The Role of the Physical Activity Environment in Obesity Among Children and Adolescents in the Industrialized World

Steven L. Gortmaker

Department of Health and Social Behavior, Harvard School of Public Health, Boston, Massachusetts, USA

The prevalence of obesity among children and adolescents has been increasing rapidly in the United States and other industrialized countries (1). While the etiology of obesity is complex and is related to both genetic and environmental determinants, obesity ultimately results from an imbalance of energy intake over energy expenditure (2). Because both energy intake and energy expended through physical activity have substantial discretionary components, they can be influenced by the social and physical environment, and hence are the foci of intervention and policy.

This chapter is focused on describing patterns of physical activity among children and adolescents in industrialized societies, reviewing evidence for how these patterns influence energy imbalance and obesity prevalence, and documenting how these physical activity patterns are in turn influenced by social, economic, and physical environments.

In discussing these issues, I will first examine the entire distribution of physical activity levels among children and adolescents, ranging from very inactive to very physically active. Using computerized electronic monitoring data among adolescents aged 13 to 15 in the United States, I will document the very low levels of activity found in this free ranging youth population, and note the potentially significant contribution to physical activity of habitual patterns such as school attendance.

I will next examine in detail evidence for the potential impact of both low levels of activity—including sitting in school and television viewing—and moderate and vigorous physical activity levels on obesity. These analyses point to the strong evidence for the unique influence of broadcast television in the industrialized world on childhood obesity, the effect reflecting a mixture of time spent in an inactive state and the influence on dietary intake. I review research concerning impact of the social,
THE ROLE OF THE PHYSICAL ACTIVITY ENVIRONMENT IN OBESITY

economic, and physical environment on physical activity levels of children and adolescents, and find little solid evidence but much speculation. I discuss the implications of this science base and gaps in knowledge for programs and policies aimed at reducing obesity in the industrialized societies.

METHODS

Subjects

Data for results reported in this study were collected as part of the Planet Health intervention and evaluation program that took place in schools located in four communities in the Boston (Massachusetts) metropolitan area between autumn 1995 and spring 1997. For the present analyses, subjects were from the five randomly assigned control schools that did not take part in the intervention program designed to reduce obesity prevalence (3). The median household income of zip code areas where the five schools were located averaged $34,200. This median is lower than that for all households in Massachusetts in the 1990 census ($41,000), but similar to the US figure ($33,952) (3). Sixty-five percent of those eligible completed the baseline evaluation in autumn 1995, after exclusion of individuals who transferred schools at baseline, were in special education classes, were in grades other than sixth or seventh, or did not complete the English language version of the questionnaire. Follow-up data were collected in spring 1997 (19 months later) for 84% of the baseline sample.

From all subjects with baseline and follow-up data, we subsequently selected a random sample (stratified by school, sex, and grade) of students in these five schools in the winter of 1997. These 139 students wore Tritrac monitors on their hip using an elasticized belt; with activity data stored electronically every minute in three (tri-axial) dimensions. Staff recorded time of initiation and instructed the participants to return the monitors in either 3 days (if they received the monitor on a Tuesday), or 4 days (if they received the monitor on a Friday). Students were paid $5 for their assistance upon return of the monitor. All students who agreed to wear the monitors in one participating school also wore the monitors a second time a few weeks later, and also completed repeat 24-hour activity recalls. These participants were paid $10 for their assistance. The activity monitor data were collected during the period February through April 1997. Upon return of the monitor, staff noted the time and date of return, and interviewed the participant concerning times they may have removed the monitor during the days they had it. The study was approved by the Committee on Human Subjects at the Harvard School of Public Health.

Design and Measures

Television and Video

Time spent in television and video viewing was measured with the 11-item television and video measure (TVM) (3). Questions were asked about hours of television typically viewed during each day of the week, as well as use of video recorders and video
and computer games. Items were appropriately weighted and summed to obtain a total viewing hour-per-day estimate. In a validation sample \((N = 53)\), we found a deattenuated correlation of television viewing assessed by the TVM versus repeat 24-hour recalls of \(r = 0.54\), with equivalent means.

