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Maternal correlates of objectively measured physical activity in girls

Alyce T. Barnes, Ronald C. Plotnikoff, Clare E. Collins & Philip J. Morgan

Dr. Alyce T. Barnes

Priority Research Centre in Physical Activity and Nutrition
School of Education, Faculty of Education and Arts
University of Newcastle, Callaghan Campus 2308
Australia
Email: alyce.barnes@newcastle.edu.au
Phone: +61 4921 6566
Fax: +61 2 4921 2084

Prof. Ronald C. Plotnikoff
Priority Research Centre in Physical Activity and Nutrition
School of Education, Faculty of Education and Arts
University of Newcastle, Callaghan Campus 2308
Australia
Email: ron.plotnikoff@newcastle.edu.au
Phone: +61 4985 4465
Fax: +61 2 4921 2084

Prof. Clare E. Collins
Priority Research Centre in Physical Activity and Nutrition
School of Health Sciences, Faculty of Health
University of Newcastle, Callaghan Campus 2308
Australia
Email: clare.collins@newcastle.edu.au
Phone: +61 4921 5646
Fax: +61 2 4921 2084

Prof. Philip J. Morgan
Priority Research Centre in Physical Activity and Nutrition
School of Education, Faculty of Education and Arts
University of Newcastle, Callaghan Campus 2308
Australia
Email: philip.morgan@newcastle.edu.au
Phone: +61 2 4921 7265
Fax: +61 2 4921 2084

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Abstract

Objectives: Given the low levels of physical activity in girls, improving our understanding of the factors associated with girls' physical activity is important. In particular, exploring maternal correlates of girls' physical activity for both generations is important, given the paucity of research in this area. The primary aim of this study was to assess maternal correlates of objectively-measured physical activity in girls. Methods: A cross-sectional design was used to assess 40 girls [mean age 8.8 years; mean BMI (body mass index) z-score=0.7] and their mothers (mean age 39.1 years; mean BMI=27.6) prior to an intervention. Maternal correlates of daughters' accelerometer-assessed physical activity were evaluated. Daughters' outcomes included: % MVPA (moderate-to-vigorous physical activity), CPM (counts per minute) and % SED (sedentary behavior), screen time (mother-proxy) and BMI z-score (objectively measured). Maternal correlates included demographic, anthropometric, behavioral, activity-related parenting practices, and physical activity cognitions. Correlates were examined using regression models. Results: For daughters' % MVPA, mothers' beliefs was significant in the final model ($R^2=0.14$; $P=0.01$). For daughters' CPM, mothers' logistic support ($P=0.03$), mothers' CPM ($P=0.02$) and outcome expectations ($P=0.01$) were all significant ($R^2=0.24$). For daughters' % SED, mothers' logistic support ($P=0.02$) was significant ($R^2=0.11$). Conclusions: A number of maternal behaviors, social-cognitive and parenting correlates were found to be significantly associated with daughters' physical activity. Experimental studies are warranted, targeting mothers as the primary agents of change to increase physical activity among girls.

Keywords: parent-child relationship; mother; exercise; accelerometer; females

Significance statement:

Globally, physical inactivity is a public health concern. Alarming, a marked difference exists between the physical activity levels of males and females. Due to the low levels of physical activity displayed by females, strategies that encourage activity behavior need to be trialed and tested. One key setting for behavior change is the family environment.

Our study involved a novel intergenerational sample of mothers and daughters, revealing key predictors of girls' physical activity in relation to their mothers' parenting for physical activity. Stronger associations were found for the moderate and vigorous activity levels of girls. Our findings suggest specific maternal targets such as beliefs about the benefits of physical activity for girls, logistic support regarding girls' physical activity involvement, and outcome expectations may be important for future interventions targeting females.

Introduction

Over the years, many studies have well established that regular physical activity leads to significant physical and psychological health benefits for children (Strong et al., 2005), and is associated with a reduced risk of morbidity and mortality in adults (Lee et al., 2012). Of concern is the consistent and compelling evidence for a marked sex difference in physical activity, with females having lower activity levels than males at all ages (Hallal et al., 2012; The Department of Health & Ageing, 2007). Globally, 34 percent of adult women do not meet the physical activity recommendations of 30 minutes of moderate-to-vigorous physical activity (MVPA) at least five days per week, compared to 28 percent of men (Hallal et al., 2012). Similarly, while girls are less active than boys at all ages (Hallal et al., 2012), the gender activity gap increases with age (Davison, Cutting, & Birch, 2003). The most recent national physical activity survey in Australian children reported that 52 percent did not meet the physical activity recommendation of 60 minutes of MVPA per day, and when girls reached the age of 12 years, they participated in 21 minutes less of MVPA per week, when compared to boys (Australian Bureau of Statistics, 2013).

Factors influencing physical activity are multi-factorial and complex. One established factor is the influential role of parents on their children's physical activity behaviors (Biddle, Atkin, Cavill, & Foster, 2011). Parents provide support and encouragement for their children's physical activity through both provision of opportunities, reinforcement, social support, encouragement, and role modeling positive activity attitudes and behaviors (Sleddens et al., 2012). In a review of quantitative systematic reviews focusing on physical activity correlates in youth, Biddle et al. found that parental support was an important correlate of physical activity in youth (Biddle et al., 2011). Similarly, in a recent review of

physical activity, parenting, and child activity (Sleddens et al., 2012), specific parental correlates (e.g. parent support and modeling) were consistently associated with physical activity in children. However, confounding the interpretation of these reviews, is physical activity having been measured via parent proxy or self-report (Biddle et al., 2011; Sleddens et al., 2012), a known bias (Sallis & Saelens, 2000) and most studies have not comprehensively assessed physical activity parenting using reliable measures.

Positive associations for parental involvement and active role modeling have been reported (Edwardson & Gorely, 2010b). Maternal role modeling was positively correlated with child MVPA and parental involvement was positively related to children's overall physical activity (Edwardson & Gorely, 2010b). Some evidence also suggests that girls' physical activity is more strongly associated with parental activity and encouragement, which could be owing to the different ways in which mothers and fathers influence physical activity in their children (Davison et al., 2003), and particularly the differential influence on girls and boys (Fogelholm, Nuutinen, Pasanen, Myohanen, & Saatela, 1999).

