

Objective Physical Activity of Filipino Youth Stratified for Commuting Mode to School

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ABSTRACT

TUDOR-LOCKE, C., B. E. AINSWORTH, L. S. ADAIR, and B. M. POPKIN. Objective Physical Activity of Filipino Youth Stratified for Commuting Mode to School. *Med. Sci. Sports Exerc.*, Vol. 35, No. 3, pp. 465–471, 2003. **Purpose:** The Cebu Longitudinal Health and Nutrition Survey included self-report measures and objective measures (Caltrac accelerometer) of Filipino adolescent (ages 14–16) physical activity (PA) in 1998–99. The purpose of this subanalysis was to compare objectively monitored PA of adolescents who differed by their self-reported habitual commuting mode to school, specifically commuting by walking, motorized transport, or a combination of the two. **Methods:** Descriptive analysis included the proportion of adolescents who reported commuting to school by the different modes, participating in sport/exercise during or after school, or currently working. ANCOVA was used to estimate and compare adjusted mean Caltrac-derived energy expenditure (kcal·d⁻¹) by commuting mode for each gender. Covariates were age, weight, and height. **Results:** The analysis sample of 1518 Filipino adolescents included 691 male (BMI = 18.5 ± 2.5) and 827 female subjects (BMI = 18.7 ± 2.3). A total of 323 male subjects (46.8% of all male subjects) walked to school, 160 (23.2%) took motorized transport, and 208 (30.0%) used a combination of the two modes. The corresponding values for female subjects were 303 (36.6%), 177 (21.4%), and 347 (42.0%). The absolute difference in Caltrac-derived energy expenditure that appeared to be due to active commuting was 44.2 kcal·d⁻¹ for Filipino male adolescents and 33.2 kcal·d⁻¹ for female adolescents. These differences between commuting modes could not be explained by participation in sport/exercise or by current employment. **Conclusions:** Assuming 200 school days in a year, the difference in energy expended due to active commuting translates to a 8840 kcal and 6640 kcal in male and female subjects, respectively. For those youth who commute to school by motorized transport a yearly positive energy balance (i.e., weight gain) of 2–3 lb would be anticipated, all other things being held constant. **Key Words:** TRANSPORTATION, SPORTS, EXERCISE, URBANIZATION

There is evidence of a worldwide trend toward obesity in youth (25,30). Researchers are interested in understanding the causes of this trend in order to prevent obesity-related health problems. A potential contributor to this epidemic is a shift in physical activity (PA) behaviors. The primary focus of youth PA assessment and promotion efforts has been on in-school physical education classes, and to a lesser extent, out-of-school structured exercise, sport, and play. A potential source of continuous moderate activity, active commuting to school by means of walking or by bicycle, has been largely ignored in surveys of PA (27).

Personal commuting modes can be classified as passive (e.g., busing, riding in a private vehicle) or active (e.g.,

walking, bicycling). Meager empirical evidence exists indicating a change in personal commuting modes. The prevalence of children walking to school in the United Kingdom declined approximately 20% from 1970 to 1991 (10). In the United States, transportation surveys indicate that there has been an increase in the use of personal vehicles for transportation purposes, including chauffeuring children (28). Further, there was a 37% decline in the number of trips made by children by foot or by bicycle between 1977 and 1995 (15). The 1995 U.S. Nationwide Personal Transportation Survey (8) indicated that approximately 50% of American school children aged 5–15 yr of age traveled to school as passengers in privately owned vehicles and just over 10% walked.