**Demographic, Social, and Behavioral Variables**

Age was calculated based on birth date and date of anthropometric examinations; in a few cases of missing birth date, self-reported age from the Food and Activity (FAS) survey was used. Sex was classified at the time of examination by measurers, except for a few missing cases where sex data from school list data were used. Ethnic categories were based on responses of students who were asked to mark all the responses that applied to the question, “How do you describe yourself?” The response categories were as follows: “white,” “black,” “Hispanic,” “Asian or Pacific Islander,” “American Indian or Alaskan Native,” “other.” Participants indicating “black” were classified “African-American.”

**Trirac Accelerometer Data**

Trirac data included activity vector magnitude readings for each minute over the time period sampled. Recent studies in children and adolescents (4–6) indicate excellent validity of triaxial accelerometers, with reported prediction of objective measures of oxygen consumption ranging from \(R^2 = 0.93\) to \(R^2 = 0.90\). Previous study with another computerized accelerometer indicates that a reasonable approximation of individual activity levels requires 3 days of data collection, owing to the significant intraindividual variability from day to day (7). Studies of data from each of the three planes indicate that the vector magnitude measure (the geometric mean of the measures of activity in each of the three planes) is the best overall indicator of energy expenditure (4).

An individual with 3 days of Trirac data would provide 4,320 data points. For assessment of activity levels, we used data on weekdays collected between 07:00 and 21:59, and on weekends from 09:00 to 21:59. We derived these intervals by examining the extent to which participants had removed their monitors (we used an indicator whereby if there was virtually no movement recorded on the Trirac for 30 consecutive minutes—indicated by a vector magnitude of less than 10—we considered the monitor removed). These analyses indicated that the time periods chosen corresponded to the times at which most of the participants had started using the monitor for the day. At both the chosen time points, the uptake of use and decrease in use changed rapidly over the previous and succeeding half-hour intervals. In estimating activity levels, we coded as missing those time intervals where there was virtually no indicated movement (a vector magnitude less than 10 for 30 consecutive minutes). We also conducted parallel analyses where we used different limits—a minimum of 3 days of data, a minimum of 9 hours a day, as well as no movement (indicated by 30 consecutive minutes of vector magnitude zero)—and the results were quite similar.
In estimating physical activity levels, we used two cutoff points: vector magnitudes of 250 and 1,000. The derivation of these cutoff points was based on the translation of accelerometer vector magnitude estimates into estimated MET (metabolic equivalent) values. For this calculation, a few equations describing assumptions are needed. One approach is to simply use the equations that come with the Tritrac monitors (8). However, these use adult equations for calculation of basal metabolic rate (BMR). Instead, we estimated BMR for participants using the WHO equations for boys and girls of this age range (9). We then calculated the equation the Tritrac software uses to estimate energy expenditure from activity (EEA), for each minute interval: \( \text{EEA} = 0.00037 \times [\text{weight of subject in kg}] \times [\text{vector magnitude}] \). We calculated regressions using Tritrac estimated energy expenditure from physical activity versus the Tritrac vector magnitude readings. These regressions were calculated using thousands of data points, for a series of individuals with known weights. The \( R^2 \) for these equations was always greater than 0.99, indicating an excellent fit. We defined a MET value for each minute interval as \([\text{EEA} + \text{BMR}] / \text{BMR}\). The estimated MET values using these equations for EEA and BMR are highly correlated with the values calculated by the Tritrac software. There is little difference between the two approaches.

Given these equations, we then solved for the vector magnitude as a function of MET level and the weight of the subject (kg):

For girls 10 years of age or more: vector magnitude = \([\text{MET} - 1][229 + 14,002/\text{weight}]\);

For boys 10 years of age or more: vector magnitude = \([\text{MET} - 1][328 + 12,218/\text{weight}]\).

Using these equations and assuming an average weight for boys of 59 kg and for girls of 56 kg (the means of these variables in our sample), we see that a MET of 1.5 corresponds to a vector magnitude of about 250 for girls and 269 for boys, and a MET of 3 corresponds to a vector magnitude of about 958 for girls and 1,072 for boys.

