Activity Levels in Mothers and Their Preschool Children

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ABSTRACT

Physical activity is beneficial to health. Parents are crucial in shaping children’s behaviors, with active mothers appearing to have active children. Little is known about this association in preschool-aged children, or about factors influencing activity in mothers of young children.

OBJECTIVES: To investigate the association between objectively measured maternal and preschool-aged children’s physical activity, determine how this association differs by demographic and temporal factors, and identify factors associated with maternal activity levels.

METHODS: In the UK Southampton Women’s Survey, physical activity levels of 554 4-year-olds and their mothers were measured concurrently by using accelerometry for ≤7 days. Two-level mixed-effects linear regression was used to model the association between maternal and children’s minutes spent sedentary, in light (LPA) and moderate-to-vigorous physical activity (MVPA). Linear regression was used to investigate correlates of maternal activity.

RESULTS: Mother-child daily activity levels were positively associated at all activity intensities (sedentary, LPA, and MVPA; all P < .001). The association for sedentary time was stronger for normal-weight children (versus those who were overweight/obese), and those attending preschool part-time (versus full-time). The mother-child association for LPA differed by maternal education and was stronger at the weekend (versus weekdays). The opposite was true for MVPA. Sedentary time and MVPA were most strongly associated in mornings, with LPA most strongly associated in the evenings. Maternal BMI, age leaving school, number and age of children at home, and working hours were independently associated with maternal daily sedentary time and LPA.

CONCLUSIONS: Physical activity levels in mothers and their 4-year-old children are directly associated, with associations at different activity intensities influenced by temporal and demographic factors. Influences on maternal physical activity levels also differ by activity intensity. Providing targeted interventions for mothers of young children may increase both groups’ activity. Pediatrics 2014;133:e973–e980

WHAT’S KNOWN ON THIS SUBJECT: Physical activity is beneficial to health. Parents are crucial in shaping children’s behaviors, with active mothers appearing to have active children. Little is known about this association in preschool-aged children, or about factors influencing activity in mothers of young children.

WHAT THIS STUDY ADDS: Mother-child physical activity levels were positively associated and influenced by temporal and demographic factors. Maternal activity levels were low, and influences differ by activity intensity. Health promotion efforts to increase activity in mothers may also benefit their young children.
Physical activity plays an important role in health and prevention of disease, with strong cross-sectional associations seen between physical activity and health outcomes in school-aged children. Similar benefits have been observed in younger children, with active children showing improved social and motor development, and decreased adiposity. Yet despite these benefits, activity levels are known to decrease through childhood into adulthood. This extends into the childbearing years, with new parents tending to be less active than their childless counterparts, and failing to meet recommended activity guidelines. As activity levels frequently fail to return to pre-parenthood levels, and parental activity may influence that of their small children, understanding this association is important for health promotion.

Both direct and indirect mechanisms have been proposed for an association between activity of children and their parents, ranging from genetic influences through the psychosocial impact parents may have via modeling or supervision of physical activity. Using an objective measure of physical activity (accelerometers), studies in older children have been proposed for an association between child and maternal physical activity levels by using objective measures of physical activity. Parental consent was obtained. Ethical approval for the study that included assessment of habitual physical activity, and assesses if this association is moderated by demographic and temporal factors. Given the potentially important influence of maternal activity, we also determine factors associated with mothers’ activity levels, providing novel information to aid future health promotion efforts.

METHODS

Participants

The Southampton Women’s Survey is a population-based prospective cohort study based in Southampton, UK. Full details of participant recruitment and data collection procedures are presented elsewhere. Between 1998 and 2002, all female patients aged 20 to 34 years were approached to participate through general practices. Subsequent live births were followed to examine how a child’s prenatal development interacts with their postnatal growth, and how both may affect risk factors for future chronic diseases. All children turning 4 between March 2006 and June 2009 and their mothers were invited into a secondary study that included assessment of habitual physical activity. Parental consent was obtained. Ethical approval for the study was granted by the Southampton and Southwest Hampshire Local Research Ethics Committee.

