Physical Activity During Soccer and its Contribution to Physical Activity Recommendations in Normal Weight and Overweight Children

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Amid the childhood obesity epidemic, understanding how organized sports participation contributes to meeting physical activity recommendations in children is important. Anthropometrics were measured in children (n = 111; 68% female, 9.1 ± 0.8yr) before one 50-min soccer match. Time spent at different physical activity intensity levels was examined using Actigraph accelerometers. 49% of the match time was spent in sedentary activity (25.4 ± 5.7 min), while 33% of the match (16.9 ± 4.7 min) was spent in moderate-to-vigorous activity (MVPA; p < .001). 22.5% of the children were overweight/obese and spent more time in sedentary activity (+3.2 ± 1.2 min; p < .05) and less time in MVPA (-3.0 ± 1.0 min; p < .01) compared with the normal weight children. These data demonstrate that playing an organized sport such as soccer only meets a portion (~25%) of the 60 min of MVPA recommended and even less of this recommendation is met by overweight/obese children.

Overweight and obesity is problematic in youth, with almost a third of United States children and adolescents overweight or obese (13). As obesity emerges as a top public health priority for America’s children, understanding physical activity patterns of children and how they attain energy expenditure is important. Currently in the U.S., 42% of children aged 6–11 meet physical activity guidelines of at least 60 min of moderate intensity physical activity daily (22,27). Regular physical activity is an important piece of both primary and secondary prevention of overweight, as well as a prescription to treat existing obesity in concert with dietary modifications in youth (20). Yet, despite the importance of physical activity in maintaining a healthy weight, some studies have indicated that overweight children participate in less daily physical activity than children of normal weight (9,23). Although some studies have indicated that total physical activity does not predict weight gain in children (31), an emphasis on the intensity of physical activity may be important as

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there is an association between 60 min of moderate-to-vigorous physical activity (MVPA) per day and lower body fat and a healthier BMI in children (33).

It is estimated that the energy gap in children responsible for the increase in body mass index (BMI) in children to be 110–165 kcal/day (29). Improving dietary patterns and increasing physical activity in children are equally important ways to reduce this gap. Participation in an organized sport is one mode through which children may achieve all or part of the recommended 60 or more minutes of moderate to vigorous physical activity per day (21,27). Sports participation is on the rise with 44 million youth currently involved (12), however there is little quantifiable information about how much organized sports contribute to daily physical activity levels and energy expenditure in this population. For many parents, their child’s participation in an organized sport may appear “adequate” to meet his or her child’s physical activity needs. Obtaining a more accurate, objective measure of the energy expended during organized sports is beneficial for public health recommendations as well as for coaches and parents who may want to know if their children are meeting physical activity recommendations. Furthermore, it is important to give parents and coaches perspective on the relative amount of energy expended during standard games/sports so that caloric needs are not overestimated and sports nutrition interventions are not initiated to replace calories expended when normal dietary intake is sufficient.

The purpose of this study was threefold: 1) to determine the amount of time elementary school children spend in sedentary, light, moderate, and vigorous physical activity using accelerometry during a standard 50-min soccer match; 2) to estimate the amount of energy these children expend during the match and how this relates to their daily energy expenditure and physical activity recommendations; and 3) to investigate whether children differ in the amount of time spent in moderate and vigorous activity and in the amount of energy expended in a standard soccer match based on their weight status (normal weight vs. overweight/obese).

Methods

Children aged 7–10 years who participated in youth indoor recreational soccer leagues at a sports facility in Acton, Massachusetts were recruited for this study. Data were collected before, during and immediately after one scheduled 50-min indoor soccer game (two 25-min halves separated by a two-minute half-time break). A total of twenty games were observed and each team consisted of 8–12 players each. Players arrived approximately one hour before their scheduled game to be fitted with an accelerometer, to answer a dietary questionnaire, and for measurement of anthropometrics. All parents of participants signed a written informed consent document and children provided their written assent. The study was approved by the Tufts University Institutional Review Board.