Studies of the Tritrac (and other computerized accelerometers) indicate that on average they underestimate total energy expenditure during a given time period by anywhere from 30% to 70% among free-ranging populations (10,11). This underestimation makes theoretical sense, as the accelerometers, worn typically on the hip, will provide underestimates of upper-body movement, will underestimate expenditure during certain activities (e.g., bike riding, walking up stairs), and do not typically take into account other aspects of energy expenditure, such as carrying heavy loads (like a backpack) or weight training.

We report activity in terms of estimated minutes per day. The basic analyses of the Tritrac data estimated the proportion of the time period that corresponds to various MET levels. Thus if in the sample there were 30,000 data points gathered on weekdays between 09:00 and 09:29, and 7% of these points were spent at activity \( \geq 3.0 \) MET, we report 7% for this period, and this can be translated into 7% of a 30-minute interval, or 2.1 minutes. Note that in other analyses (not shown) we examine individual level variability, including duration of bouts of activity.
RESULTS

Physical Activity Levels Among Youngsters Throughout the Day

These Tritrac data indicate a relatively sedentary population of youngsters 11 to 14 years of age (Fig. 1). Data were collected from 139 subjects who contributed a total of 1,017,421 person-minutes of data—an average of 7,320 observations per subject. A typical weekday for this sample (07:00 to 22:00) consists of 73% of the day—or about 11 hours—spent at sedentary activities (1.0 to 1.5 MET). These results are consistent with our sense of the sedentary nature of industrialized society. There is some evidence for slightly greater levels of inactivity among girls than among boys. In Fig. 1 the charted line for female inactivity is generally higher throughout the day than the line for male inactivity (an average of 74% of the day versus 72%).

An examination of these data taken half-hour by half-hour clearly indicates two low points of inactivity on these weekdays: These occur at about 07:30 and at about 14:00. These low points of inactivity coincide with the times that youngsters are going to school in the morning and leaving school in the afternoon.

These results are mirrored in our analysis of time spent in moderate and vigorous activity (time spent at \( \geq 3.0 \) MET) (Fig. 2). The time of day with the highest level of \( \geq 3.0 \) MET activity in the population appears to occur after school, at around 14:00, with substantial activity also occurring early before school begins at 07:30. In general, boys showed higher rates of physical activity of \( \geq 3.0 \) MET during much of the day, but particularly during the period 14:00 to 19:00. Overall, boys spend on average about 1.2 hours a day at activities involving \( \geq 3.0 \) MET, and girls spend an average of 0.8 hours a day at this level. Note that this time at 3.0 MET or greater for a particular individual can consist of many short intervals or a few larger intervals.

An important fact about the inactivity time spent by youngsters is that only part of this time is spent viewing television and other video activities such as video games. Our estimates of total video use per day in the sample in 1997 was about 3.2 hours (based both on self-report survey and on 24-hour diary estimates) (3), or less than 30% of the average day's level of inactivity time.

We found a minimal empirical relation between time spent in moderate and vigorous physical activity and time spent in a specific inactivity such as television viewing (12). Although it is obvious that increased time spent in inactivity automatically constrains the time spent in more vigorous activity, because there is a relatively small amount of moderate and vigorous activity in the lives of youngsters (on average) in industrialized societies—and television viewing comprises just a fraction of inactive time—this means there are many ways to fit in small amounts of active time with patterns of television viewing. Hence average daily hours viewing television and time spent at \( \geq 3.0 \) MET are generally minimally correlated variables.

Analytic Estimates of Changes in Physical Activity Levels on Obesity

It is helpful to distinguish the potentially different roles of moderate and vigorous physical activity versus the impact of inactivity, including television viewing, on
FIG. 1. Percentage of half-hour weekday time periods with Tritrac vector magnitude of <250 (≤1.5 MET); N = 139; 1,017,421 person-minutes.
FIG. 2. Percentage of half-hour weekday time periods with Trifrac vector magnitude of >1,000 (≥3.0 MET); N = 139.
1,017,421 person-minutes.
obesity. One perspective would be simply to note the energy expended on these activities. Analysis of physical activity from this perspective indicates that both inactivity and moderate and vigorous activity can alter risk of excess weight gain significantly. For example, here are two scenarios where altering physical activity levels could affect the risk of obesity:

**Reduce inactivity:** If we assume that youngsters watch about 3 hours of television a day, imagine replacing this 3 hours with less viewing time: 2.5 hours of television (assuming 1.1 MET) and 0.5 hours of walking (assuming 3.0 MET). For a girl aged 12 (weight 46 kg), this translates into a difference in energy expenditure of an additional 52 kcal/day.\(^1\) Based on the assumption that a 1-lb (454 g) weight gain is equivalent to 3,500 kcal, an imbalance of 52 kcal/day could account for a difference in weight of 5.4 lb (2.45 kg) in a year (13).