Physical Activity Assessment

At the age 4 visit, children and their mothers were fitted with an Actiheart monitor (Cambridge Neurotechnology Ltd, Cambridge, UK) to measure free-living physical activity. The Actiheart is a lightweight combined heart-rate monitor and accelerometer, positioned on the chest, previously validated in preschool-aged children and adults. The Actiheart was set to record at 60-second epochs to maximize capacity. Participants wore the monitor continuously for up to 7 days, including during sleep and water-based activities. Monitors and a previously validated maternal questionnaire assessing potential correlates of physical activity were returned by post.

Physical Activity Variables

Only accelerometer data are used for these analyses, as equations to combine accelerometer and heart-rate data to estimate free-living physical activity energy expenditure are yet to be developed for the preschool age group. Both child and maternal accelerometer data, derived as cpm, were analyzed using a bespoke program (MAHÚffe). Actiheart counts were converted to Actigraph counts by using a conversion factor of 5, derived and validated experimentally. Data periods of ≥100 minutes with zero-activity counts were removed, as were days with <600 minutes of recording. All recordings between 11 PM and 6 AM were removed, with those between 9 PM and 11 PM removed if they included more than 45 minutes of sedentary time, deemed to reflect the hours children spent sleeping. This method represents a conservative estimate of sleep time, while minimizing an overestimation of children’s evening sedentary time. To obtain concurrently measured activity, mother’s and child’s activity data were matched exactly for day and hour of recording. All hours removed as sleep for a child were also removed for their mother to ensure a like-for-like comparison.
Thresholds for light (LPA; ≥20 cpm) and moderate-to-vigorous (MVPA; ≥400 cpm) activity were used to determine time spent at each activity intensity for each hour. True sedentary time was calculated by subtracting “active” time (≥20 cpm) from total valid registered time. Average daily minutes spent at each activity intensity were also calculated. The Actiheart intensity thresholds have been derived experimentally\(^{33,36}\) and equate to 100 counts for LPA and 2000 counts for MVPA in the Actigraph 7164 accelerometer (Actigraph, Pensacola, FL). These broadly aligned with the respective preschool-specific intensity thresholds.\(^{37–40}\)

**Other Variables**

Having appraised the evidence of activity in young children,\(^{14,41}\) and mothers of young children,\(^{10,11,42}\) a range of other variables were used. Hour, time of the day, and week were obtained from the accelerometer output. Days were split into 3 periods: morning (6–12 PM), afternoon (12–5 PM), and evening (5–11 PM). Season was defined as follows: winter, December to February; spring, March to May; summer, June to August; autumn, September to November. Child’s age and gender were recorded, and child’s and mother’s height and weight were measured during the visit.\(^{43}\) Mother’s and child’s BMI and child’s BMI z score\(^{44}\) were calculated. Children and mothers were categorized as underweight, normal weight, or overweight/obese by using the International Obesity Task Force\(^{45}\) and World Health Organization\(^{46}\) classifications, respectively.

Data from the maternal self-report questionnaire were used to derive remaining demographic variables. Age mother left full-time education was classified as follows: ≤16 years, 17 to 18 years, and >18 years. Day care, nursery, or preschool attendance was classified as full-time (≥30 hours per week) or part-time/other (<30 hours per week). Presence of older or younger siblings was used to quantify children living in the home: cohort child only, child plus younger siblings, child plus older siblings, child plus older and younger siblings. A dichotomous variable was created for the child’s father being present at home (yes/no). The number of hours mothers worked each week was categorized as follows: not in work, part-time (<30 hours), full-time (≥30 hours).

**Statistical Analysis**

Analyses were carried out by using Stata/SE 12 (Stata Corp, College Station, TX). All mother-child dyads with ≥1 shared valid day of activity were included. Descriptive characteristics were calculated, and sensitivity analyses conducted to compare those dyads with ≥1 or ≥3 days of valid activity data. A significance level of .05 was set a priori.

Using children’s daily activity as the outcome, 2-level random intercept models were used to model the association between minutes children spent sedentary, in LPA and MVPA, and maternal activity. Hierarchical models allowed for variation in outcome between days (level 1) and variation between children (level 2).\(^{47}\) Correlations between observations were accounted for by allowing the intercept to vary randomly between children (ie, level 2).