In the context of understanding the familial influence on girls' physical activity levels, a review of parental correlates of physical activity in children and young adolescents found that mothers may have a more significant influence on their daughters' physical activity levels, rather than their sons'. Gustafson and Rhodes (Gustafson & Rhodes, 2006) suggest the distinction may be owing to unique maternal relationships or bonds the female generation share. This argument is supported by other studies that have found physically active mothers are likely to have physically active daughters (Aarnio, Winter, Kujala, & Kaprio, 1997). Maternal involvement in physical activity has been positively associated with child physical activity levels, and has been found to be stronger for daughters (Cleland et al., 2011; Jacobi et al., 2011). Mothers and fathers may differ in their physical activity-related parenting

practices, and further exploration of sex-specific parenting practices is warranted (Davison et al., 2003), owing to mixed findings and the rarity of objective physical activity measures.

Improving our understanding of the factors associated with girls' physical activity levels is important. In particular, we must explore maternal correlates of girls' physical activity using objective measures for both generations, given the paucity of research in this area. Further significance comes from the low levels of physical activity in girls and the limited research on the associations between mother-daughter activity.

Few studies have focused on parental physical activity influences on daughters' activity. Davison and colleagues studied activity-related parenting practices in girls only (Davison et al., 2003) and later in a sample of boys and girls (Davison, 2004), and both studies used self-report physical activity measures. Of the few studies that employed objective measures of physical activity for parental activity-related practices, few have exclusively examined girls (Adkins, Sherwood, Story, & Davis, 2004; Davison & Jago, 2009; Davison, Li, Baskin, Cox, & Affuso, 2011). However, in these studies no objective assessments of parental/maternal physical activity were provided. Having a greater understanding of maternal correlates of physical activity in girls could help shape the development of future interventions targeting physical activity. The primary aim of this study, therefore, is to assess maternal correlates of objectively-measured physical activity (% MVPA, CPM) in girls. Secondary aims include exploring the correlates of sedentary behavior and screen time.

Methods

Participants

Mothers and their primary school-aged daughters (5-12 years) were recruited into a pilot randomized controlled trial - 'M.A.D.E (Mothers and Daughters Exercising) 4 Life'. The baseline data from this trial were used for the current study. Of the 40 families recruited, eight had more than one daughter; therefore, mothers and their eldest daughter only were included for the analysis. Participants were recruited through media releases, school newsletter advertisements, school presentations to students and parents, local newspapers, and local television news. Mothers were screened for eligibility by telephone questionnaire. Eligibility criteria included mothers passing a pre-exercise risk assessment screen, and doctor's clearance (if age >40 years). Approval was obtained from the University of Newcastle Human Research Ethics Committee, mothers provided written consent, and daughter(s) provided assent.

Measures

Physical activity

Both mothers' and daughters' physical activity were objectively measured for seven consecutive days, using Actigraph GT3X and GT3X+ accelerometers (ActiGraph, LLC, Fort Walton Beach, FL), which are considered to be valid and reliable for both children (Ekelund et al., 2001) and adults (Kelly et al., 2013). Accelerometers were attached to an elastic belt and worn over the left hip. Monitors recorded 60-second epochs for mothers, and 15-second epochs for daughters (Trost, Loprinzi, Moore, & Pfeiffer, 2011). Activity counts were calculated for time spent in moderate (MPA) (4-5.9 METS) and vigorous (VPA) (≥ 6 METS) activity. Data with strings of consecutive zeros in bouts of ≥ 60 minutes were deemed non-wear time for mothers, and ≥ 20 minutes (Cain, Sallis, Conway, Van Dyck, & Calhoun, 2013) for daughters, and retracted from data for analysis. Total counts were divided by total minutes

monitored to calculate mothers' and daughters' mean count per minute (CPM). Freedson cut-points (Freedson, Pober, & Janz, 2005) were applied to the mothers' physical activity data and Evenson cut-points (Evenson, Catellier, Gill, Ondrak, & McMurray, 2008) were applied for the daughters (Trost et al., 2011), to determine the amount of time spent in sedentary and MVPA.

To account for the variation in time spent wearing the accelerometers, values were calculated for percentage of monitored time spent in sedentary behavior (% SED), and health-enhancing or moderate-to-vigorous physical activity (% MVPA). Mothers' and daughters' physical activity data were excluded from the analysis if they wore the monitor for ≤ 480 minutes on ≤ 4 days (Mattocks et al., 2008). Physical activity measurements were calculated for 39 of the 40 mothers, and all 40 of the daughters, after exclusion of participants with insufficient data.

Self-report sedentary behavior and screen time

Mothers reported their typical sitting time on a work and non-work day for transport, work, watching TV, using a computer at home, other leisure activities, and sleep time, using a sitting time questionnaire (Marshall, Miller, Burton, & Brown, 2010; Miller & Brown, 2004). This measure was adapted previously from sitting time questionnaires and shown to be a valid and reliable measure of sitting time for adults in various domains (Marshall et al., 2010; Miller & Brown, 2004).

Mothers proxy-reported their daughter's leisure activity over a typical week, using the Children's Leisure Activities Study Survey (CLASS) previously validated in children (Telford, Salmon, Jolley, & Crawford, 2004). Total minutes of sedentary behavior were reported for a typical week. For the current analysis, only time spent in small-screen

recreation (SSR), including TV and DVD viewing, playing computer games, and using the internet, were reported in the total screen time score.

Assessments of maternal correlates

Body mass index

Weight was measured in light clothing, without shoes, and on a digital scale to 0.1kg (model CH-150kp, A&D Mercury Pty, Adelaide, Australia). Height was measured to 0.1cm, using the stretch stature method (Mentone Educational Centre, Victoria, Australia) and the Biospace Stadiometer (BSM370, Seoul, Korea). Mothers' BMI was calculated using the standard equation, weight kg/height m². Daughters' BMI z-score was calculated using age- and sex-adjusted standardized scores (z-scores) (Kuczmarski et al., 2000).