**Increase vigorous activity:** In contrast, let us assume another change, this time in vigorous activity. Let us assume that this same individual moves from virtually no activity of 5 MET or higher to 20 minutes of physical activity at 5.0 MET or higher three times a week, consistent with one of our national goals. This shift would produce \((20 \times 3)/7\), or about 8.6 minutes a day of new activity greater than 5.0 MET. If we assume the replaced activity was at 1.1 MET, the extra expended energy for a female subject of 46 kg would total about 32 kcal/day, an imbalance that has the potential to produce a difference in weight of 3.3 pounds (1.5 kg) in a year.

A wide range of such scenarios is possible. However, simply from the perspective of energy expenditure, these scenarios illustrate that the potential long-term consequences of relatively minor changes in levels of both inactivity and vigorous physical activity can be significant. The key issue is that relatively small daily differences aggregated over the course of a year or more can produce substantial shifts in relative weight.

**Empirical Evidence for the Impact of Physical Activity on Obesity**

A review of epidemiologic and experimental studies indicates that the strongest relation between obesity and physical activity is found with a specific form of inactivity—television viewing. Television viewing has been cited as one cause of the increasing prevalence of obesity, based on both longitudinal (14,18) and cross-sectional observational studies (15,16,17). These observational studies have recently been corroborated by randomized controlled trials of reduced levels of television viewing designed to reduce obesity (3,19,20). The impact of television viewing on obesity most probably reflects both the displacement of more vigorous activities by television, as illustrated above, and also effects on diet. Foods are heavily advertised on children’s television (21), and television viewing is associated with between-meal snacking by children (22). Similar findings of an independent effect of television viewing on obesity have been reported from adult prospective studies (23,24).

There are substantial numbers of observational studies that indicate an inverse relation between moderate and vigorous physical activity levels and obesity in children.
and adolescents (25–29). In contrast, there is more limited evidence that programs of increased physical activity can reduce obesity, although increased physical activity can clearly assist in maintaining energy balance. Long-term effectiveness in reducing obesity has been demonstrated in intensive clinical programs for obese children (30) that require parental participation and which focus on modifications in both diet and physical activity. There is also evidence for short-term effects following forced increases in physical activity (31). All this evidence points to the potentially important role that increased physical activity levels can play in the prevention of obesity (32,33).

A useful intervention strategy may be to encourage replacing television time with physical activities of the youngster’s choice (34,35). This approach has been found effective in school-based (3,36) and clinical interventions (37).

Social, Economic, and Physical Environmental Effects on Physical Activity Levels

How the environment influences physical activity levels of children and adolescents has not been well studied as a science, but some areas of influence are apparent. As noted in the recent report to the president of the United States:

Behavior is shaped, in large measure, by one’s environment. Our young people live in a social and physical environment that makes it easy to be sedentary and inconvenient to be active. Developments in our culture and society over the past few decades that have discouraged youth physical activity include the following:

• Community design centered around the automobile has discouraged walking and bicycling and made it more difficult for children to get together to play.
• Increased concerns about safety have limited the time and area in which children are allowed to play outside.
• New technology has conditioned our young people to be less active, while new electronic media (for example, videos and computer games, cable and satellite television) have made sedentary activities more appealing.
• States and school districts have reduced the amount of time students are required to spend in physical education classes, and many of those classes have so many students that teachers cannot give students the individual attention they need.
• Communities have failed to invest adequately in close-to-home physical activity facilities (e.g., parks, recreation centers). [38]