Due to a non-normal distribution, child’s MVPA was log-transformed before analysis. Regression coefficients were subsequently back-transformed and presented as a geometric mean ratio (GMR); any deviation from 1 indicates a percentage change in child’s MVPA per unit change in mother’s MVPA relative to the reference category. All models were adjusted for child’s gender and weight status, age mother left full-time education, time child spent at preschool, and time of the week (weekday versus weekend). To test for effect modification, each of these variables was entered separately as an interaction with maternal activity. Finally, the association between maternal and child activity segmented across the day (morning, afternoon, evening) was assessed.

To explore the potential correlates of maternal activity, average daily activity (during her child’s waking hours) at each of the 3 intensities was used as the outcome variable in univariable linear regression models. All models were adjusted for child’s activity and plausible predictors of maternal physical activity were added into the models, including maternal age and BMI, age leaving full-time education, children at home, living with a partner, and hours worked. All variables significantly associated with mother’s activity were carried forward and entered simultaneously into a multiple regression analysis. Variables not meeting the predefined \(P < .05\) significance level were sequentially removed.

**RESULTS**

A total of 554 mother-child dyads had valid physical activity data for 1 or more shared days (mean 4.9 days [SD 1.6]). Compared with those not participating in activity assessment, participating mothers were slightly older when their child was born (mean age 30.4 [3.8] vs 31.1 [3.6] years, respectively; \(P = .004\)) and better educated (27.5% with higher degree versus 31.3%, \(P = .014\)). No differences in activity levels were observed between those children (and therefore mothers) with ≥1 and ≥3 days; therefore, all dyads with ≥1 shared day(s) of valid activity data were included. Descriptive characteristics for mother-child dyads are presented in Table 1, with average activity levels presented in Table 2.
TABLE 1 Descriptive Characteristics for Children and Their Mothers (n = 554)

<table>
<thead>
<tr>
<th></th>
<th>Children</th>
<th>Mothers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls, n (%)</td>
<td>284 (51.3)</td>
<td>170 (30.6)</td>
</tr>
<tr>
<td>Age, y, mean (SD)</td>
<td>4.1 (1.1)</td>
<td>5.6 (1.8)</td>
</tr>
<tr>
<td>BMI, mean (SD)</td>
<td>16.0 (1.4)</td>
<td>25.3 (5.6)</td>
</tr>
<tr>
<td>Weight status, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underweight</td>
<td>35 (6.3)</td>
<td></td>
</tr>
<tr>
<td>Normal weight</td>
<td>443 (80.0)</td>
<td>234 (42.2)</td>
</tr>
<tr>
<td>Overweight/obese</td>
<td>76 (13.7)</td>
<td>252 (46.8)</td>
</tr>
<tr>
<td>BMI ≥ score, mean (SD)</td>
<td>0.16 (1.0)</td>
<td></td>
</tr>
<tr>
<td>Children at preschool full-time, mean (SD)</td>
<td>36 (7.4)</td>
<td></td>
</tr>
<tr>
<td>Age mother left full-time education, y, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤16</td>
<td>164 (31.8)</td>
<td></td>
</tr>
<tr>
<td>17–18</td>
<td>185 (35.9)</td>
<td></td>
</tr>
<tr>
<td>&gt;18</td>
<td>167 (32.3)</td>
<td></td>
</tr>
</tbody>
</table>

All values are mean (SD) unless stated.