Much of what we do know about PA, and in particular commuting modes, has been limited to developed countries where vehicle ownership is widespread and transportation by motorized vehicle is ubiquitous. A recent report of school transportation modes in Georgia indicates that fewer than 19% of school-aged children who lived ≤ 1 mile from school walked to school the majority of days of the week and almost 42% were chauffeured to school in a private vehicle (1). Against such a background, the contribution of active commuting behaviors may be insignificant when compared with other sources of PA, including sport, exer-

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cise, and play. An opportunity exists to study the PA in youth in countries where the prevalence of overweight/obesity is currently low and a social and economic transition is underway that will doubtless lead to increases in passive commuting behaviors. As part of an ongoing study of children and youth in the Philippines, the Cebu Longitudinal Health and Nutrition Survey included objectively monitored and self-report measures (including sport/exercise/play and personal commuting mode to school) of adolescent PA in 1998–1999. Therefore, the purpose of this study was to compare objectively monitored PA of adolescents who differed by their personal commuting mode to school. Further, we explored select household factors for association with active commuting in this developing country.

METHODS

Cebu Longitudinal Health and Nutrition Survey.

The Cebu Longitudinal Health and Nutrition Survey (CLHNS) is a community-based study of a 1-yr birth cohort of index children born between May 1, 1983, and April 30, 1984. A single-stage cluster-sampling procedure was used at baseline to randomly select 33 communities or barangays (17 urban, 16 rural) from the metropolitan Cebu area. The barangays, which contained about 28,000 households, were completely surveyed in late 1982 and again in early 1983 to locate all pregnant women. Women of the selected barangays who gave birth between May 1, 1983, and April 30, 1984, were included in the sample. A baseline interview was conducted among 3327 women during the sixth to seventh month of pregnancy so that all births, including preterm births, could be identified. Subsequent surveys took place immediately after birth, then at bimonthly intervals for 24 months. From the baseline sample, there were 3080 non-twin live births. Approximately 2600 households were studied intensively for the full 2 yr. Each survey collects detailed health, nutrition, demographic, and socioeconomic data. The index children and their families live in diverse communities, ranging from densely populated urban and peri-urban neighborhoods to more isolated rural villages in the mountains or on nearby islands. Additional details about the study design and sampling strategies are available at the World Wide Web site for the CHLNS (<http://www.cpc.unc.edu/cebu/datasets.html>).

Originally designed as a study of infant feeding patterns, the index children, other caretakers, and selected siblings continue to be followed at regular intervals through the child's adolescence and future childbearing years in order to have a high quality, longitudinal intergenerational study of health. Typically, teams of trained local interviewers visit households to collect CLHNS data. Self-report measures of index children's PA (including commuting mode to school and participation in sport/exercise activities) and objective monitoring of energy expenditure due to PA were added to the survey in 1998–99. At that time, data were collected from 1091 male (760 or 70% enrolled in school) and 992 female (873 or 88% enrolled in school) youth 14–16 yr of age. Because we could not pragmatically collect all the data

at once, the decision to stagger the data collection times by gender was made, in part, to minimize within sex variation at age as much as possible by focusing on completely on female subjects (in 1998) first then boys (in 1999). We also wanted to get a height measurement as close to puberty as possible for both genders. Parents or caretakers followed in the CLHNS also provided a wide range of demographic, socioeconomic, and environmental data. Written parental informed consent, and adolescent assent was obtained according to protocols reviewed and approved by the University of North Carolina School of Public Health Institutional Review Board for the Protection of Human Subjects. This process conforms to the *Medicine and Science in Sport and Exercise* policy statement regarding the use of human subjects and informed consent. The prevalence of overweight/obesity (based on >85th percentile cut point for age-specific BMI from the 2000 National Center for Health Statistics) is currently low (<3%) in this sample of Filipino adolescents.