Demographics

Demographic information, including mothers' age, occupation, education level, marital status, socioeconomic status (SES), and postcode were collected from the mothers. SES was based on postal code of residence, using the Index of Relative Socioeconomic Advantage and Disadvantage from the Australian Bureau of Statistics census-based Socio-Economic Indexes for Areas (SEIFA) (Australian Bureau of Statistics, 2008).

Maternal parenting for physical activity

Mothers' parenting for physical activity was measured by adapting either full scales or selected items of previously-validated scales (detailed below). Principal components factor analysis and reliability analysis were performed for each of the maternal physical activity parenting scales in the current study. Items were deleted if they did not adequately load on their intended factor and adversely impacted on internal reliability as assessed by Cronbach's

alpha. The scores for each individual scale were summed and mean scores were calculated. In detail, the following subscales were assessed:

Maternal beliefs about daughters' physical activity. Psychosocial measures of parental beliefs were modified from Lee et al. (2010), and the title 'parents' was changed to 'mothers' (Lee et al., 2010). Five items on maternal beliefs about physical activity were measured on a 4-point Likert scale, ranging from 'strongly disagree' to 'strongly agree', about the outcomes of physical activity for girls, e.g. 'Girls who do regular physical activity have more self-confidence'. Cronbach's α for the *maternal beliefs* scale was 0.84.

Maternal logistic support & maternal explicit modeling. The Activity Support Scale (ACTS) (Davison et al., 2003) integrates two domains of parents' support for children's physical activity: logistic support and explicit modeling. These scales were adapted from Davison, Cutting, et al. (2003), and an updated version known as the Activity Support Scale for Multiple Groups (ACTS-MG) (Davison et al., 2011). For the current study, the logistic support and explicit modeling ACTS were used from Davison and colleagues (2003), however, for explicit modeling, an additional item was added as per Davison and colleagues (2011): 'I encourage my daughter to be physically active by leading by example'. Both logistic support and explicit modeling were answered on a 4-point Likert scale with response items ranging from 'strongly disagree' to 'strongly agree.' The logistic support scale consisted of three items, focusing on a mother taking her daughter places to be active, enrolling her in physical activity, and watching her participate in physical activity. The Cronbach's α for *mothers' logistic support* scale was 0.80. Explicit modeling was assessed through five items, ranging from mother's organisation for family physical activity, frequency of doing activity with her daughter, using behavior to encourage activity, and

mother's own physical activity. The Cronbach's α for *mothers' explicit modeling* scale was 0.88.

Mothers' Self-efficacy (confidence) and Mothers' Support for physical activity. Confidence and support parenting activity-related measures were adapted from a previous study (Adkins et al., 2004). The self-efficacy (confidence) scale consisted of five items, asking mothers to rate a response on a 4-point Likert-type scale of 'very hard' (1) to 'not hard at all' (4), focusing on mothers' confidence to do physical activity with her daughter, e.g. 'How hard would it be to get your daughter to be physically active, take your daughter to the park, go for a walk with your daughter?' The Cronbach's α for *mothers' self-efficacy scale* was 0.74. The original support scale by Adkins et al. (2004) included six items. However, one item was deleted after factor analysis. The modified support scale consisted of five items, asking mothers to rate on a 4-point scale of 'almost never' (1) to 'almost always' (4). These questions related to the mother's level of support for their daughter's physical activity levels, e.g. 'I try to get my daughter to play outside, get her to be active, take her to the park, and go for a walk with my daughter'. The Cronbach's α for *mothers' support* was 0.74.

Maternal social-cognitive variables

Key constructs (i.e. self-efficacy, outcome expectations, social support, and goal setting/intention) of Bandura's Social Cognitive Theory (Bandura, 1986) relating to mothers' physical activity were assessed and adapted from validated measures.

Self-efficacy. Mothers' physical activity self-efficacy related to their confidence to participate in regular physical activity, and was assessed with five-item response options ranging from 'not at all confident' (1) to 'completely confident' (5) (Rodgers & Sullivan, 2001). These questions reflected a mother's confidence to participate in physical activity when feeling tired, when in a bad mood, when the weather was bad, add regular physical activity into a

daily routine, and arrange a schedule to include regular physical. Cronbach's α for *mothers' self-efficacy* was 0.94.

Outcome expectations. Outcome expectations related to mothers' beliefs about the effects of regular physical activity on her health was assessed via three items, with response options ranging from 'not at all likely' to 'extremely likely' (5) (Sallis, Grossman, Pinski, Patterson, & Nader, 1987). These questions reflected mothers' likelihood of increasing fitness, improving health and losing weight. Cronbach's α for *mothers' outcome expectations* was 0.86.

Social support. The physical activity social support response asked mothers to report the amount of physical activity support received from people closest to them, ranging from 'no support' (1) to 'a great deal of support' (5) (Courneya, Plotnikoff, Hotz, & Birkett, 2001).

Intention. Physical activity intention (goals) was measured using one item, which asked mothers to indicate how strongly they agreed with the statement: 'I intend to participate in regular physical activity over the next two months', ranging from 'strongly disagree' (1) to 'strongly agree' (5) (Courneya et al., 2001).

Data Analyses

The statistical program SPSS version 19.0 was used for analyses. Means and standard deviations were calculated for normally distributed data. Where data were skewed, medians and interquartile ranges were examined. Counts per minute (CPM) was transformed (square root) to meet normality standards for both mothers and daughters. Pearson correlations were used to determine maternal associations of girls' objectively-measured physical activity. Furthermore, linear regression analysis was utilized to examine the potential maternal correlates for girls' physical activity measures (primary outcome), sedentary behavior (%)

SED), adiposity (BMI z-score), and total screen time. Statistical significance was set at an alpha level of 0.05 for all analyses. The regression analysis was performed, whereby each significant variable $P < 0.05$, or close to significance $P < 0.20$, was entered into the regression model. The regression models were calculated using the backward method, where non-significant variables were dropped (least significant first) while controlling for all variables in the model. All two-way interactions between significant independent variables were tested for significance in the multiple linear regression models. Correlations between explanatory variables were checked to investigate potential problems of collinearity in the multiple variable models; however, collinearity was not an issue.

