 0.19–0.49). In the group aged 11 years and younger, the prevalence was 14.7% in the OOA, 37.3% in ES non-Hispanic whites ($P <$ 0.0001), and 36.9% in NHANES non-Hispanic whites. In the group aged 12 years and older, the prevalence was 12.5% in the OOA, 31.9% in ES non-Hispanic whites ($P <$ 0.0001), and 34.7% in NHANES non-Hispanic whites.

Correlates of PA in the OOA children

Actical recordings were not available for 72 of the 270 OOA children because of device shortages during times of increased demand, noncompliance, or device malfunction (see RESEARCH DESIGN AND METHODS). The 72 subjects who had no Actical data were slightly older than the 198 that did (13.9 ± 3.7 vs. 12.3 ± 2.7 years, P = 0.0008), but there were no differences in sex distribution (56 vs. 51% girls, P = 0.51) or z-BMI (0.15 ± 0.84 vs. 0.09 ± 0.82, P = 0.61). Correlates of PA were examined in the 198 OOA children who had Actical data.

Compared with OOA girls, OOA boys collected significantly more total average daily Actical counts (427 ± 114 vs. 311 ± 109 × 10^3 counts/day, $P <$ 0.0001), spent more time in MVPA (117 ± 42 vs. 74 ± 40 min/day, $P <$ 0.0001), and spent less time in sedentary activity (835 ± 83 vs. 867 ± 94 min/day, P = 0.009). The OOA children belonged to 80 nuclear families (mean number of participating siblings per family was 3.4 ± 1.0 [range 1–8]). In separate mixed

Table 1—*Physical characteristics for OOA and ES children*

	Ages 8–11		P	Ages 12–19		P
	OOA	ES*	OOA vs. ES	OOA	ES	OOA vs. ES
Sex						
Girls	45	53		96	77	
Boys	57	48		72	51	
Age (years)	9.5 ± 1.1	9.8 ± 1.1	0.15	14.7 ± 2.1	14.4 ± 1.8	0.06
Body weight (kg)	34.0 ± 8.6	41.4 ± 13.2	<0.0001	54.7 ± 12.3	63.8 ± 17.3	<0.0001
Above CDC age and sex median (kg)	1.3 ± 6.7	7.4 ± 12.1	0.0003	2.0 ± 9.4	11.2 ± 17.3	<0.0001
BMI (kg/m^2)	17.4 ± 2.7	20.5 ± 4.5	<0.0001	20.7 ± 3.1	23.5 ± 5.7	<0.0001
z-BMI	0.08 ± 0.84	0.77 ± 1.12	<0.0001	0.13 ± 0.82	0.62 ± 1.08	<0.0001
Weight ≥85th percentile for age and sex	15 (14.7)	45 (44.6)	<0.0001	21 (12.5)	45 (35.2)	<0.0001

Data are shown as n (%) or means ± SD. *The youngest children in ES group were 7 years old (n = 2).

models, adjusting for family as a random effect, z-BMI ($\beta = -4.93 \times 10^{-3}$, $P = 0.0009$), and body weight above the CDC age- and sex- specific median ($\beta = -46.2 \times 10^{-3}$, $P = 0.003$) were both inversely correlated with time spent in MVPA (Fig. 1), but not with time spent in sedentary activity ($P = 0.48$–0.62). When the above models with relative body size as the dependent variable were expanded to include sex as an independent variable in addition to MVPA (and family number), there was no significant effect of sex ($P = 0.13$–0.20).