PA data. For Filipino adolescents enrolled in school, the PA questionnaire focused on usual moderate and vigorous intensity PA behaviors at school and after school. For all activities identified, respondents were queried about their frequency ($d \cdot wk^{-1}$) and duration (min or $h \cdot wk^{-1}$). Verbatim-reported activities were classified as sport/exercise activities (e.g., dancing, conditioning exercises, running, sports) or not (e.g., home activities, music playing, self-care, volunteer activities), using the major headings of the updated Compendium of Physical Activities (3). Adolescents were also asked about their habitual commuting modes to school. Specifically, youth were asked how they usually traveled to school with listed response options: 1) walk; 2) ride bicycle; 3) ride in/on motorized vehicle (car, jeepney, bus, tricycle, etc.); 4) combination of 1 and 3; or 5) other. A jeepney is a form of public transportation that has a modified jeep with bench seating. This is an inexpensive and popular form of transportation; there are extensive jeepney transportation routes. Of those youth enrolled in school, 40% (343 male and 317 female subjects) walked to school, less than 1% (12 male and 1 female subject) rode a bicycle, 22% (171 male and 185 female subjects) rode in/on a motorized vehicle (motorized transport), and 37% (234 male and 367 female subjects) used some combination of walking and motorized transport (this is most likely to represent a combination of walking to a jeepney stop). Three female subjects used some other form of transportation.

An objective measure of energy expenditure due to PA was obtained using a Caltrac accelerometer (Muscle Dynamics, Torrance, CA). The Caltrac accelerometer has been established as a valid (6,18,20,22) and reliable (24) objective measure of energy expenditure due to PA. It is a small, lightweight electronic device that monitors vertical acceleration of the body and automatically computes energy expenditure due to PA considering a subject's age, weight, height, and gender (16,31). Accordingly, Caltracs were pre-programmed as per manufacturer's instructions for each individual by entering the required variables into the instrument's memory. Caltracs were worn on a school day in a

pouch attached to a waist belt, centered over either leg. Subjects were instructed not to remove the device, except for bathing or sleeping for approximately 24 h, or until the interviewer returned the next day for retrieval. Time programmed, time retrieved, and energy expenditure due to PA ($\text{kcal}\cdot\text{d}^{-1}$) were recorded, having been corrected for 24 h of observation. In both genders, 24-h Caltrac PA kcal have been inversely and significantly correlated with time reported watching television, and positively and significantly correlated with reported time spent active commuting, in after school moderate/vigorous activities, and in total moderate/vigorous activities as assessed by the CLNS (26).

Data treatment and statistical analysis. Data reduction strategies employed in this subanalysis of the 1998–99 CLNHS database included, in order: 1) those adolescents not attending school (male = 331, female = 119); 2) those commuting to school by means other than walking, motorized transport, or a combination of the two (male = 12, female = 4); 3) those not wearing the Caltrac for 22–26 h before correction (male = 41, female = 42); and those lying above the 99th percentile of distribution for Caltrac-derived energy expenditure due to PA (male = 16).

For those youth reporting walking to school, time spent active commuting was computed assuming a round trip (2 trips per day). The energy cost ($\text{kcal}\cdot\text{d}^{-1}$) of walking to school was determined using individual body weight and intensity classification [$(3.5 \text{ METs} \times \text{body weight in kg}) \times (\text{time for round trip}/60 \text{ min})$] (2,3). Unfortunately, we were not able to confidently determine the relative contribution of walking and motorized transport to daily commuting in those youth who reported a combined approach; neither time nor energy expenditure due to the active commuting component could be estimated. Time (and energy expenditure) spent active commuting to school was assumed to be negligible (zero) in those adolescents who reported traveling to school using motorized transportation exclusively.

Differences in age, BMI, height, and weight were tested between commuting modes by using one-way ANOVA. In the case of a significant finding, *post hoc* analyses (Student-Newman-Keuls test) were used to compare specific differences between commuting modes. ANCOVA was used to estimate and compare adjusted mean (and 95% CI for the mean) Caltrac-derived energy expenditure by commuting mode for each gender. Covariates were age, weight, and height. These specific covariates were chosen on the basis of their requisite entry into the Caltrac program, after confirming homogeneity of slopes. Differences in the adjusted Caltrac-derived energy expenditure between the commuting modes were contrasted.