Results

The demographic characteristics and summary data for physical activity variables and maternal correlates of physical activity are summarised in Table 1. A total of 40 mothers and 40 daughters were included in all analyses; however, one had incomplete data, hence, 39 mothers were analysed for the accelerometer data. Mothers were predominately born in Australia and more than half (57.5%) had completed university education, with 50 percent reporting their occupation as office-based. For mothers' weight category, 67.5 percent were overweight or obese. Mothers' marital status ranged from married: 72.5 percent, separated/divorced: 15 percent, de facto: 10 percent, to never married 2.5 percent.

In the daughters' group, 100 percent met the criteria for wearing an accelerometer a minimum of eight hours on $\geq$ four days, and of the 40 mothers, 39 met the accelerometer criteria. No significant changes in the physical activity variables were found after adjusting for self-reported logged data (e.g. swimming or cycling), so unadjusted results are reported. On average, mothers wore activity monitors with at least eight hours of wear time for 6.6

days (SD= 1.0). Mothers' total wear time mean was 854.6 minutes (SD=76.9). The mean minutes mothers spent in MVPA per day was 30.1 (SD=18.5). Mothers' total sitting time on a typical work day was 451 minutes (SD=201.7), and 356 (SD=159.0) minutes on a typical non-work day.

For daughters, 65 percent were healthy weight, and 30 percent overweight or obese. Daughters' mean accelerometer wear time was 6.6 days (SD=0.8). Total wear time mean was 737.1 minutes (SD=61.2). Daughters' mean minutes spent in MVPA was 41.6 minutes (SD=16.8).

Maternal correlates of daughters' physical activity

Bivariate correlations for the maternal correlates of girls' physical activity are presented in Table 2. Significant positive correlations were found between daughters' % MVPA and mothers' beliefs, daughters' total activity (CPM) and mothers' logistic support, and mothers' beliefs. Further details on bivariate correlations for the maternal correlates of girls' physical activity are presented in Table 2.

Linear regression models were used to examine the variance explained and significant correlates of physical activity [% MVPA, CPM], % SED, screen time and BMI z-score (Table 3). For daughters' % MVPA, mothers' beliefs about physical activity ($P=0.01$, $\beta=0.40$) explained 14 percent of the variance. Significant correlates for daughters' total activity (CPM) included mothers' logistic support ($P<0.05$, $\beta=0.32$), mothers' CPM ($P<0.05$, $\beta=0.37$), and mothers' outcome expectations ($P=0.01$, $\beta=0.40$), and this model explained 24 percent of the variance. For the model daughters' % SED, mothers' logistic support for daughters' physical activity was the sole correlate of daughters' % SED, having a negative association with daughters' % SED ($P<0.05$, $\beta=-0.37$), ($R^2=0.11$). For

daughters' total screen time, mothers' % SED was the sole correlate ($P < 0.001$, $\beta = 0.59$); ($R^2 = 0.33$). Finally, for daughters' BMI z-score, mothers' BMI was the sole correlate ($P < 0.001$, $\beta = 0.57$) ($R^2 = 0.31$).

Discussion

The study's primary aim was to examine maternal correlates of objectively-measured physical activity in girls. A number of maternal parenting practices, cognitions and behaviors were found to be significant. In relation to girls' % time in MVPA, data revealed mothers' beliefs were significantly related.

To our knowledge, this study is the first to examine maternal correlates of objectively-measured physical activity using accelerometry in both the mothers and daughters. Mothers' beliefs about girls' physical activity were significantly related to daughters' % time in MVPA. Mothers who believed physical activity was important for their daughters were more likely to have daughters who participated in health-enhancing levels of physical activity. Daughters would likely be supported and provided with more opportunities to engage in MVPA if their mothers believed in the importance of physical activity, which might also influence behavior through provision of more physical activity opportunities. Further, girls who are aware of their mother's beliefs regarding physical activity might also seek opportunities to be involved in MVPA.

Our findings are supported by the studies of Trost and colleagues, who found that parents who believed in the importance of physical activity had more physically active children, compared to parents who did not report strong beliefs (Trost et al., 2003). However, in their study, physical activity was measured via self-report, and possible gender-specific intergenerational influences were not explored. Dempsey and colleagues (1993) found that

parental beliefs about their children's self-reported MVPA explained only a small amount of variance (6%) (Dempsey, Kimiecik, & Horn, 1993) compared to our findings of 14 percent of variance explained. Our variance of 14 percent may be strengthened due to the use of an objective measure of physical activity.

For daughters' CPM (total activity), mothers' logistic support, outcome expectations, and mothers' CPM were all significantly related. Beliefs of mothers appear to be key, whether it be their beliefs about physical activity benefits for themselves and/or their daughters. Logistic parental support is a form of support that involves practical tasks such as enrolling a child in sport, transporting them to/from sporting activities, and watching them participate in sporting activities (Davison et al., 2003). Our results suggest that mothers who provide high levels of physical activity-related logistic support to daughters have more active daughters. This association between daughters' CPM and mothers' logistic support could also reflect that daughters who are more active may prompt their mothers to provide such logistic support, i.e. positive reinforcement cycle (Davison et al., 2003). The recent review by Trost and Loprinzi (2011), on parental influences on physical activity in youth, found strong and consistent correlations between parental support for physical activity and children's physical activity (Trost & Loprinzi, 2011). In addition, Sleddens et al. (2012) highlighted parental supporting behaviors, including role modeling, were positively correlated to children's physical activity (Sleddens et al., 2012). Other reviews investigating parental correlates and youth physical activity have concluded that parental support (Gustafson & Rhodes, 2006) is correlated to physical activity.