TABLE 2 Average Daily Activity Levels for Children and Their Mothers

<table>
<thead>
<tr>
<th></th>
<th>Children</th>
<th>Mothers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registered time, min</td>
<td>847.6 (66.4)</td>
<td>848.2 (68.1)</td>
</tr>
<tr>
<td>Average activity intensity, cpm</td>
<td>150.4 (45.8)*</td>
<td>80.4 (30.2)</td>
</tr>
<tr>
<td>Sedentary time, min</td>
<td>282.8 (94.5)</td>
<td>426.5 (119.5)</td>
</tr>
<tr>
<td>Light physical activity, min</td>
<td>498.3 (88.1)*</td>
<td>402.8 (110.6)</td>
</tr>
<tr>
<td>Moderate-to-vigorous physical activity, min</td>
<td>68.8 (41.0)*</td>
<td>19.0 (21.5)</td>
</tr>
<tr>
<td>Percent of days activity guidelines metb</td>
<td>100</td>
<td>22</td>
</tr>
<tr>
<td>Percent of participants meeting physical activity guidelinesc</td>
<td>100</td>
<td>53</td>
</tr>
</tbody>
</table>

All values are mean (SD) unless stated.

a Significant difference by gender P < .05.
b Children’s guideline: 180 min of activity at any intensity; adult: 30 min MVPA.
c Meeting activity guidelines for at least 1 measurement day.

Associations Between Child and Maternal Physical Activity

In adjusted models, there was a positive association between children’s and their mother’s average daily activity at each intensity (Table 3); for each extra minute of maternal activity, children engaged in 0.18 minutes more sedentary time, 0.14 minutes LPA, and 10% more MVPA. These associations did not differ by child’s gender. Maternal physical activity was positively associated with maternal average sedentary time and MVPA in the evenings for LPA (Table 3).

Correlates of Maternal Activity

In adjusted analyses, maternal BMI (β = 2.8 minutes [95% confidence interval (CI) 1.3 to 4.3]) and working full-time (44.8 [14.3 to 75.4]) were positively associated with mother’s average sedentary time, whereas maternal duration of schooling was negatively associated with sedentary time (ie, leaving school at 17–18 years: −26.9 minutes [−47.1 to −6.7]; >18 years: −27.5 minutes [−48.3 to −6.7] compared with leaving at age 16) (Supplemental Table 4). The converse was true for LPA, with BMI (β = −2.8 [−4.2 to −1.4]) and working (part-time: −26.9 [−47.1 to −6.7]; full-time: −39.4 [−68.7 to −10.1]) negatively associated with activity. Having more than 1 younger child at home was positively associated with mothers’ average daily LPA (48.7 [25.8 to 71.7]). There were no significant associations with maternal MVPA.

DISCUSSION

Using a large population-based sample, this study showed a direct positive association between the activity levels of mothers and their 4-year-old children. This association was apparent for overall daily activity levels and activity segmented across the day, controlling for confounders. This suggests mothers and children are active concurrently, but as the association differed by child’s weight status, time spent at preschool, duration of mother’s schooling, and by time of the day and week, that it is moderated by demographic and temporal factors. We also established several correlates associated with both maternal average sedentary time and LPA. Interventions to increase activity in preschool-aged children may therefore consider including an element of maternal co-participation, while also targeting specific times throughout the day to achieve maximum gains.

This work supports previous observations in smaller studies (up to 100 dyads), also showing positive associations between objectively measured physical activity in mothers and their preschoolers.12,19,48,49 In a US-based study, young children were more likely to be active if their mother, father, or both parents were active (versus inactive parents: odds ratios: 2.0, 3.5, and 5.8, respectively).19 Here, we found a stronger association between child’s and mother’s MVPA on weekdays compared with weekends, similar to a study in Canadian preschoolers.12
Our study also showed that the association was stronger for LPA on the weekends. Mothers may be more likely to engage in LPA, with fathers participating in higher-intensity activities with their children on weekends. Due to the study design, physical activity data were not available for fathers. However, both parents have been shown to influence young children’s activity levels. Moreover, other household members should be considered, as having older siblings has been shown to be associated with a positive change in girls’ activity. Given that both parents being active may have a greater effect on their child’s activity than the sum of their individual parts, active siblings may further encourage activity in young children. Health promotion efforts targeting physical activity in young children may therefore consider the inclusion of whole families.