Frequency and duration of reported activities were used to construct time ($\text{min}\cdot\text{wk}^{-1}$) spent in sport/exercise; participation in sport/exercise was categorized as ANY or NONE. Questionnaire-derived PA data were positively skewed and therefore are presented as the proportion of the sample reporting any defined PA and the median time (minutes) and interquartile range (IQR) of distribution for those reporting any of the defined activity. Chi-square analyses were used to examine likelihood of engaging in alter-

native forms of PA (participation in school sport/exercise, after school sport exercise, or currently working) between genders and between commuting categories within genders. Differences in time (between commuting categories) in sport/exercise for those reporting ANY were tested using a nonparametric test (Kruskal-Wallis of k independent samples). Evidence of potential confounding (i.e., a statistical difference between commuting mode strata that could otherwise explain differences in Caltrac-derived energy expenditure due to PA) was further investigated by comparisons within subsamples of those with and without the suspected factor.

Association of commuting mode with select household factors (urban vs rural dwelling, television and motor vehicle ownership) was examined using chi-square analyses. Household income (pesos) was also compared across commuting modes using a one-way ANOVA with *post hoc* Student-Newman-Keuls analyses where appropriate. Statistical analyses were conducted using SAS Version 8.01. Significance was set at an alpha level of $P < 0.05$.

RESULTS

The analysis sample of 1518 Filipino adolescents included 691 male subjects ($\text{BMI} = 18.5 \pm 2.5$) and 827 female subjects ($\text{BMI} = 18.7 \pm 2.3$). Walking to school was typical commuting behavior for 323 male subjects (46.8% of all male subjects), 160 (23.2%) took motorized transport, and 208 (30.0%) used a combination of the two modes. The corresponding values for female subjects were 303 (36.6%), 177 (21.4%), and 347 (42.0%). There were no significant gender differences in the proportion living in an urban setting (76% of male subjects vs 74% of female subjects, $\chi^2 = 0.63$, $P = 0.427$). More male than female subjects came from households owning a television (80% vs 73%, $\chi^2 = 9.20$, $P = 0.002$) and a motor vehicle (42% vs 36%, $\chi^2 = 4.88$, $P = 0.027$).

Household characteristics of the sample stratified by commuting mode are assembled in Table 1. Household income was significantly different across commuting modes for both genders (walking < combined < motorized transport). Although there was a significant relationship between commuting mode and dwelling region (notably a reduced proportion of those who commuted to school by walking lived in urban vs rural settings) for female subjects, the trend was not significant for male subjects. For both male and female subjects, television ownership was significantly lower among those who reported commuting to school by walking. There was also a statistical relationship between commuting mode and motor vehicle ownership; a greater proportion of male and female subjects reporting commuting to school by motorized transportation also reported household motor vehicle ownership.

Male subjects were significantly older (15.5 ± 0.5 vs 14.5 ± 0.5 yr; $t = -38.83$, $P < 0.0001$), taller (158.3 ± 6.7 vs 148.6 ± 5.7 cm; $t = -24.38$, $P < 0.0001$), and heavier (46.9 ± 8.2 vs 41.8 ± 6.2 kg; $t = -13.7$, $P < 0.0001$) than female subjects. Caltrac-derived energy expenditure due to

TABLE 1. Household characteristics of Filipino youth stratified by commuting mode to school (walking vs motorized transport).

	Male (N = 691)			Findings across Groups	Female (N = 827)			Findings across Groups
	Walking (N = 323)	Combined (N = 208)	Motorized Transport (N = 160)		Walking (N = 303)	Combined (N = 347)	Motorized Transport (N = 177)	
Household income (pesos) [mean ± SD, 95% CI]	3382 ± 3237 (3028–3736)	4081 ± 3285 (3630–4532)	5075 ± 4756 (4332–5817)	F = 11.6 P < 0.0001	2660 ± 1752 (2462–2858)	3595 ± 3389 (3235–3955)	4353 ± 3966 (3771–4936)	F = 18.4 P < 0.001
% urban vs rural dwelling	231 (72%)	166 (80%)	125 (78%)	$\chi^2 = 5.46$ P = 0.065	200 (66%)	278 (80%)	132 (75%)	$\chi^2 = 16.71$ P = 0.0002
% tv ownership	242 (75%)	168 (81%)	140 (88%)	$\chi^2 = 10.67$ P = 0.005	196 (65%)	268 (77%)	139 (79%)	$\chi^2 = 16.49$ P = 0.0003
% motor vehicle ownership	125 (39%)	81 (39%)	83 (52%)	$\chi^2 = 8.65$ P = 0.013	89 (29%)	120 (35%)	91 (51%)	$\chi^2 = 24.22$ P < 0.0001

