The first 1000 days and beyond

Küpers, Leanne Karen

CHAPTER 9

PARENTAL PHYSICAL ACTIVITIES ARE ASSOCIATED WITH DIRECTLY MEASURED PHYSICAL ACTIVITY IN YOUNG CHILDREN

Silvia Brouwer, Leanne K Küpers, Lotte Kors, Anna Sijtsma,
Pieter JJ Sauer, Carry M Renders and Eva Corpeleijn.

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Abstract

Background: Physical activity (PA) is an important energy balance-related behaviour when targeting childhood obesity. According to the ecological systems theory, parents, and thereby parental PA, may influence PA in young children.

Objective: We examined whether the intensity and type of parental PA is associated with children's PA at age 6, using detailed questionnaires for parents and accelerometry for children. We paid specific attention to gender differences.

Design: All participants were recruited form in the GECKO Drenthe birth cohort and were 4-7 years old during measurement. In children, PA was measured using the ActiGraph GT3X (at least 3 wearing days, more than 10 hours per day). In parents, PA was assessed by the validated SQUASH questionnaire providing PA levels and the domains in which the activity was spent. Income and education were derived from questionnaires.

Results: From the N=1,146 children with valid ActiGraph data and 838 mothers and 814 fathers with valid questionnaire data, 623 child-parent pairs with complete data were analyzed. For mothers, more leisure time PA was associated with more moderate-to-vigorous PA (MVPA) in children (Spearman r=0.079, P<.05). Maternal PA was significantly related to PA in girls, but not in boys. E.g. higher maternal vigorous PA, more time in sports activity or leisure time PA were related to higher MVPA in girls (Spearman r=0.159, r=0.133 and r=0.127 respectively, Pall<.05). For fathers, PA levels were predominantly related to PA in sons. Spending more time in light physical activity, mostly office work, related to more sedentary time and less MVPA of sons. Also high MVPA in fathers was related to high MVPA in sons (r=0.132). We found no evidence for moderation by parental education level or income.

Conclusion: In particular MVPA of young children may be influenced by their parental activities, which may depend on gender of both parent and child.

INTRODUCTION

Overweight and obesity are a growing problem in children. According to the World Health Organization, the number of overweight children younger than five years was estimated to be more than 42 million worldwide in 2013[1] rising from 4.2% in 1990 to 6.7% in 2010. This prevalence is expected to be 9.1% in 2020[2]. In comparison to normal-weight children, children who are overweight or obese have four times the risk of being overweight as adults, account for increased costs for healthcare[3-5], and experience premature illness and death later in life[5,6].

Overweight and obesity are a consequence of a disturbed energy balance[7]. An important energy balance-related behaviour, in addition to diet, is daily physical activity (PA)[8]. In young children, habitual exercise and lower levels of PA are related to higher body mass index (BMI)[9], greater skinfold thickness[9,10], greater fat mass[11], and obesity status[12-14]. To prevent future overweight in children, it is important to find determinants of their PA behavior, not only at the individual level, but with the obesogenic environment taken into consideration. The ecological system closest to a child is the microsystem, which includes family, peers, school, health services, and church[15], with parents as the most important socializing agents[16]. Parents highly determine the social and physical environment of their young children[17]. This interaction might also provide an important link between PA of parents and PA of their children[18].

Numerous studies have examined the relationship between parenting styles or parental support and PA of children[19-21]. Several studies have focused on the specific relationship between PA in parents and their children. In one review, little evidence was found to support the hypothesis that more PA in parents is associated with more PA in their children[22]. In another review, the results of an association between the PA level of parents and the PA level of their children were mixed. Six studies found an association, while seven studies found a weak or no association[23]. These mixed findings may be due to a large heterogeneity of studies with regard to the age ranges, geographical location, number of participants, and methods used to asses PA.

Particularly in young children, PA assessment is difficult. Relatively short bouts of spontaneous, intense PA are characteristic for the PA behavior of young children which is considered less structured than the PA of adults[24,25]. This spontaneous behavior of children is difficult to summarize and report by observation, thus questionnaires or

parental reports are prone to measurement errors[26]. Objective measurements, for example with tri-axial accelerometers, are less prone to these biases[27,28]. Thus, the use of tri-axial accelerometry to obtain more valid and precise measurements of children's PA may help to better identify the association between the PA of parents and the PA of their children.