PA in OOA and ES children

The entire cohort of 229 ES children was used for comparison with the 43 Actiwatch-wearing OOA children because neither total Actiwatch activity counts, time spent in light activity, nor time spent in MVPA differed by race or ethnicity in the ES participants (total counts 227 ± 69 [non-Hispanic White], 225 ± 64 [non-Hispanic black], 228 ± 40 [Hispanic] $\times 10^3$ counts/day; $P = 0.49$ for non-Hispanic white vs. non-Hispanic black). OOA children collected approximately 1.5 times as many total Actiwatch counts as ES children (338 ± 97 vs. 227 ± 67 $\times 10^3$ counts/day; $P < 0.0001$). Compared with the ES, the OOA spent more time in both light activity (442 ± 56 vs. 408 ± 75 min/day, $P = 0.005$) and MVPA (106 ± 54 vs. 53 ± 32 min/day, $P < 0.0001$). A multivariate regression analysis of differences in PA between OOA and ES, adjusted for age and sex, produced least-squares means that deviated minimally from the crude means, demonstrating that minor imbalances in sex and age between the OOA and ES groups were inconsequential for the group comparisons (least-squares means [95% CI] total counts in OOA vs. ES: 333 [312–351] vs. 228 [219–236] $\times 10^3$ counts/day, $P < 0.0001$; light activity 439 [417–461] vs. 409 [399–418] min/day, $P = 0.001$; MVPA 102 [92–112] vs. 54 [50–58] min/day, $P < 0.0001$). Although OOA girls collected fewer total counts and spent less time in MVPA than OOA boys, OOA girls collected more total counts than ES boys (310 ± 105 vs. 252 ± 63 $\times 10^3$ counts/day; $P = 0.01$) and spent more time in MVPA than ES boys (90 ± 56 vs. 67 ± 31 min/day, $P = 0.002$). All statistically significant comparisons of PA between the OOA and the multiracial/ethnic group of ES children remained significant when the ES group was limited to the 166 non-Hispanic white children. Table 2 and Fig. 2 provide further stratification by age-group and sex.

To examine whether the 43 OOA Actiwatch studies—which were done in March and April—were subject to seasonal bias or sampling error, we took advantage of the following circumstances: *1*) all OOA children wearing the Actiwatch had simultaneously been wearing Actical devices, and 2) the Actical devices had been used year-round in the greater OOA sample. Thus, we could compare the Actical counts of the dual device–wearing children with the means of the Actical counts of the entire OOA sample. The Actical total counts in the dual device–wearing children did not differ from the means of the entire OOA sample in any of the four strata defined by sex and age-group ($P = 0.22$–0.46), indicating that the PA levels of the dual device–wearing children were indeed representative of the greater OOA sample.

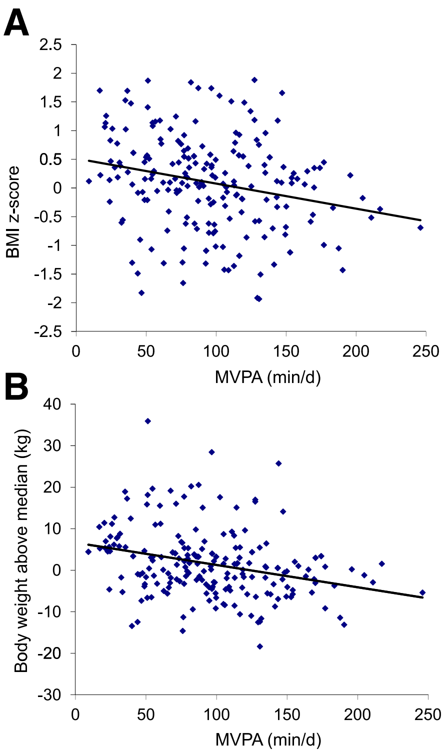

Figure 1—A: *BMI z-score as a function of time spent in MVPA in OOA children* (r = −0.24, P = 0.0006). *The correlation was robust to adjustment for age by partial correlation* (r = −0.24, P = 0.0007). B: Body weight above the age- and sex-specific CDC median *as a function of time spent in MVPA in OOA children* (r = −0.29, P < 0.0001). *The correlation was robust to adjustment for age by partial correlation* (r = −0.28, P < 0.0001). *(A high-quality color representation of this figure is available in the online issue.)*

As an additional analysis, we examined differences between weekend and nonweekend days. In the OOA children, total activity counts on Saturdays were within ±1% of the Monday through Friday average and on Sundays were 14.8% below the Monday through Friday average ($P < 0.0001$). In the ES, total activity counts on Saturdays were within ±1% of the Monday through Friday average and on Sundays were 5.3% below the Monday through Friday average ($P = 0.02$).