PA was also significantly higher in the male subjects compared with the female subjects after adjustment for age, height, and weight (358.6, 95% CI 347.3–369.9 vs 276.5, 95% CI 266.6–286.5 kcal·d⁻¹; F = 80.0, P < 0.0001). Reported median time spent active commuting was 20, IQR 10–30 min·d⁻¹ for those male subjects who walked to school and 30, IQR 20–40 min·d⁻¹ for female subjects; the gender difference was statistically significant (Z = 2.38, P = 0.017). Converted to energy expenditure, the corresponding values were 67, IQR 42–102 kcal·d⁻¹ and 58, IQR 33–86 kcal·d⁻¹ for male and female subjects, respectively. Again, the gender difference was statistically significant (Z = 4.39, P < 0.0001). As stated previously, neither time nor energy expenditure due to active commuting could be estimated for those adolescents who reported using a combination of walking and motorized transport to get to school. Further, these parameters were assumed to be negligible (zero) for adolescents who commuted by motorized transport exclusively. Table 2 displays descriptive characteristics and adjusted energy expended due to PA in Filipino youth stratified for usual mode of commuting to school within each gender.

Male subjects more frequently reported participating in school sport/exercise (62% vs 50%; $\chi^2 = 23.37$, P < 0.0001), and after school sport/exercise (74% vs 12%, $\chi^2 = 598.98$, P < 0.0001) compared with female subjects. For those youth reporting any in school sport/exercise, male subjects engaged in longer durations than female subjects (180, IQR 60–300 vs 80, IQR 30–180 min·wk⁻¹; Z = -8.01, P < 0.0001). Male subjects also reported engaging

in after school sport/exercise for longer durations than female subjects (204, IQR 100–360 vs 60, IQR CI 30–120 min·wk⁻¹; Z = -7.94, P < 0.0001). There was no difference between genders in the proportion who reported currently working (36% vs 33%, $\chi^2 = 2.41$, P = 0.121). Table 3 displays the proportion of Filipino youth reporting participation in ANY sport/exercise (in school or after school) or currently working by commuting mode to school within each gender. Commuting mode was not significantly related to these alternative contributions to PA with a single exception: compared with the other two commuting modes, a lower proportion of female adolescents who commuted to school by motorized transport also participated in any in school sport/exercise ($\chi^2 = 9.32$, P = 0.010).

An apparent difference by commuting mode in time in school sport/exercise for male subjects was not statistically significant (walking = 150, IQR 60–300; motorized transport = 215, IQR 90–315; combined = 150, 60–270 min·wk⁻¹; $\chi^2 = 5.51$, P = 0.063). The corresponding values for female subjects were walking = 78, IQR 30–140; motorized transport = 80, IQR 40–160; combined = 80, IQR 40–180 min·wk⁻¹; $\chi^2 = 1.72$, P = 0.422). Similarly, there were no significant differences by commuting mode in time in after school sport/exercise for male subjects (walking = 240, IQR 120–360; motorized transport = 180, IQR 90–360; combined = 205, IQR 120–360 min·wk⁻¹; $\chi^2 = 2.89$, P = 0.236) or for female subjects (walking = 240, IQR 120–360; motorized transport = 180, IQR 90–360 min·wk⁻¹; combined = 205, IQR 120–360 min·wk⁻¹; $\chi^2 = -0.144$, P = 0.930).