Similar to the current study, mothers' logistic support has been shown to be associated with girls' activity (Davison et al., 2003), where maternal support explained 12 percent of the variance in girls' self-reported activity (Davison et al., 2003). Our regression model for

daughters' CPM explained 24 percent variance, and the individual contribution of mothers' logistic support explained 10 percent of the variance. It has been found that mothers offer higher levels of logistic support for girls than boys (Edwardson & Gorely, 2010a). In a more recent study assessing parenting practices and physical activity in 10- to 11-year-old boys and girls, maternal logistic support was associated with girls' CPM only (Jago et al., 2011). Although in the current study we found maternal logistic support to be a correlate of daughters' CPM, the parenting activity-related measure of support was not significant, which was adapted from Adkins and colleagues (2004) (Adkins et al., 2004). Our findings align with Adkins and colleagues (2004), with this support measure not revealing a significant association with daughters' physical activity. Adkins and colleagues did, however, report parents' self-efficacy for being active with their daughters significantly correlated with daughters' activity.

Although we found a correlation between mother-daughter total activity (CPM), no significant relationship between mother-daughter % time in MVPA was found. A review focusing on parent-child physical activity correlations revealed that overall findings are largely varied, which could be owing to the lack of objective physical activity measures being adopted (Gustafson & Rhodes, 2006). It may be that our sample of daughters had more opportunity for engaging in MVPA, such as in the after-school period or on weekends, and their mothers are providing the logistic support for this engagement. For example, mothers who offer logistical support, i.e. by taking her daughter to sport, may be more sedentary while sitting on the sideline or waiting for her daughter to finish the physical activity. Mothers may have had less time in their day for engaging in MVPA, as 50 percent of our mothers reported an office job as their occupation. A large proportion of mothers in the current study were categorized as overweight or obese (67.5%), which is much greater than

national averages (50%). This data may also explain the lack of association between mothers' % time in MVPA and daughters' % time in MVPA.

Overall, it appears findings are varied regarding parental physical activity levels and the association with children's physical activity levels. Further, very little is known about mother-daughter physical activity associations. In other reviews, Gustafson and Rhodes (2006) found mothers' physical activity correlated with daughters' physical activity, although findings across individual studies are mixed and differences are exacerbated by the different methods used to assess physical activity (Gustafson & Rhodes, 2006).

Mothers' outcome expectations were also a significant correlate of daughters' CPM. The outcome expectations scale asked mothers to report their beliefs surrounding the benefits of regular physical activity for themselves. The mean score for this scale was high, at 4.6/5, indicating that the mothers had high expectations about the effects of regular physical activity on their health, and this score was also associated with more active daughters. We also found that mothers' total physical activity level (CPM) was a significant correlate of daughters' total activity (CPM). This finding is novel, which is strengthened by the study's use of an objective measure of physical activity for both mothers and daughters. It may be that the daughters of mothers who have high outcome expectations model higher levels of physical activity due to their mother's beliefs. Evidence from the review conducted by Trost and Loprinzi (2011) revealed weak associations between parental and child physical activity. However, only 31 percent of these studies used an objective measure of physical activity. In addition, only three out of nine studies reported a positive significant association between mothers' and daughters' physical activity, and these studies used self-report measures.

Our regression model for daughters' sedentary time revealed mothers' logistic support was significantly inversely associated with daughters' sedentary time. Therefore, our results

suggest the more logistical support, i.e. physical activity-related support, mothers provide to their daughters, the less likely their daughter is to be involved in sedentary behaviors. This finding also suggests that the logistic support may occur at a time when the daughters would otherwise be sedentary (e.g. taking daughters to sport in the after-school period or weekends). Mothers providing this support for activity may displace daughters' sedentary time. Further studies are needed that adopt objective measures of physical activity. Furthermore, parents who are sedentary are likely to have daughters who are sedentary (Jago, Fox, Page, Brockman, & Thompson, 2010).

In the final model for daughters' screen time, mothers' sedentary time was positively associated with daughters' total screen time. Mothers who have higher levels of sedentary behavior were more likely to have daughters who engaged in higher levels of screen time. This finding may be explained, as parents are important role models for their children. Sedentary behaviors of children may be learned from their parents (Jago et al., 2010). Jago et al. (2010) examined associations between objectively-measured physical activity, sedentary and screen time practices from a large sample of British children and parents, and found parental sedentary minutes predicted girls sedentary minutes (Jago et al., 2010). Of note, over 80 percent of the parent sample were mothers and they found that parents who watched two to four hours of television (TV) per day increased their daughters' risk by over three times, of watching more than four hours of TV (Jago et al., 2010).

A unique aspect of the current study is the examination of maternal behaviors, social-cognitive and parenting-related correlates of girls' physical activity. This study is one of few that have examined maternal parenting correlates of girls' objectively-measured physical activity. Moreover, a strength of this study is the comprehensive use of reliable parenting physical activity measures. Study limitations include the cross-sectional design, which does

not allow causality to be determined between the girls' activity and maternal behaviors and cognitions, and the small sample size of participants who were a relatively homogenous sample of mothers and daughters, in terms of socio-economic status. Of note, mothers' answers to the questionnaire may have socially desirable responses, as they had registered for a physical activity intervention.

Conclusion

This study extends the literature related to maternal correlates of objectively-measured physical activity and suggests that future interventions aiming to increase girls' physical activity levels should include mothers. We have shown specific aspects of mothers' parenting for physical activity that are significantly associated with daughters' physical activity levels. The current study indicates mothers' beliefs about their daughters' physical activity are key correlates of daughters' health-enhancing physical activity. Mothers' sedentary behavior and logistic support are also influential in terms of their daughters' SSR and sedentary behavior, respectively. A potential strategy to increase girls' physical activity may be to target improving mothers' beliefs about girls' physical activity. Providing mothers with logistic support strategies, to reduce their own and their daughters' screen time, could lead to decreased sedentary behavior and increase total physical activity, and increased health-enhancing activity. These findings can be used to inform and tailor interventions targeting mothers and daughters.