CONCLUSIONS—Diabetes is only half as prevalent in adult OOA as it is in non-Amish Americans of European origin, despite a similar mean BMI in both populations (1). Because the number of years lived with obesity is a risk factor for diabetes independent of age and current BMI (2,3), we wanted to investigate whether the trajectory of weight gain in the OOA is delayed relative to that of other Americans. If so, this might be a factor contributing to the decreased risk for developing diabetes in this population (13). Our study compared anthropometric observations from 270 OOA children with those of 166 non-Hispanic white participants from a multiracial/ethnic cohort of 229 non-Amish, rural children living nearby. Indeed, our study confirmed that OOA children are very rarely overweight compared with non-Amish rural children of European background, in whom the prevalence of a high BMI approximates national survey estimates from NHANES. Incidentally, the OOA children were extremely close to the historical populations on which the current CDC norms are based (10), as indicated by a mean z-BMI of ~0.1 or a mean body weight only 1 to 2 kg above the age- and sex-specific CDC median. Our observations are consistent with the notion that the OOA experience a delayed accretion of excess body weight compared with other Americans, a phenomenon that may protect against the development of diabetes.

Furthermore, we found that total PA and MVPA were inversely correlated to excess weight in the OOA. Some (8,14,15), but not all, pediatric studies have made concordant findings in the entire sample or a subgroup. Treuth et al. (8) found such a relationship in the ES children, but only in girls; in the OOA, there was no effect of sex on these relationships. We believe that the relatively wide range of PA levels in the OOA, the use of an objective measure of

Table 2—*PA as assessed by Actiwatch monitors for OOA and ES children*

	Ages 8–11 years		*P*	Ages 12–19 years		*P*
	OOA	ES*	OOA vs. ES	OOA	ES	OOA vs. ES
Sex						
Girls	9	53		10	77	
Boys	13	48		11	51	
Actiwatch counts (10^3/day)	378 ± 84	248 ± 67	<0.0001	297 ± 94	210 ± 62	<0.0001
Time spent in light activity (min/day)	434 ± 40	430 ± 73	0.82	450 ± 68	391 ± 72	0.001
Time spent in MVPA (min/day)	128 ± 45	61 ± 34	<0.0001	83 ± 54	47 ± 29	<0.0001

Data are shown as *n* or means ± SD. *The youngest children in ES group were 7 years old (*n* = 2).

PA, and limited variability in other environmental factors may have enhanced our ability to demonstrate a true correlation between PA and body composition. Regarding the direction of causality, some prospective studies of adults provide evidence that acquisition of excess weight precedes a decrement in activity (i.e., that obesity causes sedentary behavior [16]), although the traditional explanation that sedentary behavior causes obesity is probably also true (17).

Lastly, we compared PA between the OOA and the ES children living nearby. There was no effect of race or ethnicity within the ES group. In OOA children, compared with ES children, time spent in light activity was up from 408 to 442 min/day, and more dramatically, time spent in MVPA doubled from 53 to 106 min/day. These findings agree with those of Esliger et al. (18), who reported high levels of PA in a sample of Amish children residing in Canada. The magnitude of the differences in PA between the OOA and the ES is intriguing because other studies (6,7) comparing groups whose environments were thought to differ crucially found that the groups had similar levels of PA. The exact origins of the differences between OOA and ES children are unclear, but certain circumstances deserve mention. The OOA lifestyle affects the whole family, involving the children in household or farming chores from an early age. OOA children also seem to spend a substantial amount of time in outdoor play with their siblings and neighbors, facilitated by the large size of the average OOA nuclear family. OOA children do not use computers or electronic games, nor do they watch television. OOA children attend Amish one-room schoolhouses and almost always go outside for recess. Even the youngest OOA students use active transportation to get to school, generally walking in a group. Bicycles are banned, but some use a foot-propelled scooter, which is less energy-efficient than a bicycle. By contrast, the ES almost universally travel to school and other destinations by bus or car.