TABLE 2. Descriptive characteristics in Filipino youth stratified for usual commuting mode to school.

	Male (N = 691)			F P	Female (N = 827)			F P
	Walking (N = 323)	Combined (N = 208)	Motorized Transport (N = 160)		Walking (N = 303)	Combined (N = 347)	Motorized Transport (N = 177)	
Age (yr)	15.5 ± 0.5 ^A 15.4–15.5	15.5 ± 0.5 ^A 15.4–15.6	15.7 ± 0.5 ^B 15.6–15.7	6.78 0.001	14.5 ± 0.5 ^A 14.4–14.5	14.5 ± 0.5 ^A 14.5–14.6	14.6 ± 0.5 ^B 14.6–14.7	4.75 0.009
Weight (kg)	45.8 ± 7.5 ^A 45.0–46.6	47.4 ± 7.8 ^{A,B} 46.3–48.4	48.7 ± 9.8 ^B 47.2–50.2	6.99 0.001	41.2 ± 5.8 ^A 40.5–41.8	41.9 ± 6.2 ^A 41.2–42.5	42.5 ± 6.8 ^A 41.5–43.5	2.80 0.062
Height (cm)	158.2 ± 6.7 ^A 157.5–158.9	160.0 ± 6.4 ^B 159.1–160.8	160.1 ± 6.6 ^B 159.1–161.2	6.73 0.001	148.7 ± 5.8 ^A 148.0–149.3	149.5 ± 5.2 ^A 148.9–150.0	149.8 ± 5.4 ^A 149.0–150.6	2.63 0.073
BMI (kg·m ⁻²)	18.2 ± 2.3 ^A 18.0–18.5	18.4 ± 2.4 ^{A,B} 18.1–18.8	18.9 ± 3.0 ^B 18.4–19.4	3.58 0.28	18.6 ± 2.2 ^A 18.3–18.8	18.7 ± 2.4 ^A 18.5–19.0	18.9 ± 2.5 ^A 18.5–19.3	1.09 0.334
Caltrac (kcal)	375.0 ^A 360.8–389.2	376.3 ^A 358.6–393.9	330.8 ^B 310.5–351.0	7.18 0.0008	288.5 ^A 277.7–299.3	263.9 ^B 253.8–274.0	255.3 ^B 241.1–269.5	8.3 0.0003

Values are means ± SD, 95% CI with a single exception: Caltrac kcal (adjusted for age, height, weight) is adjusted mean, 95% CI. Means with same letter superscript are not significantly different within gender stratum. For example, females who walk to school expend significantly more Caltrac kcal than girls who take either combined or motorized transport and these latter two transportation modes do not differ significantly.

TABLE 3. Proportion of Filipino youth engaging in potential alternative forms of physical activity stratified for usual commuting mode to school.

	Male (<i>N</i> = 691)				Female (<i>N</i> = 827)			
	Walking (<i>N</i> = 323)	Combined (<i>N</i> = 208)	Motorized Transport (<i>N</i> = 160)	χ^2 <i>P</i>	Walking (<i>N</i> = 303)	Combined (<i>N</i> = 347)	Motorized Transport (<i>N</i> = 177)	χ^2 <i>P</i>
ANY in school sport/exercise (%)	190 (59%)	133 (64%)	106 (66%)	2.94 0.230	152 (50%)	188 (54%)	71 (40%)	9.32 0.010
ANY after school sport/exercise (%)	232 (72%)	150 (72%)	129 (81%)	4.82 0.090	37 (12%)	43 (12%)	20 (11%)	0.14 0.933
Currently working	193 (60%)	138 (66%)	109 (68%)	4.16 0.125	202 (67%)	241 (70%)	115 (65%)	1.21 0.545