References

- Aarnio, M., Winter, T., Kujala, U. M., & Kaprio, J. (1997). Familial Aggregation of Leisure-Time Physical Activity - a Three Generation Study. *International Journal of Sports Medicine*, 18(7), 549-556. doi: 10.1055/s-2007-972680
- Adkins, S., Sherwood, N. E., Story, M., & Davis, M. (2004). Physical Activity among African-American Girls: The Role of Parents and the Home Environment. *Obesity Research, Supplement 12*, 38S-45S. doi: 12/suppl_1/38S [pii] 10.1038/oby.2004.267
- Australian Bureau of Statistics. (2008). Socio-Economic Indexes for Areas (Seifa) Australia - 2006: Postal Areas, Index of Relative Socio-Economic Advantage and Disadvantage. Canberra, Australia: Author.
- Australian Bureau of Statistics. (2013). Australian Health Survey: Physical Activity, 2011-2012 (No. 4364.0.55.004). Canberra, Australia: Author.
- Bandura, A. (1986). *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs, NJ: Prentice-Hall
- Biddle, S., Atkin, A., Cavill, N., & Foster, C. (2011). Correlates of Physical Activity in Youth: A Review of Quantitative Systematic Reviews. *International Review of Sport and Exercise Psychology*, 4(1), 25-49.
- Cain, K. L., Sallis, J. F., Conway, T. L., Van Dyck, D., & Calhoon, L. (2013). Using Accelerometers in Youth Physical Activity Studies: A Review of Methods. *Journal of Physical Activity and Health*, 10(3), 437-450.
- Cleland, V., Timperio, A., Salmon, J., Hume, C., Telford, A., & Crawford, D. (2011). A Longitudinal Study of the Family Physical Activity Environment and Physical Activity among Youth. *American Journal of Health Promotion*, 25(3), 159-167. doi: 10.4278/ajhp.090303-QUAN-93

- Courneya, K. S., Plotnikoff, R. C., Hotz, S. B., & Birkett, N. J. (2001). Predicting Exercise Stage Transitions over Two Consecutive 6-Month Periods: A Test of the Theory of Planned Behaviour in a Population-Based Sample. *British Journal of Health Psychology*, 6(Pt 2), 135-150. doi: 10.1348/135910701169115
- Davison, K. K. (2004). Activity-Related Support from Parents, Peers, and Siblings and Adolescents' Physical Activity: Are There Gender Differences? *Journal of Physical Activity and Health*, 1, 363-376.
- Davison, K. K., Cutting, T. M., & Birch, L. L. (2003). Parents' Activity-Related Parenting Practices Predict Girls' Physical Activity. *Medicine and Science in Sports and Exercise*, 35(9), 1589-1595.
- Davison, K. K., & Jago, R. (2009). Change in Parent and Peer Support across Ages 9 to 15 Yr and Adolescent Girls' Physical Activity. *Medicine and Science in Sports and Exercise*, 41(9), 1816-1825. doi: 10.1249/MSS.0b013e3181a278e2
- Davison, K. K., Li, K., Baskin, M. L., Cox, T., & Affuso, O. (2011). Measuring Parental Support for Children's Physical Activity in White and African American Parents: The Activity Support Scale for Multiple Groups (Acts-Mg). *Preventive Medicine*, 52(1), 39-43. doi: 10.1016/j.ypmed.2010.11.008
- Dempsey, J. M., Kimiecik, J. C., & Horn, T. S. (1993). Parental Influence on Children's Moderate to Vigorous Physical Activity Participation: An Expectancy-Value Approach. *Pediatric Exercise Science*, 5, 151-167.
- Edwardson, C. L., & Gorely, T. (2010a). Activity-Related Parenting Practices and Children's Objectively Measured Physical Activity. *Pediatric Exercise Science*, 22(1), 105-113.
- Edwardson, C. L., & Gorely, T. (2010b). Parental Influences on Different Types and Intensities of Physical Activity in Youth: A Systematic Review. *Psychology of Sport and Exercise*, 11, 522-535.

- Ekelund, U., Sjostrom, M., Yngve, A., Poortvliet, E., Nilsson, A., Froberg, K., . . . Westerterp, K. (2001). Physical Activity Assessed by Activity Monitor and Doubly Labeled Water in Children. *Medicine and Science in Sports and Exercise*, 33(2), 275-281.
- Evenson, K. R., Catellier, D. J., Gill, K., Ondrak, K. S., & McMurray, R. G. (2008). Calibration of Two Objective Measures of Physical Activity for Children. *Journal of Sports Sciences*, 26(14), 1557-1565. doi: 10.1080/02640410802334196904797576 [pii]
- Fogelholm, M., Nuutinen, O., Pasanen, M., Myohanen, E., & Saatela, T. (1999). Parent-Child Relationship of Physical Activity Patterns and Obesity. *International Journal of Obesity and Related Metabolic Disorders*, 23(12), 1262-1268.
- Freedson, P., Pober, D., & Janz, K. F. (2005). Calibration of Accelerometer Output for Children. *Medicine and Science in Sports and Exercise*, 37(Supplement 11), S523-530. doi: 00005768-200511001-00005 [pii]
- Gustafson, S. L., & Rhodes, R. E. (2006). Parental Correlates of Physical Activity in Children and Early Adolescents. *Sports Medicine*, 36(1), 79-97.
- Hallal, P. C., Andersen, L. B., Bull, F. C., Guthold, R., Haskell, W., & Ekelund, U. (2012). Global Physical Activity Levels: Surveillance Progress, Pitfalls, and Prospects. *Lancet*, 380(9838), 247-257. doi: 10.1016/S0140-6736(12)60646-1 S0140-6736(12)60646-1 [pii]
- Jacobi, D., Caille, A., Borys, J. M., Lommez, A., Couet, C., Charles, M. A., & Oppert, J. M. (2011). Parent-Offspring Correlations in Pedometer-Assessed Physical Activity. *PLoS ONE*, 6(12), e29195. doi: 10.1371/journal.pone.0029195