Although these assertions appear reasonable, in fact very few potential policy and environmental changes have been documented to affect either physical activity levels or obesity (39,40). Although data are very limited, the potential impact of “environmental limitations” seems obvious: If there are no neighborhood parks or traffic-free places to play, few youngsters will engage in such activities. While most published reports have focused on individual level risk factors and behaviors, some environmental factors have been identified (41–43). Studies among adolescents and young adults indicate that a range of environmental barriers, including neighborhood safety, influence physical activity (44,45). We have examined data from the National Longitudinal Survey of Youth, and the corresponding surveys of their children aged
10 to 15 years in 1992, a nationally representative sample of 1,513. Fifty-one percent of the children of parents who rate their child’s schools unsafe are reported to watch 5 or more hours of television a day, compared with 31% among those rating their schools safest ($p < 0.001$). A study of a multiethnic sample of youth indicated that racial/ethnic disparities in exercise levels were mediated by disparities in access to exercise facilities and programs (46). Another study of a multiethnic sample of high school students (47) indicated that the “primary SES difference appeared to be related to participation in activity lessons or classes and higher quality physical education in the school serving more affluent students.” Some European studies have shown an association of areas with physical activity levels among adults (48), disparities in physical activity resources (49), and variations in physical activity levels of adolescents (50).

Walking and cycling are common pastimes with children and adults (51). Research indicates that fear of walking or cycling in traffic is a frequently cited reason for not choosing these ways of travel (52). In a recent study of police districts, Macpherson et al. (53) found correlations between traffic patterns and injury rates at the neighborhood level, as well as an inverse association between street crossings and the area socioeconomic status. Other reports have shown that pedestrian and bicycle injuries in low-income areas are significantly more common than in affluent areas (54–56) and for certain racial and ethnic groups. Evaluations of traffic-calming interventions showed increases in bicycle traffic following environmental changes (57). These environmental strategies point to the importance of looking at the physical characteristics of a neighborhood as important influences on the physical activity patterns of its residents.

There is some evidence that school- and community-based programs may increase physical activity in young people. However, data from the Centers for Disease Control Youth Risk Behavior Surveillance System (YRBSS) suggest that opportunities for formal physical activity are limited in school settings, where youngsters spend the most time. An estimated 42% of high school students surveyed in 1991 were enrolled in daily physical education classes, well below the Year 2000 objective of 50%. A more recent report indicates that by 1997 this rate had fallen to 27% (58). The School Health Policies and Programs Study in 1994 (59) also found that school-based physical education in the United States was limited, that classes rarely focus on lifetime physical activity as recommended by the CDC (1), and that only a fraction (15%) of physical education teachers required students to develop individualized fitness programs (60).

Some data on transportation reinforce the assertion about community design: “National transportation surveys found that walking and bicycling by children aged 5 to 15 dropped 40% between 1977 and 1995” (38). However, we do not know if these changes can be attributed to community design, or perhaps to a search for efficiency among busy households (many with two wage earners), attempting to minimize transit time. Our Tritrac data, however, provide one reassuring note: Although youngsters may be generally inactive, the data clearly indicate that the one active thing they do on weekdays is to go to and from school. This transit journey may
provide a good opportunity to add activity to the lives of all youngsters. It has been reported in the United States that "more than one third (37%) of all trips to school are made from one mile away or less, but only 31% of these trips are made by walking" (38). The journey to and from school may offer a fine opportunity for community interventions at relatively low cost that could significantly boost activity levels among young people in the United States. Comparative data from other industrialized countries would be informative. Right now we have no experimental data indicating the impact of new "walk-and-bike-to-school" programs, but clearly the potential is substantial.

Environmental and policy change offers the opportunity to create environments for children and adolescents that increase physical activity, reduce inactivity, and prevent obesity. Unfortunately, our science base is very limited for making informed policy and environmental choices. However, programs and policies that reduce television viewing by providing alternatives and increasing opportunities for physically active play and sport will be unlikely to do harm, and in fact were the norm in many communities in the past. A return to less television and more play seems essential (61).

DISCUSSION

Modern industrialized society is generally characterized by low levels of physical activity, where individuals typically use motorized transport rather than walking or running, most work (including schooling for children) involves sedentary days, and vigorous physical activity consists of rare leisure-time pursuits. The quantitative work from our research group, using both 24-hour physical activity recalls and computerized electronic monitoring of physical activity levels, has confirmed these views in a study of children and adolescents (62). A larger sample of data in the present study has clearly indicated these same patterns of pervasive inactivity and moderate and vigorous activity. Because of the general underestimation of energy expenditure by the Tritrac monitors in free-living populations, these are probably underestimates of time spent daily at 3.0 MET or more. Our estimates of an average of 1 hour a day spent at 3.0 MET activity or more is consistent with two other studies using computerized accelerometers (63,64).