Evidence of potential confounding was only apparent in female subjects reporting any participation in school sport/exercise (see Table 3). An ANCOVA (adjusting for age, weight, height) of Caltrac-derived energy expenditure due to PA comparing only those female subjects reporting any in school sport/exercise (*N* = 152) by commuting strata was significant (walking = 302.6, 95% CI 286.5–318.7 kcal·d⁻¹; motorized transport = 263.2, 95% CI 239.5–287.0 kcal·d⁻¹; combined = 270.2, 95% CI 255.8–284.6 kcal·d⁻¹; *F* = 5.58, *P* = 0.0041). Planned comparisons indicated significant inter-strata differences only between walking and motorized transport (*F* = 7.18, *P* = 0.008), and between walking and combined commuting modes (*F* = 8.65, *P* = 0.004). Differences in those female subjects reporting no school sport/exercise (*N* = 71) by commuting strata were marginally significant (walking = 274.9, 95% CI 260.3–289.5 kcal·d⁻¹; motorized transport = 248.5, 95% CI 231.1–265.9 kcal·d⁻¹; combined = 256.9, 95% CI 242.8–271.1, *F* = 2.89, *P* = 0.057). Planned comparisons revealed that the only significant difference was between the walking and motorized transport commuting modes (*F* = 5.20, *P* = 0.023).

DISCUSSION

Observed gender differences in PA in the present study are consistent with the preponderance of published empirical literature (5); male subjects more frequently engage in sport/exercise and for longer durations. Compared with female subjects, male subjects expended 82.1 kcal·d⁻¹ more due to PA (having adjusted Caltrac-derived energy expenditure due to PA for age, weight, and height). This study adds, however, to accumulating evidence of the importance of active commuting to overall PA in youth, regardless of gender. Calculated as the difference in adjusted Caltrac-derived energy expenditure between walking and motorized transport modes, energy expenditure that appeared to be due to active commuting was 44.2 kcal·d⁻¹ for adolescent Filipino male subjects and 33.2 kcal·d⁻¹ for female subjects. These differences between commuting modes could not be explained by participation in school sport/exercise, after school sport/exercise, or current employment. Assuming 200 school days in a year, this translates to a yearly expenditure of 8840 kcal and 6640 kcal due to active commuting in male and female subjects, respectively. For those youth who commute to school by motorized transport a yearly positive energy balance (i.e., weight gain) of 2–3 lb would be anticipated, all other things being held constant.

It is unlikely that the result obtained is an artifact of a single day of objective monitoring. An imprecise measure (e.g., only one day) would be expected to decrease our ability to see significant differences between groups because the group SD should be exaggerated compared to a result obtained from longer monitoring (e.g., for seven consecutive days). Although it is not possible to rule out confounding by unmeasured variables, we attempted to explain differences in Caltrac-derived energy expenditure between commuting modes using analyses strategies. By design, Caltrac-derived energy expenditure is modulated by gender, age, weight, and height; analyses necessarily adjusted for these affects. Further, we explored differences in energy expenditure between commuting modes by participation in sport/exercise (in school and after school) and working behaviors. The findings were consistent with a single exception: compared with the other two commuting modes, a lower proportion of Filipino female adolescents who commuted to school by motorized transport also participated in any in school sport/exercise. Further analysis by additional stratification based on reported participation in sport/exercise (ANY, NONE) showed that Caltrac-derived energy expenditure continued to be greater in female subjects who commuted to school by walking as compared to motorized transport.

Unfortunately, we do not know exacting commuting distances or the relative contribution (time or energy expenditure) of walking to commuting in those youth who reported a combined approach. Further, gender differences in reported time and energy expenditure (due specifically to the daily commute; male > female subjects) for those adolescents who walked to school might be due to differences in distance traveled and/or speed of travel (and increased body weight in specific regards to energy expenditure). Regardless, commuting by either walking or using a combined approach was related to greater Caltrac-derived energy expenditure than to exclusive use of motorized transport, at least for male adolescents. For female subjects, neither the motorized transport nor the combined approach to commuting was related to as much daily energy expenditure.