- Jago, R., Davison, K. K., Brockman, R., Page, A. S., Thompson, J. L., & Fox, K. R. (2011). Parenting Styles, Parenting Practices, and Physical Activity in 10- to 11-Year Olds. *Preventive Medicine*, 52(1), 44-47. doi: 10.1016/j.ypmed.2010.11.001
- Jago, R., Fox, K. R., Page, A. S., Brockman, R., & Thompson, J. L. (2010). Parent and Child Physical Activity and Sedentary Time: Do Active Parents Foster Active Children? *BMC Public Health*, 10. doi: 10.1186/1471-2458-10-194
- Kelly, L. A., McMillan, D. G., Anderson, A., Fippinger, M., Fillerup, G., & Rider, J. (2013). Validity of Actigraphs Uniaxial and Triaxial Accelerometers for Assessment of Physical Activity in Adults in Laboratory Conditions. *BMC Medical Physics*, 13(1), 5. doi: 10.1186/1756-6649-13-5
- Kuczarski, R. J., Ogden, C. L., Grummer-Strawn, L. M., Flegal, K. M., Guo, S. S., Wei, R., . . . Johnson, C. L. (2000). Cdc Growth Charts: United States. *Advance Data*(314), 1-27.
- Lee, I., Shiroma, E., Lobelo, F., Puska, P., Blair, S., & Katzmarzyk, P. (2012). Effect of Physical Inactivity on Major Non-Communicable Diseases Worldwide: An Analysis of Burden of Disease and Life Expectancy. *Lancet*, 380(9838), 219-229. doi: 10.1016/S0140-6736(12)61031-9
- Lee, S., Nihiser, A., Strouse, D., Das, B., Michael, S., & Huhman, M. (2010). Correlates of Children and Parents Being Physically Active Together. *Journal of Physical Activity and Health*, 7(6), 776-783.
- Marshall, A. L., Miller, Y. D., Burton, N. W., & Brown, W. J. (2010). Measuring Total and Domain-Specific Sitting: A Study of Reliability and Validity. *Medicine and Science in Sports and Exercise*, 42(6), 1094-1102. doi: 10.1249/MSS.0b013e3181c5ec18
- Mattocks, C., Ness, A., Leary, S., Tilling, K., Blair, S. N., Shield, J., . . . Riddoch, C. (2008). Use of Accelerometers in a Large Field-Based Study of Children: Protocols, Design

- Issues, and Effects on Precision. *Journal of Physical Activity and Health*, 5 Suppl 1, S98-111.
- Miller, R., & Brown, W. (2004). Steps and Sitting in a Working Population. *International Journal of Behavioral Medicine*, 11, 219-224.
- Rodgers, W., & Sullivan, M. (2001). Task, Coping, and Scheduling Self-Efficacy in Relation to Frequency of Physical Activity. *Journal of Applied Social Psychology* 31, 741-753.
- Sallis, J. F., Grossman, R. M., Pinski, R. B., Patterson, T. L., & Nader, P. R. (1987). The Development of Scales to Measure Social Support for Diet and Exercise Behaviors. *Preventive Medicine*, 16(6), 825-836.
- Sallis, J. F., & Saelens, B. E. (2000). Assessment of Physical Activity by Self-Report: Status, Limitations, and Future Directions. *Research Quarterly for Exercise and Sport*, 71(2 Suppl), S1-14.
- Sleddens, E. F., Kremers, S. P., Hughes, S. O., Cross, M. B., Thijs, C., De Vries, N. K., & O'Connor, T. M. (2012). Physical Activity Parenting: A Systematic Review of Questionnaires and Their Associations with Child Activity Levels. *Obesity Reviews*, 13(11), 1015-1033. doi: 10.1111/j.1467-789X.2012.01018.x
- Strong, W. B., Malina, R. M., Blimkie, C. J., Daniels, S. R., Dishman, R. K., Gutin, B., . . . Trudeau, F. (2005). Evidence Based Physical Activity for School-Age Youth. *Journal of Pediatrics*, 146(6), 732-737. doi: 10.1016/j.jpeds.2005.01.055
- Telford, A., Salmon, J., Jolley, D., & Crawford, D. (2004). Reliability and Validity of Physical Activity Questionnaires for Children: The Children's Leisure Activities Study Survey (Class). *Pediatric Exercise Science*, 16, 64-78.
- The Department of Health & Ageing. (2007). Australian National Children's Nutrition and Physical Activity Survey - Main Findings (pp. 1-44). Canberra, ACT.

- Trost, S., Loprinzi, P., Moore, R., & Pfeiffer, K. A. (2011). Comparison of Accelerometer Cut Points for Predicting Activity Intensity in Youth. *Medicine and Science in Sports and Exercise*, 43(7), 1360-1368.
- Trost, S., & Loprinzi, P. D. (2011). Parental Influences on Physical Activity Behavior in Children and Adolescents: A Brief Review. *American Journal of Lifestyle Medicine*, 5(2), 171-181. doi: 10.1177/1559827610387236
- Trost, S., Sallis, J. F., Pate, R. R., Freedson, P. S., Taylor, W. C., & Dowda, M. (2003). Evaluating a Model of Parental Influence on Youth Physical Activity. *American Journal of Preventive Medicine*, 25(4), 277-282. doi: 10.1016/s0749-3797(03)00217-

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Table 1. Descriptive statistics of mothers' and daughters' demographic, anthropometric, physical activity variables, and maternal characteristics

<i>Variables</i>	<i>Mothers</i>		<i>Daughters</i>	
	<i>Total (N=40)</i>		<i>Total (N=40)</i>	
	<i>Mean</i>	<i>(s.d.)</i>	<i>Mean</i>	<i>(s.d.)</i>
<i>Age (years)</i>	39.1	4.8	8.8	1.6
<i>Height (cm)</i>	164.3	5.4	134.4	10.4
<i>Weight (kg)</i>	74.32	14.47	33.60	9.10
<i>BMI (kg/m²)</i>	27.58	5.45	18.33	2.99
<i>BMI z-score</i>	N/A	N/A	0.69	1.19
<i>Waist (umbilicus) (cm)</i>	93.60	11.74	66.09	9.21
<i>Physical Activity^a</i>				
<i>Mean CPM^b</i>	320.69	116.75	421.97	169.55
<i>% time in MVPA</i>	3.49	2.08	5.26	2.12
<i>% time in SED</i>	58.44	8.03	62.78	7.14
<i>Screen time</i>				
<i>Total screen time (minutes)</i>	N/A	N/A	1074.75	560.53
<i>Mothers' sitting time (minutes)</i>				
<i>Work day</i>	451.3	201.7	N/A	N/A
<i>Non-work day</i>	355.9	159.0	N/A	N/A