One previous study found a strong correlation between children’s and mothers’ objectively measured sedentary time. Here, a stronger association was seen between activity of mothers and children attending preschool part-time (versus full-time). To date, most studies have measured children’s activity either during or outside preschool hours. Future work should determine what effect child care attendance and maternal employment have on children’s activity levels. Indeed, maternal working hours were positively associated with their sedentary time, and negatively associated with LPA. This suggests that mothers who work more are more likely to be more sedentary, but also have less influence on their child’s sedentary time. As evidence increasingly suggests an association between maternal and child activity, the wider potential influence of maternal activity should not be overlooked. Although mothers may provide most informal child care, they may have limited amounts of time available to engage in activity throughout the working week. Thus, innovative interventions are needed to facilitate greater activity during mother-child time, ultimately benefiting them both.

Few studies have explored factors associated with physical activity levels of mothers of young children. On average, mothers engaged in approximately equal amounts of sedentary and LPA each day, with only 53% of mothers meeting the recommended 30 minutes of MVPA on 1 or more days. Working full-time and having a higher BMI were associated with increased sedentary time and decreased LPA. Living with a partner has previously been shown to be associated with positive health behaviors in adults. Living with the participating child’s father was not associated with maternal activity at any intensity here, although limited heterogeneity in this exposure may in part account for this finding. As mothers tend to be less active than fathers (and men), and consume a less

### TABLE 3 Associations Between Child and Maternal Physical Activity Levels, and Influence of Temporal and Demographic Factors

<table>
<thead>
<tr>
<th></th>
<th>Sedentary Time</th>
<th></th>
<th>LPA</th>
<th></th>
<th>MVPA</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unadjusted</td>
<td>Adjusted*</td>
<td>Unadjusted</td>
<td>Adjusted*</td>
<td>Unadjusted</td>
<td>Adjusted*</td>
</tr>
<tr>
<td></td>
<td>β (95% CI)</td>
<td>β (95% CI)</td>
<td>β (95% CI)</td>
<td>β (95% CI)</td>
<td>β (95% CI)</td>
<td>β (95% CI)</td>
</tr>
<tr>
<td>Average daily activity interaction terms</td>
<td>0.17 (0.14 to 0.20)**</td>
<td>0.18 (0.13 to 0.22)**</td>
<td>0.18 (0.15 to 0.21)**</td>
<td>0.14 (0.09 to 0.19)**</td>
<td>1.10 (1.08 to 1.12)**</td>
<td>1.10 (1.06 to 1.14)**</td>
</tr>
<tr>
<td>Gender</td>
<td>−0.01 (−0.08 to 0.05)</td>
<td>0.03 (−0.03 to 0.10)</td>
<td>1.17 (0.93 to 1.07)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight status</td>
<td>−0.11 (−0.24 to 0.03)</td>
<td>−0.08 (−0.17 to 0.01)</td>
<td>0.96 (0.89 to 1.04)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overweight/obese</td>
<td>−0.10 (−0.19 to 0.00)*</td>
<td>−0.13 (−0.27 to 0.01)</td>
<td>1.01 (0.91 to 1.13)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full-time preschool</td>
<td>−0.16 (−0.28 to −0.03)*</td>
<td>−0.11 (−0.23 to 0.02)</td>
<td>0.99 (0.90 to 1.09)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age mother left full-time education (ref: ⩾16 y)</td>
<td>0.03 (−0.11 to 0.04)</td>
<td>0.09 (0.01 to 0.17)*</td>
<td>1.00 (0.94 to 1.06)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17–18 y</td>
<td>0.04 (0.03 to 0.05)</td>
<td>0.05 (−0.13 to 0.03)</td>
<td>0.95 (0.94 to 0.99)*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;18 y</td>
<td>0.05 (0.00 to 0.10)*</td>
<td>0.95 (0.90 to 0.99)*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time of the week</td>
<td>0.03 (−0.02 to 0.08)</td>
<td>0.05 (0.00 to 0.10)*</td>
<td>0.95 (0.90 to 0.99)*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Association by time of day</td>
<td>0.21 (0.19 to 0.24)**</td>
<td>0.21 (0.18 to 0.24)**</td>
<td>0.26 (0.22 to 0.29)**</td>
<td>0.22 (0.19 to 0.26)**</td>
<td>1.17 (1.13 to 1.21)**</td>
<td>1.15 (1.12 to 1.21)**</td>
</tr>
<tr>
<td>Morning (6 AM—12 PM)</td>
<td>0.13 (0.09 to 0.18)**</td>
<td>0.12 (0.09 to 0.16)**</td>
<td>0.08 (0.05 to 0.11)**</td>
<td>0.08 (0.05 to 0.11)**</td>
<td>1.14 (1.09 to 1.17)**</td>
<td>1.13 (1.10 to 1.18)**</td>
</tr>
<tr>
<td>Afternoon (12–5 PM)</td>
<td>0.16 (0.12 to 0.20)**</td>
<td>0.18 (0.14 to 0.22)**</td>
<td>0.34 (0.30 to 0.38)**</td>
<td>0.35 (0.31 to 0.40)**</td>
<td>1.08 (1.02 to 1.14)**</td>
<td>1.07 (1.02 to 1.15)**</td>
</tr>
</tbody>
</table>