If accurate and generalizable, these objective data could have important implications for surveillance and monitoring of physical activity levels among young people in the United States. Yet there is a serious gap between what these Tritrac estimates indicate and the national goals for physical activity of children and adolescents. Various national panels have recommended that youngsters engage in physical activity levels that vary widely, as follows:

1. "Some of the child's activity each day should be in periods lasting 10 to 15 minutes or more and include moderate to vigorous activity" (65).
2. "[There should be] three or more sessions per week of activity that last 20 or more minutes at a time and that require moderate to vigorous levels of exertion" (66,67).
Children and teenagers are advised by the 2000 version of the Dietary Guidelines for Americans to “aim for at least 60 minutes of moderate physical activity most days of the week, preferably daily” (67).

Clearly, these three goals represent different levels of activity among youngsters, with daily averages ranging from 9 to 60 minutes of moderate (≥3.0 MET) activity. Our studies using Tritrac computerized accelerometers indicate that the vast majority of youngsters are on average meeting a goal of 30 minutes a day of moderate and vigorous activity (≥3.0 MET), with a conservative estimate of a mean of 60 minutes a day.

These results are in contrast to other estimated levels of physical activity among young people in the United States. The Surgeon General’s Report on Physical Activity and Health cites inadequate levels of physical activity among only a small percentage of youngsters, but also notes the limited evidence for these self-reported data (51). We know very little about the validity of the self-report measures used to assess national goals.

The Healthy People 2010 goal for television viewing is that youngsters watch no more than 1 or 2 hours a day (69). National estimates of television viewing indicate levels of about 3 hours a day (70–72). These goals are clearly lower than the averages found in our study and others.

When we recently designed a school-based intervention trial, we encouraged students to meet a goal of 30 minutes of moderate to vigorous physical activity every day (3). Our intervention was not successful in increasing moderate and vigorous physical activity, although it reduced television viewing, reduced obesity, and improved diet among girls. One hypothesis is that students at baseline considered they were already engaging in more than 1 hour of physical activity a day—including walking to and from school, sports, walking at school, and so on. This is what they reported in their surveys, and, as noted earlier, this is what the Tritrac data indicated. Our failure may have been in setting the wrong goals.

What are the right physical activity goals? The present findings may lead us to question how these various physical activity and inactivity goals were derived, and whether the goals, when objectively measured and targeted, represent our best science. Are these goals set too low because previous research could not measure precisely all the small bursts of activity that occur throughout a typical day? Are these goals optimal to both improve cardiovascular health and reduce obesity risk? Do we need sustained bursts of activity for 10 or 20 minutes or more a day, or are smaller bursts adequate? Are our goals for television viewing realistic? Do we need to revise them in the light of the internet revolution? What are youngsters thinking?

We need objective data on physical activity among children and adolescents to both create surveillance systems and examine their impact on outcome. We need to validate our surveillance measures, and we need to understand these data in relation to the perceptions of children and adolescents. Finally, we need to document effective policy and environmental changes that can affect physical activity and obesity. We have much work to occupy us in the future.
THE ROLE OF THE PHYSICAL ACTIVITY ENVIRONMENT IN OBESITY

ACKNOWLEDGMENTS

We thank Arthur Sobol for crucial assistance with statistical programming. This work was supported by the National Institutes of Child Health and Human Development (HD-30780), and the Centers for Disease Control and Prevention (Prevention Research Centers grant U48/CCU115807). This work is solely the responsibility of the author and does not represent official views of the Centers for Disease Control and Prevention.

REFERENCES


DISCUSSION

Dr. Strauss: I think there is an important type of activity that is very much ignored, involving between 1.5 and 3 METs, and this corresponds to play and pre-play activity. People
either focus on complete sedentary inactivity or on vigorous activity. We just did a study sponsored by Nestlé where we put activity monitors on 100 children aged 10 to 16 years. We found that the children were vigorously active for only about 12 minutes a day. The majority of the time spent being active involved low level activity in the 1.5 to 3 METs range, and this was negatively correlated with television viewing. Do you have any comments on that?