Anthropometrics

Height was measured without shoes (for both height and weight) in triplicate to the nearest eighth of an inch using a portable stadiometer (Shorr Infant/Child/Adult Height/Length Measuring Board; Healthometer, Boca Raton, FL) with the head in the Frankfurt plane made with a right angle height procedure (11). Weight was
measured in light clothing to the nearest half pound in triplicate using a digital scale (Seca, Bella model 840; Hanover, MD). BMI was calculated and z-scores were determined from age- and gender-specific cut-offs from the Centers for Disease Control growth charts (3).

### Dietary Recall

A short dietary recall questionnaire was administered to the children before the game to measure what the child consumed for the 24 hr before the study to estimate an average daily energy intake (Block Kids Food Screener, Block Dietary Data Systems). This questionnaire is intended to measure food groups, as well as consumption of calorie-dense, nutrient-poor foods in 8–17 year olds as well as estimating average daily calories.

### Accelerometry

Accelerometry is increasingly used to measure physical activity in children (17). Accelerometers have been validated using a variety of assessments including indirect calorimetry, heart rate monitoring, and the doubly labeled water method (16,17,25). Children were fitted with one of twenty Actigraph uniaxial accelerometers (model 7164; Actigraph, LLC; Pensacola, FL) that were used in this study. The ActiGraph accelerometer has been shown to be a reliable and valid instrument to measure physical activity among children (5,6,15,25). Monitors were manually calibrated (model CAL71; Actigraph, LLC) and initialized the day before they were distributed. One-second epochs were specified. Study staff placed the accelerometer over the right hip near the level of the iliac crest of each child on an elasticized belt. Children were also instructed on the proper placement and the importance of wearing the monitor during the entire game/study-period. Monitors were programmed to begin measuring one hour before game start time and synchronized with the measurement clock time. Accelerometers were removed postgame. Game start and stop times were noted by study staff to measure game-time physical activity.

### Data Analysis

#### Accelerometry

Accelerometer data were downloaded into ActiSoft Analysis Software (Actigraph, LLC), transferred to SAS statistical software version 9.1 (SAS Institute Inc., Cary, NC) for data reduction, and then statistical analyses were performed using SPSS version 14.0 (SPSS, Inc; Chicago, IL). Data were examined for any invalid counts including counts of zero for greater than 300 s and any consecutive large counts (greater than 500 per second). Consecutive large counts are potential outliers that indicate biologically implausible data. Although there were counts greater than 500, there were no consecutive seconds with identical large counts. All data were included in the analyses.

For each participant, all data points were summed for total number of counts at each 1-s epoch. All seconds of wear time for the game period were also summed, resulting in total counts during game wear time for each individual. Total number of seconds of sedentary activity, light activity, moderate activity, vigorous activity
and total number of seconds of moderate and vigorous activity combined were also summed for each individual. Physical activity levels were defined based on the value of the accelerometer counts at each second. The count cutoffs for the current study were based on those used in a childhood accelerometry study by Puyau et al. (15). In this study however, accelerometers were initialized to measure activity in one-minute epochs so counts for the current study were divided by 60 to determine activity counts per minute. This resulted in the following activity level definitions per second: sedentary activity = counts less than 13; light activity = counts from 13 to 53; moderate activity = counts from 53 to 136; and vigorous activity = counts greater than 136.

Energy expenditure regression equations have been formed using accelerometer data (5,17), many of which have been validated as useful for estimating moderate and vigorous activity (26). Activity energy expenditure (AEE) for the soccer match was calculated using the data values of counts/minute using the following formula (14): \( AEE \text{ (kcal/kg/min)} = 0.0183 + 0.00001 \text{ (counts/min)} \). For each individual, the AEE value was then multiplied by weight in kg and by game wear time in minutes to determine their kilocalories expended from activity. Basal metabolic rate (BMR) was calculated from the validated Schofield method which factors in gender, age, weight, and height (6,18). Game time BMR was calculated by dividing each individual’s total daily BMR by 1440 (total minutes in a day) and then multiplying the results by minutes of wear time for that individual. The calories calculated from the activity energy expenditure equation above were then summed with the calories from game wear time BMR to calculate total game-time energy expenditure (TGEE = AEE + BMR).