β, β regression coefficient (minutes of activity).
* Model adjusted for child gender, weight status, time spent at preschool, age mother left full-time education, and time of the week.
# EXPONENTIALIZED OR GM.R: ANY DEVIATION FROM 1 INDICATES A % CHANGE IN CHILD’S MVPA PER UNIT CHANGE IN MOTHER’S MVPA RELATIVE TO THE REFERENCE CATEGORY.
** P < .05.
*** P < .005.
healthy diet than women without children, mothers of young children may be at greater risk of negative health outcomes and remain a target for health promotion interventions in their own right.

Mothers with more than 1 child younger than 5 accumulated more LPA than those with 1 child. Active children are likely to require their mothers to be active, just as mothers who engage in activity may also encourage their children to be active. Contextual information is required to determine if mothers and children are active together. Although the direction of causality remains to be established, this work suggests that health practitioners and pediatricians may wish to consider the influence of maternal activity when discussing ways to promote activity in preschoolers. Even in the absence of mutual participation, a mother may facilitate her child’s activity and act as a positive role model. Moreover, stressing the potential importance of this mother-child relationship could potentially increase activity levels in the less-active of the pair, leading to improved social and health outcomes in both, setting a precedent for positive shared behaviors early in a child’s life.

Using a large population-based sample of more than 500 mother-child dyads, an objective measure of activity, and hourly time-stamped data, this study provides a detailed picture of the association between mothers and preschool-aged children’s physical activity. Further, it is one of the first to assess factors related to maternal activity, suggesting sociodemographic factors influence sedentary activity behavior in mothers of young children. The Actiheart monitor was worn continuously during measurement and is therefore likely to have captured more active time than Actigraph monitors, which are removed for water-based activities and sleep. There may have been a slight underestimation of both child and maternal activity after the hours of 9 PM, and by excluding sleep time. However, exploration of hourly activity data showed this was minimal, with children and mothers engaging in little activity and being largely sedentary in the evenings. The use of 60-second epochs, necessary to allow sufficient memory to record for 7 days, may underestimate MVPA,52 while overestimating LPA53 in small children. Despite this, there was a strong association between physical activity in mothers and their children at all intensities over the course of the day, suggesting that activity in 1 of the pair is likely to influence the other.

Participants were drawn from all socioeconomic backgrounds in Southampton and the surrounding areas. Mothers included here were, however, better educated and older when they gave birth compared with the Southampton Women’s Survey mothers initially recruited. Fewer children were overweight or obese compared with the national average,54 and participants were predominately white British, in keeping with the Southampton region (~82%).55 This should not bias relationships within the data set, but caution when generalizing to other populations is required.

CONCLUSIONS
We found that objectively measured physical activity levels and sedentary time in 4-year-old British children and their mothers are significantly and directly associated, the strength differing by temporal and demographic factors. Given low levels of activity were seen here in mothers of young children, these results support developing targeted interventions to increase their activity, but also providing additional opportunities for mothers to be active with their young children. Pediatricians may be particularly well placed to encourage this mutual participation during well-child visits, promoting increased physical activity in both mothers and their preschool-aged children.

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