Dr. Gortmaker: These results are consistent with our findings and make an interesting point. So you think that most of the energy that pre-teen and teenage children expend during the day is in the 1.5 to 3 METs range?

Dr. Strauss: Yes. About 80% of their time is spent inactive, 5% to 6% of their time—that is, around 12 minutes a day—is spent being vigorously active, but the majority of the time spent in physical activity involves low level activity that tends to be ignored.

Dr. Gortmaker: I think this is a very important perspective. What do you think are the intervention implications of your findings?

Dr. Strauss: I think the implication is that if you decrease television viewing, though the children would not necessarily then go out and play soccer and engage in sports, they would nonetheless be more active.

Dr. Gortmaker: I would definitely agree with that, but at the same time I would not want to emphasize only the trade-off between television viewing and low level activity. I agree that this is an important part of the mechanism, but the advertising for food on TV found is the other very important link to obesity. I don’t know if you studied the patterns of activity levels over the day, but I would guess they correspond to what we have seen—that children tend to increase the level of 1.5 to 3 METs activity as they go to school and during different parts of the school day. We have found the lowest levels of overall activity on weekends, when there are fewer structured activities. The point you make suggests that if we are interested in obesity prevention, we need to think about what factors contribute to overall energy expenditure among young people. My guess is that our data are consistent with this view that energy expenditure in the 1.5 to 3 METs range explains much of the expenditure above basal that is related to physical activity.

Dr. Koletzko: I was impressed by the Tritrac data, particularly where they show that our traditional concept of children being more inactive at school—and therefore more active out of school—appears to be wrong, now that video games and computer time are becoming more popular as free time occupations. I have a couple of questions. Do the Tritrac data allow you to differentiate between active movement and passive movement, such as might occur when being driven in a car or a bus to school? Also, heart rate has been used as an index of energy expenditure in adults. Are there any data showing whether it is a useful measure of energy expenditure in children?

Dr. Gortmaker: With regard to the first question, we have investigated this a bit. Generally, when persons wearing Tritracs are in buses or cars you don’t see very much movement. When you hit bumps you may get a small increase in the activity recorded, but the amount depends on the stiffness of the springs of the bus. I have worn one of these devices for many days myself, and have become embarrassed at my low level of activity! I have found that when I drive my car, which has very stiff springs, I get virtually no movement registered, so these monitors are quite accurate in that way. They don’t tell you if the subjects are lifting weights or engaging in similar types of activity, so they do tend to underestimate overall energy expenditure, but I think in general they do a very good job in recording minute-to-minute activity.

With regard to your second question, there are a couple of very nice studies relating Tritrac and other computerized accelerometers to measures of energy expenditure, and they do quite well, with $r^2$ values around 0.8 in children engaged in a range of activities (1). So those data look quite good. Some studies using heart rate monitors show similar patterns of activity, but I have not seen direct comparisons with accelerometers and energy expenditure measures.
THE ROLE OF THE PHYSICAL ACTIVITY ENVIRONMENT IN OBESITY

Dr. Jiang: Have you found that your measurements of activity level correlate with the presence or absence of obesity?

Dr. Gottmacher: We actually found very little difference in the activity levels in this age group among children who were obese or not obese. There was a slightly higher rate of vigorous activity among children who were obese, but the curves were remarkably similar.

Dr. Yanovski: I am interested in the role of TV in obesity. Are there any studies comparing individuals who primarily watch videos or use the computer, where they would not be getting commercial messages stimulating intake, versus those who primarily watch commercial TV, with the many child-centered food commercials? This might help to separate the reduced activity versus increased intake roles of TV viewing.

Dr. Gottmacher: A former student of ours, Dr. Bernardo Hernandez, did a nice study like that among adolescents in Mexico City. He found a strong relation between hours of broadcast TV viewing and levels of obesity in children, but no relation between the use of video games and obesity (2). These data suggest that the advertising component is more important than the inactivity component, though this is only one study and the results need to be confirmed. It is also important to note that we have found that 80% of video time of youth is still broadcast TV.