Parenting for physical activity^c

<i>Confidence</i>	3.45	0.42	N/A	N/A
<i>General Support</i>	2.74	0.55	N/A	N/A
<i>Logistic Support</i>	3.25	0.60	N/A	N/A
<i>Explicit modeling</i>	2.73	0.60	N/A	N/A
<i>Beliefs</i>	3.52	0.43	N/A	N/A

Physical activity cognition^d

<i>Self-efficacy</i>	3.62	0.96	N/A	N/A
<i>Outcomes expectations</i>	4.61	0.58	N/A	N/A
<i>Social support</i>	3.40	1.35	N/A	N/A
<i>Intention</i>	4.67	0.52	N/A	N/A

	n	%	n	%
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BMI category^{e,f}

<i>Healthy weight</i>	13	32.5	28	70
<i>Overweight</i>	15	37.5	8	20
<i>Obese</i>	12	30.0	4	10

Socio-Economic Status^g

<i>1-2 (lowest)</i>	1	2.50	-	-
<i>3-4</i>	4	10.00	-	-
<i>5-6</i>	11	27.50	-	-

7-8	22	55.00	-	-
9-10 (highest)	2	5.00	-	-
<i>Marital Status</i>				
<i>Married</i>	29	72.50	-	-
<i>De facto</i>	4	10	-	-
<i>Separated</i>	3	7.5	-	-
<i>Divorced</i>	3	7.5	-	-
<i>Never married</i>	1	2.5	-	-

Abbreviations: s.d., standard deviation; cm. centimeters; BMI, body mass index; ^an=39; ^btransformed (square root) & median and IQR presented; ^cRange 1-4; ^dRange 1-5; ^eRepresentations of BMI categories for daughters based on BMI z-score; ^fChild grade 1 thinness and healthy weight combined; ^gSocio-economic status by population decile for SEIFA Index of Relative Socioeconomic Advantage and Disadvantage.

Table 2. Bivariate correlations between potential maternal correlates physical activity behavior

Maternal variables	Daughters variables (N=40)				
	% <i>MVPA</i>	<i>CPM</i>	% <i>SED</i>	<i>Screen time</i>	<i>BMI-z</i>
Background					
Mothers' age	-0.15	-0.18	0.24	0.04	0.17
Family Seifa decile ^a	-0.05	-0.14	0.30	0.20	-0.07
Mothers' BMI	0.08	-0.01	-0.05	-0.12	0.57**
Mothers' physical activity^b					
% MVPA	0.17	0.24	-0.13	-0.16	0.05
CPM ^c	0.20	0.23	-0.24	-0.40*	0.07
% SED	-0.27	-0.31	0.34*	0.56**	-0.06
Mothers' sitting time					
Work day	-0.17	-0.05	-0.13	-0.11	0.20
Non-work day	-0.24	-0.23	0.09	-0.12	0.06
Parenting for physical activity					
Confidence	0.20	0.06	-0.02	-0.07	-0.16
Support	0.14	0.15	-0.13	-0.12	0.13
Logistic support	0.31	0.36*	-0.37*	-0.22	0.04
Explicit modeling	-0.02	0.05	-0.15	-0.23	0.04

Beliefs	0.40*	0.40*	-0.27	-0.27	0.10
Physical activity cognitions					
Self-efficacy	0.17	0.12	-0.05	0.03	0.21
Outcomes expectations	0.28	0.25	-0.16	-0.14	0.14
Social support	0.10	0.18	-0.16	0.07	0.07
Intention	0.19	0.26	-0.29	0.03	0.14

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Abbreviations: SED, sedentary behavior; MVPA, moderate-to-vigorous intensity physical activity; CPM, counts per minute; ^a SEIFA Index of Relative Socioeconomic Advantage and Disadvantage ^bn=39; ^cTransformed (square root).

1 **Table 3.** Linear regression analyses results of physical activity, % time spent in sedentary behavior, screen time, and BMI z-score in daughters (Daughters
2 n=40; Mothers n=40)

Variables in final model	Standardized β	<i>P</i> value	Part R^2	R^2
<i>Daughters' % time in MVPA</i>				Model $R^2 = 0.14$
Mothers' beliefs about physical activity	0.40	0.01	0.40	0.16
				$F(1,38) = 7.17 P = 0.01$
<i>Daughters' CPM^a</i>				Model $R^2 = 0.24$
Mothers' logistic Support	0.32	<0.05	0.32	0.10
Mothers' CPM ^{a c}	0.37	<0.05	0.33	0.11
Mothers' outcome expectations	0.40	0.01	0.37	0.13
				$F(3,36) = 5.20 P = 0.004$
<i>Daughters' % time in SED</i>				Model $R^2 = 0.11$
Mothers' logistic support	-0.37	<0.05	-0.37	0.14

$F(1,38) = 6.01$ $P = 0.019$

Daughters' total screen time

Model $R^2 = 0.33$
Mothers' % time in SED^c

0.59

<0.001

0.59

0.34

 $F(1,38) = 19.74$ $P = 0.000$

Daughters' BMI z-score

Model $R^2 = 0.31$

Mothers' BMI

0.57

<0.001

0.57

0.32

 $F(1,38) = 18.25$ $P = 0.000$

Abbreviations: MVPA, moderate-to-vigorous intensity physical activity; CPM, counts per minute; SED, sedentary behavior;

^aTransformed (square root); ^c n=39