Weight Status

BMI-for-age was used to determine if a child was underweight (<5th percentile), normal weight (5th-85th percentile), overweight (85th-95th percentile), or obese (>95th percentile). BMI z-score was calculated for each participant using the Centers for Disease Control’s growth charts (4) and SAS version 9.1. Comparisons were made between normal weight and overweight/obese children and the underweight participants were excluded from these analyses (n = 4, female).

Statistical Analysis

SPSS statistical software was used for all remaining analyses (SPSS Inc., Chicago, Ill.) Group differences for gender and BMI were tested using independent t tests. One-way ANOVA was used to compare mean differences of caloric expenditure and time spent in varying activity levels across gender and BMI groups. Data are presented as means ± SD unless otherwise noted. Significance was set at \( p < .05 \) to determine statistical significance.

Results

Participant anthropometrics and estimated energy intake by gender are shown in Table 1. There were no significant differences by gender. Participants were 9.1 ± 0.9 years and 90% Caucasian with an average BMI of 17.4 ± 2.1 kg·m⁻². In total, 16.2% were classified as overweight while 6.3% were classified as obese. Average
energy intake for the prior day as estimated by the food screener was 1516 ± 591 kcal. The estimated energy intake of the overweight/obese players was higher than the normal weight group by ~19 kcals, but this did not reach statistical significance (1530 ± 707 vs. 1511 ± 558 kcal).

Table 2 displays minutes and percent of time children spent in each physical activity intensity level for a 50-min soccer game by gender. The average accelerometer game wear time was 51.8 ± 3.0 min with children averaging 45.5 ± 14.0 counts per second. On average, the children spent 16.9 min (33%) of the 50-min match in moderate to vigorous activity (range = 5.8–30.3 min or 12–60% of the

| Table 1 | Subject Descriptive Information and Estimated Daily Caloric Intake by Gender |
|-------------|-----------------------------|-----------------------------|
| Males (n = 36) | Females (n = 75) | |
| Age (yr) | 9.2 ± 0.7 | 9.0 ± 0.9 |
| (8–10) | (7–10) | |
| Height (cm) | 138.6 ± 6.0 | 137.4 ± 7.6 |
| (122–150) | (120–154) | |
| Weight (kg) | 34.1 ± 5.7 | 33.0 ± 6.3 |
| (25–51) | (22–48) | |
| BMI (kg·m⁻²) | 17.6 ± 2.3 | 17.3 ± 2.0 |
| (14.8–23) | (14.1–22) | |
| Overweight (%) | 11.1 | 18.7 |
| Obese (%) | 16.7 | 1.3 |
| Energy intake (kcal/day) | 1639 ± 687 | 1427 ± 538 |
| (775–4410) | (516–3360) | |

Means ± SD; range in parentheses. Overweight/obese = > 85th percentile BMI z-score.

Table 2 | Amount of Time Spent in Various Intensities of Physical Activity by Gender During a 50-Min Soccer Match Determined by Accelerometry |
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Males</td>
<td>Females</td>
<td></td>
</tr>
<tr>
<td>Intensity</td>
<td>Time</td>
<td>%</td>
</tr>
<tr>
<td>Sedentary</td>
<td>25.9 (4.5)</td>
<td>50.0 (8.6)</td>
</tr>
<tr>
<td>Light</td>
<td>10.2 (3.7)</td>
<td>19.7 (6.6)</td>
</tr>
<tr>
<td>Moderate</td>
<td>11.9 (3.0)*</td>
<td>23.0 (5.6)**</td>
</tr>
<tr>
<td>Vigorous</td>
<td>3.9 (2.7)</td>
<td>7.4 (5.0)</td>
</tr>
<tr>
<td>MVPA</td>
<td>15.8 (4.4)</td>
<td>30.4 (8.0)</td>
</tr>
</tbody>
</table>