Dr. Yanovski: My other comment is that in most adult studies, until you get to extraordinary levels of activity, additional intake will balance out additional activity to a large degree and so there will not be a net weight change. Thus it seems quite plausible to me that the effects of TV might be mediated through a non-activity-related change.

Dr. Steinbeck: In the Planet Health study, why was there no observed weight loss in the boys compared with the girls?

Dr. Gottmacher: There was actually weight gain in both boys and girls, because they were all growing, but it is true we did not see effects of the intervention on obesity in boys. In this age range, girls are growing more rapidly than boys, and it could be that this is a more opportune time to see intervention effects emerging among girls. Another explanation might be that our intervention resonated less with the boys than with the girls on issues of diet. I should say that in the Planet Health intervention we never focus on obesity or talk about it; lessons discuss healthy eating, reducing saturated fats, eating more fruit and vegetables, and reducing TV time and replacing it with more active time—those are the four messages. These messages may appeal less to the boys, who at this age may want to be big and muscular. Also in the United States, though obesity is also increasing rapidly among boys, there has been very much of a focus on girls and women. We have a series of national programs now focusing on obesity in girls, but nothing focusing on obesity in boys. I do think this is an important area for research. In addition, one school in particular did not implement the program well. If we drop this school (and its control) we find effects for boys (p = 0.05). Do you have any ideas?

Dr. Steinbeck: I think you can appeal to boys much more on the grounds of physical activity and sporting prowess than you can on health. That extends into the adult age group as well.

Dr. Ruslisjarif: I have a question about physical activity for obese preschool children. In Indonesia about 40% of obese children are in the preschool age. What kind of activity can you suggest for them?

Dr. Gottmacher: That is an interesting question. In the United States, preschool children typically engage in lots of play, and most neighborhoods provide environmental and cultural support for engagement in play activities. The problems are more likely to start around later primary school, middle school, and adolescence, when cultural issues and lack of opportunities tend to limit activity. My question to you would be, "What support is available in Indonesia for children’s play activities, and are there supportive environments where they can play?"
Dr. Ruslisjarif: In Indonesia, usually both parents are working, and the child is left at home with a carer. So these children are usually with their parents only at weekends and during holidays.

Dr. Gortmaker: Does anyone else have any thoughts on this problem?

Dr. Bar-Or: Maybe just to send them outdoors! Obviously, there are safety issues, but if you can satisfy those issues, then the children will find active things to do. You don’t need to give them aerobic activity or structured activity. Indoors, they are much more limited, but going outdoors can be a simple and effective solution.

Dr. Cole: You have told us that television watching is strongly associated with obesity, and of course that it is also associated with very low levels of activity. This isn’t meant to be as tongue-in-cheek as it may sound, but I’ve always thought that what is required is something like a clockwork radio—a clockwork TV that you have to cycle to allow it to be viewed. I can think of a lot of strategies you could build in so that the parent can control the child’s activity level as they watch TV.

Dr. Gortmaker: Thank you. Dr. Tom Robinson has an intervention involving an electronic devise called “the TV allowance.” This is not inexpensive, but it does allow you to achieve some of the things we have been talking about and to set limits in a way that puts the control more in the hands of the children. I also believe there is a study by Dr. Len Epstein’s group where children did have to cycle on a bike to “power” the TV. I don’t think they liked it very much, however. Dr. Robinson, do you want to comment?

Dr. Robinson: Yes, the idea is that if children have the ability to control their TV viewing time, as opposed to restrictions being imposed by parents or others, they are more motivated to try to comply with those restrictions. I’ve heard from many parents about how, by letting their children control their own TV time or even setting their own goals, the children find it much more rewarding, and the parents don’t have to be policemen to make sure that the children are complying with the goals. In relation to pedal power, I don’t believe the technology is available to generate enough energy to power a TV from a bicycle, but it is possible to devise switches that allow the power to flow to the TV when a certain level of output is achieved on a bicycle or treadmill. But this is a fairly expensive solution.

Dr. Buenaluz: In school, teachers should resort to role playing more, and involve the children in active demonstrations instead of making them sit passively at their desks. Children usually enjoy learning activities more if they are physically involved.

REFERENCES