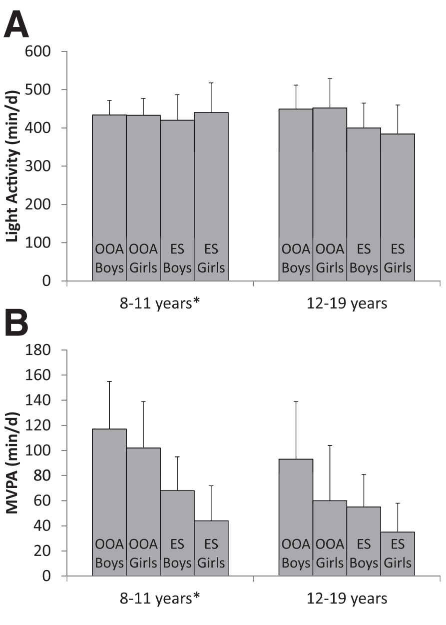

Figure 2—*Time spent in light activity* (A) *and MVPA* (B) *in 43 OOA and 229 ES children by age-group and sex. *The ES group included 2 boys aged 7 years. Mean data are presented with the SD.*

The high level of PA in the OOA is notable because despite public recommendations to increase PA (19–22), little is known about how to produce such an increase in youths (23). Although it would not be realistic to propose that non-Amish individuals adopt the OOA lifestyle, it is possible that future studies, mapping the nature of activities undertaken by OOA youths and the attitudes of their parents, may provide novel ideas for the design of interventions at the individual and community level to increase PA in non-Amish boys and girls. OOA girls were easily more active than ES boys.

Some challenges and limitations of our study deserve mention. First, only the 43 Actiwatch-wearing OOA children were used in the OOA-to-ES PA comparison. Because these 43 Actiwatch-wearing OOA children were nested in the group of Actical-wearing OOA children and wore the two devices simultaneously, we could determine that the PA levels of the Actiwatch-wearing OOA children were representative of the greater OOA sample (*n* = 198). The overall comparison with the ES children showed that these 43 OOA children spent twice as much time in MVPA as the ES children. However, because of small cell sizes (*n* = ~10) in the OOA when we split the Actiwatch-wearing children into four strata by age-group and sex, we have included Fig. 2 for orientation only and refrained from stratified statistical tests to support any suggested age- or sex-specific trends.

Second, the data collection in the OOA children took place 3 to 5 years after the data collection in the ES children. Nevertheless, we find it unlikely that this temporal difference is a major contributor to the vast differences in BMI and PA observed between the OOA and the ES.

Lastly, although the OOA and ES studies were performed by overlapping groups of investigators using similar protocols and instrumentation, the BMI data for the general U.S. population were obtained from NHANES, which is very different in size and scope from our local studies. However, ignoring the excellent national estimates that NHANES provides would be foolish. The NHANES data support our conclusion that OOA children are rarely overweight compared with other groups.

In summary, together with our previous study of adult OOA, the current study implies that the OOA tend to gain their excess weight relatively late in life and that OOA children are very physically active, both of which may provide some long-term protection against diabetes.

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K.G.H. designed the study; collected, managed, and analyzed data; and wrote, reviewed, and edited the manuscript. J.L.D. collected, managed, and analyzed data, and wrote, reviewed, and edited the manuscript. M.S.T. collected, managed, and analyzed data, and reviewed and edited the manuscript. W.-C.H. collected data and reviewed and edited the manuscript. A.M.J. collected data and reviewed and edited the manuscript. K.A.R. and X.S. managed and analyzed the data. B.D.M. reviewed and edited the manuscript. A.R.S. designed the study and reviewed and edited the manuscript. S.S. designed the study, managed and analyzed the data, and wrote the manuscript. S.S. is the guarantor of this work and, as such, had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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