Values are means (SD). Moderate-to-vigorous activity (MVPA).
* P < 0.05, ** P < 0.01, vs. females
Overall, children spent a significantly greater amount of time in sedentary activity (25.4 ± 5.7 or 49% of the game) when compared with the other activity levels \((p < .001)\). Boys spent fewer minutes \((p < .05)\) and a smaller percent of time in moderate activity \((p < .01)\) than females, but there were no gender effects on total time spent in MVPA. Age had no significant effect on different physical activity intensity levels (data not shown).

When stratified by weight status, normal weight children had higher average counts per second during a standard soccer game compared with the overweight/obese children \((47 ± 14.8 \text{ vs. } 39 ± 8.5 \text{ counts/sec; } p < .01)\). There were no differences between overweight and obese children in overall physical activity levels. Time spent in different activity intensity levels by weight status is presented in Table 3 and as a percentage of game time in Figure 1. The overweight/obese participants spent more time in sedentary activity with an average of 3.1 min more than their normal weight counterparts \((p < .05)\). Conversely, overweight/obese group spent 3 min less in MVPA \((p < .01)\) than their normal weight counterparts during a standard soccer game. Both weight classes spent approximately 18% of the game time in light activity.

For boys and girls combined, the estimated BMR for game wear time was 42.8 ± 5.6 kcals and AEE was 78.8 ± 21.0 kcals, yielding a TGEE of 121.6 ± 25.0 kcals. There were no significant differences in TGEE or AEE between genders but estimated BMR was higher in the boys \((45.6 ± 5.9 \text{ vs. } 41.5 ± 4.9 \text{ in females; } p < .01)\). TGEE was significantly less in seven and eight year-olds as compared with kids aged nine and ten \((106.5 ± 18.7 \text{ vs. } 125.3 ± 25.1 \text{ kcals; } p < .01)\).

Even though overweight/obese children had lower counts per second than normal weight children, children who were overweight/obese had a significantly higher AEE \((87.9 ± 18.8 \text{ vs. } 76.1 ± 20.8 \text{ kcals; Figure 2})\) due to their greater body weight \((40.3 ± 5.1 \text{ kg vs. } 31.3 ± 4.7 \text{ kg; } p < .001)\), which yielded a higher TGEE. In this sample, overweight/obese children expended approximately 18.5 more calories than the normal weight children in a standard soccer match \((136.0 ± 23.5 \text{ vs. } 117.5 ± 24.0 \text{ kcals, } p < .01)\) despite less MVPA. However, once appropriately corrected for differences in body size \((7)\), normal weight children expended more energy per kilogram of body weight during the game \((1.7 ± 0.2 \text{ vs. } 1.5 ± 0.1 \text{ kcal/kg; } p < .001)\).

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Normal Weight</th>
<th>Overweight or Obese</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedentary</td>
<td>24.7 (5.9)</td>
<td>27.8 (4.3)*</td>
</tr>
<tr>
<td>Light</td>
<td>9.5 (3.2)</td>
<td>9.7 (2.4)</td>
</tr>
<tr>
<td>Moderate</td>
<td>13.5 (3.7)</td>
<td>11.8 (2.6)*</td>
</tr>
<tr>
<td>Vigorous</td>
<td>4.1 (2.6)</td>
<td>2.8 (1.4)**</td>
</tr>
<tr>
<td>MVPA</td>
<td>17.6 (4.8)</td>
<td>14.6 (3.1)**</td>
</tr>
</tbody>
</table>

Values are means \((SD)\). Moderate to vigorous activity \((MVPA)\). Normal weight > 5th and <85th percentile for BMI z-score. Overweight/obese \(³ 85th\) percentile for BMI z-score.