The primary limitation of this study is its cross-sectional nature; causal relationships cannot be inferred. Contextual information about commuting to school in the Philippines is incomplete. Urban dwelling was only associated with passive commuting in female adolescents and may reflect increased safety concerns for female

adolescents living in metropolitan areas. Indicators of socioeconomic status (i.e., household income and television and motor vehicle ownership) were consistently associated with passive commuting modes in both genders. Although both types of consumer good ownership are indicators of higher socioeconomic status; motor vehicle ownership also represents ready availability or opportunity for passive commuting behaviors.

Choice of commuting mode is likely influenced by a host of factors including: 1) distance to school, 2) cost, 3) economic circumstances of the family, and 4) availability of motorized transport (either household owned or public transit options). We do know that the proportion of Filipino youth in this sample who commuted to school by walking was 40% compared with 10% of U.S. youth (8). This reflects between-country differences in household vehicle ownership; 40% of the households in this study owned a motor vehicle compared with approximately 92% in the United States in 1995 (21). It will be important to follow trends in PA as motor vehicle ownership peaks in this developing country. Despite these limitations, however, this study represents an important step in understanding the potential health impact of seemingly inconsequential amounts of short-distance personal transportation behaviors. Active commuting behaviors have also been associated with reduced cardiovascular risk factors in a municipal sample of Chinese adults (11–13).

Whether or not active commuting to school is a healthful source of physical activity for children remains an unanswered question (23). Turning to the adult literature, a cross-sectional study of 30,000+ Finnish women found that those who reported commuting, walking, or bicycling to work 30 min or more daily had slightly lower adjusted risk of breast cancer (14). A prospective study of over 30,000 men and women has shown that bicycling to work decreased risk of all-cause mortality approximately 40%, even after adjustment for leisure-time physical activity (4). In a prospective study based on physician-recommended active commuting to work in Japanese business men, greater reported time spent walking to work (independent of leisure-time activities) decreased risk of hypertension (9). Intervention studies in working adult populations have demonstrated the efficacy (with regard to health and fitness outcomes) and cost-efficiency of promoting active commuting to work (19,29). A recent randomized controlled trial examined the impact of written materials on increasing active commuting to work behaviors (17). At the present time, however, we are aware of no similar studies that exam the health impact of active commuting to school in children.

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Empirical evidence implicating shifting transportation modes (from active to passive) as a cause of obesity is also sparse. In a recent study of motorized transportation and obesity in Chinese adults that used both cross-sectional and cohort data, household ownership of motorized transportation was associated with obesity in men and women, and, further, acquisition of a motorized vehicle increased the odds of becoming obese in men over an 8-yr time period (7). As stated previously, overweight/obesity is currently low in Filipino youth. Increased use of motorized transportation is anticipated. This cross-sectional study of the contribution of active commuting to youth PA undertaken herein establishes an important baseline for examining whether a shift toward motorized forms of transportation decreases PA and promotes obesity in Filipino youth. Longitudinal analysis of these questions is planned as CLNHS data continue to be collected.

While the advantages of a more modern society probably outweigh the drawbacks, there are consequences that can negatively influence important public health goals. It is unlikely that forward momentum will be completely arrested, however, to benefit public health. Increased dependence on motorized vehicles is not necessarily an inevitable ramification of social and economic development, however. Viable approaches to promoting and sustaining adequate levels of PA include implementing public transportation policies that promote continued reliance on more active forms of commuting. Concomitantly, it would be prudent to promote increased participation in active leisure-time alternatives as the transition to more motorized transportation modes continues.

In conclusion, relative to passive commuting, active commuting to school (defined as walking in the present study) was associated with increased objectively determined daily energy expenditure in both Filipino male and female adolescents. The Philippines is currently undergoing a social and economic transition that will doubtless favor population-wide adoption of passive commuting behaviors (i.e., increased motor vehicle ownership and patterns of use). It will be important to continue to study the impact of this transition on both PA and obesity trends in longitudinal studies.

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