\*\(p < 0.05\), \**\(p < 0.01\) vs. normal weight
Figure 1 — Percent of time spent in sedentary, light, moderate, and vigorous activity during a 50-min soccer match by BMI categories (open bars = normal weight; dark bars = overweight or obese). Values are means ± SE. Different than normal weight individuals, **p < .01

Figure 2 — Estimated kilocalories for basal metabolic rate (BMR), activity energy expenditure (AEE) and total energy expenditure (TEE = BMR + AEE) during a 50-min soccer match by BMI categories (open bars = normal weight; dark bars = overweight or obese). Values are means ± SE. Different than normal weight individuals, *p < .05, **p < .01
In terms of the contribution of the organized soccer match to daily physical activity recommendations, normal weight children are only meeting 17.6 min (~29%) of the recommended 60 min of physical activity while overweight/obese children are only meeting 14.6 min (~24%) of the recommendation. Of the approximate 585 kcal/day they should be expending per day in MVPA, which is associated with acceptable levels of BMI and body fat (based on 8 kcal/kg/day; 32), it can be estimated that only ~20% of this goal is achieved through this soccer activity.

Discussion

As nearly one third of U.S. children are overweight or obese, it is important to understand both the dietary and physical activity patterns of children that contribute to a positive energy balance and weight gain. Organized sports are popular in the U.S. and can be an important way for children to become and stay physically active, yet only a minority of children are meeting current physical activity recommendations (2,24). We found that an organized sport, one indoor 50-min soccer match, only provides 28% of the MVPA minutes recommended to meet daily physical activity recommendations. Although 50 min of organized sport participation contributes to the daily recommendation, the majority of this time is spent in sedentary activity. Importantly, this “sporting activity time” clearly does not satisfy a child’s daily physical activity needs nor does it require that additional calories be provided from extra snacks or sports drinks to prevent weight loss or enhance growth. This is important because it can be deceiving to parents who may believe their child is getting enough moderate to vigorous exercise from their sporting practices and events to meet the recommendations.

Surprisingly, children spent 33 min or 67% of the game in sedentary or light-intensity activity. In a study of 6–12 year old boys, the authors similarly found that children obtained 23% of total daily MVPA from organized sports (soccer, basketball and flag football were examined) and about 52% of organized sport time was spent in sedentary or light-intensity activity (30). However, they did find that on nonsport days, children spent significantly more time in sedentary activities, suggesting that participating in organized sports at least contributes to more MVPA minutes even though it is not a large portion of the daily goal (30). In teens, organized sport participation has been found to help them to be more active during adolescence, although it does not prevent the decline in physical activity levels with age (2). This highlights that even though children are not exercising vigorously for a good portion of their sporting event, their participation on these days is better than on “non-organized sport” days.

To compound matters, overweight and obese children spent fewer minutes in MVPA and more minutes in sedentary activity during the match than the normal weight children. Although the difference was not very large (3 min more of sedentary time and 3 min less of moderate to vigorous time) this lack of intensity and more time in sedentary activity can significantly contribute to a child’s health over time. Unfortunately, as the relationship between physical activity intensity and overweight is cross-sectional, the direction of causality cannot be determined. For instance, overweight children may be simply less active during play time due to their physiology or their less active time may be due to social factors such as a
coach subconsciously giving an overweight child less time on the field. Whether the physiology of overweight and obese children cause them to be less active or whether their weight is a barrier for them to engage in more vigorous activity needs to be addressed in future studies.

Others have found that similar-aged overweight and obese children obtain fewer minutes of MVPA on a daily basis than normal weight children (9,23,33). Wittmeier et al. (33) found that lower durations of MVPA were associated with increased odds of both overweight and adiposity and that 15 min of vigorous activity and 45 min per day of moderate activity were associated with reduced body fat. The overweight children in our study only exercised vigorously for about 3 min and moderately for about 12 min during a soccer match; not even a quarter of what was found in the Wittmeier et al. (33) study that was associated with reduced body fat. This is striking, as the likelihood of other sources of MVPA, especially vigorous activity, on a daily basis is uncertain. In contrast with other studies, girls in the current study participated in more moderate to vigorous activity than boys (19,24). One possible explanation for this is that a greater percentage of boys were overweight (27.8%) compared with girls (20.0%) or that more active girls self-select into sports like soccer.

On a per kilogram basis, normal weight children are burning more calories, but in total, overweight children are expending more calories during a soccer match (about 18.5 kilocalories) due to their higher body mass. Ironically, the estimated energy intake of the overweight and obese children was ~19 kcal more per day which would negate the extra energy burned. Yet, the energy intake difference was not significant and these values should be interpreted with caution. Accurately determining caloric expenditure and intake can be extremely difficult. Prior research has used various equations for determining both accelerometer AEE and BMR values (10,14,15,18,23). Although the results of the AEE, BMR and TGEE kilocalorie values are estimations, the formulas used to calculate AEE kilocalories and BMR for this study’s data are validated and the best choice when considering the characteristics of the data and the objectives of the study. In addition, the diet questionnaire only estimated what the children consumed on the prior day. A more detailed dietary recall would be necessary to better determine our observed relationship between energy intake and expenditure, especially as the daily self-reported energy intakes may be on the low end for this population. The 2010 Dietary Guidelines for Americans report recommends 1600–1800 kcals per day for moderately active children (30–60 min of moderate activity per day) for both males and females aged 7–10 years (28).

On average, the children in this study expended ~80 calories attributable to activity during 50 min of an organized sport. If children are moderately to vigorously active only during their organized sport, then the estimated energy gap that contributes to weight gain (~110–165 kcal/day) compared with the estimated expended calories demonstrates that children may still be in positive energy balance. Over time, this will result in excess weight gain unless caloric intake is reduced and/or caloric expenditure is increased. It is important for parents and coaches to recognize and understand that extra snacks and sports drinks are likely not necessary for children participating in physical activities that comprise less than one hour of their day. It may also be beneficial for children to participate in more physical activity that is less structured so that children are not confined to a coach dictating when they can “play” or be “substituted out” of a game.
Accelerometry is a useful way to objectively measure physical activity in children because of its ability to measure short bouts of activity and to qualify the relative intensity of activity. A limitation encountered when using accelerometers to evaluate physical activity in children is that studies use different cut-offs for counts. These cut-offs have ranged from 500 to 3200 counts per minute in other various published articles (1). To obtain the most accurate analysis for the Actigraph 7164, the count cut-offs used in this study are based on the work of Puyau et al. (14,15), which validated acceptable count cut-offs for the Actigraph 7164 in children performing vigorous activity. When using alternative cut-points for children by Freedson et al. (8) results were significantly different for each group (data not shown). The Freedson et al. (8) cut-points demonstrated that the children may be participating in even less MVPA (9.5 ± 43.9 min vs. 16.9 ± 4.7 min; p < .01) and even more sedentary activity (28.3 ± 5.6 vs. 25.4 ± 5.7; p < .01). Even though significant differences were found using different cut-points, this comparison further highlights that our estimates of the time that children spend in sedentary activity during an organized sport may be more than anticipated.

Participation in organized sports offers a great venue for children to socialize and be active, however it is important to recognize that by simply “participating” in a daily sporting event, we have shown that most children are only obtaining a low percentage of the daily physical activity recommendation and other opportunities for moderate to vigorous activity are needed. Overweight and obese children obtain even less of the physical activity benefit, which may be due to several factors that were not examined in the current study. Furthermore, it is not uncommon for children to drink sports drinks or have an extra snack before or after a game, as parents and/or coaches feel that kids will need the additional energy. Total additional activity expenditure was only about 80 kcals on top of what a child is expending at rest—this equates to the calories in an apple or 1 cup of a sports drink. However many children may already be in positive energy balance and may not require additional calories. Finally, in addition to this practical application, these results should be beneficial in helping to mold future recommendations and guidelines for physical activity and organized sport in children.

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Disclosure

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References