The aim of this study was to examine whether PA of parents is associated with daily PA of their 4 to 7-year old offspring in the Groningen expert center for kids with obesity (GECKO) Drenthe birth cohort using tri-axial accelerometry. Special attention will be paid to gender differences. Associations of PA behaviors from father to son, father to daughter, mother to son and mother to daughter may differ[29,30]. It is expected that children with more active parents are more physically active compared to children with less active parents.

METHODS

Participants

All children, 6.1 ± 0.5 years of age (between 4 to 7 years), who were participating in the GECKO Drenthe birth cohort were included in this study. The GECKO Drenthe study is a population-based birth cohort studying early risk factors for overweight and obesity in children living in Drenthe, a northern province of The Netherlands. Babies born between April 2006 and April 2007 in Drenthe were recruited to participate in the study. Details of the study design, recruitment and study procedures were described in detail elsewhere[31]. At baseline, parents of 2,997 children intended to participate in the study, of whom 2,874 ever actively participated. Data were collected from the last trimester of pregnancy onwards by midwives, gynecologists and after birth during regular check-up visits to the Well Baby Clinics and municipal health services as part of the nationwide Youth Health Care program in which health, growth and development of children from birth till 18 years are monitored. At the age of six years, height and weight were measured by trained Youth Health Care nurses as part of a regular check-up. Overweight and obesity of children was classified according to the cut-offs of Cole et al.[32]. Socioeconomic status (SES) was assessed as by educational level of the parent (low/middle education or higher vocational education) and highest household income, both addressed during pregnancy. Height and weight of parents were self-reported in questionnaires during the periodical check-up as part of the youth Health Care program. Adult overweight was

defined as BMI between 25 and 29.9 kg/m^2 and obesity as ≥ 30 kg/m^2. Written informed consent was obtained from parents and the study was approved by the Medical Ethics Committee of the University Medical Center Groningen in accordance to the declaration of Helsinki of 1975 as revised in 1983.

Physical activity

Families were contacted individually by research assistants between 2009 and 2013 to obtain data from parents and children simultaneously. PA in children was assessed using the ActiGraph GT3X (ActiGraph, Pensacola, FL). The ActiGraph is shown to be a reliable and valid device to measure PA volume and intensity in young children[33,34]. The ActiGraph was worn by the child with an elastic belt. Parents were instructed to let their child wear the ActiGraph on the iliac crest on the right hip for four days, of which at least one weekend day, during all waking hours except while bathing or swimming[35,36]. For this paper, to be included in the analysis, the accelerometer had to be worn for at least 600 minutes/day for at least 3 days, regardless whether these were week or weekend days. Non-wearing time of the ActiGraph was classified as a minimum length of 90 minutes without any observed counts[37]. Cut-off points recommended by Butte et al. were used to calculate time spent in sedentary vs light PA (LPA)(240 counts per minute), LPA vs. moderate PA (MPA) (2120 counts per minute), and MPA vs vigorous PA(VPA) (4450 counts per minute)[38]. Collected data were analyzed in 15-second epochs. Data were collected using a frequency of 30 Hz[39]. All children with wearing time ≥ 840 min./day (14 h./day) were checked manually for sleeping time. Adherence to the Dutch healthy exercise norm was defined as ≥ 60 minutes of moderate to vigorous PA (MVPA) per day.

Parental physical activity was assessed by the validated questionnaire SQUASH (Short QUestionnaire to ASsess Health enhancing physical activity)[40]. The SQUASH estimates habitual physical activities and is pre-structured in commuting activities, leisure time activities, sports, household activities, and activities at work or school. Questions included type of activity, duration, frequency and intensity. Total amount of physical activity in minutes per week was calculated and outcomes were analyzed as time spent in light, moderate and vigorous physical activity, as well as physical activity in categories of commuting, leisure time, sports, household, and activities at work or school, according to Wendel-Vos et al.[40]. In the SQUASH questionnaire a mixture of sedentary and light activities like 'office work' is classified under 'light physical activity'. Implausible values from the SQUASH questionnaire that were excluded were: 1) PA ≥ 18 hours/day, 2) separate categories exceeding plausible values on that particular category and 3) more

than two categories of the questionnaire missing. All data cleaning was recorded and audited by a second investigator. When they remained inconclusive, a third researcher was consulted. PA data from 1,475 children, 838 mothers and 814 fathers was obtained. Children were included in the present data analysis if valid PA data from the child and at least one parent were available (N = 623, **Figure 1**). Reasons for non-response in this analysis were withdrawal of the informed consent, never active participation of the parents, loss to follow up (no contact details for PA assessment, because of a move to another province/country), not willing to participate in PA measurements or logistic problems in distributing the questionnaires or ActiGraphs.

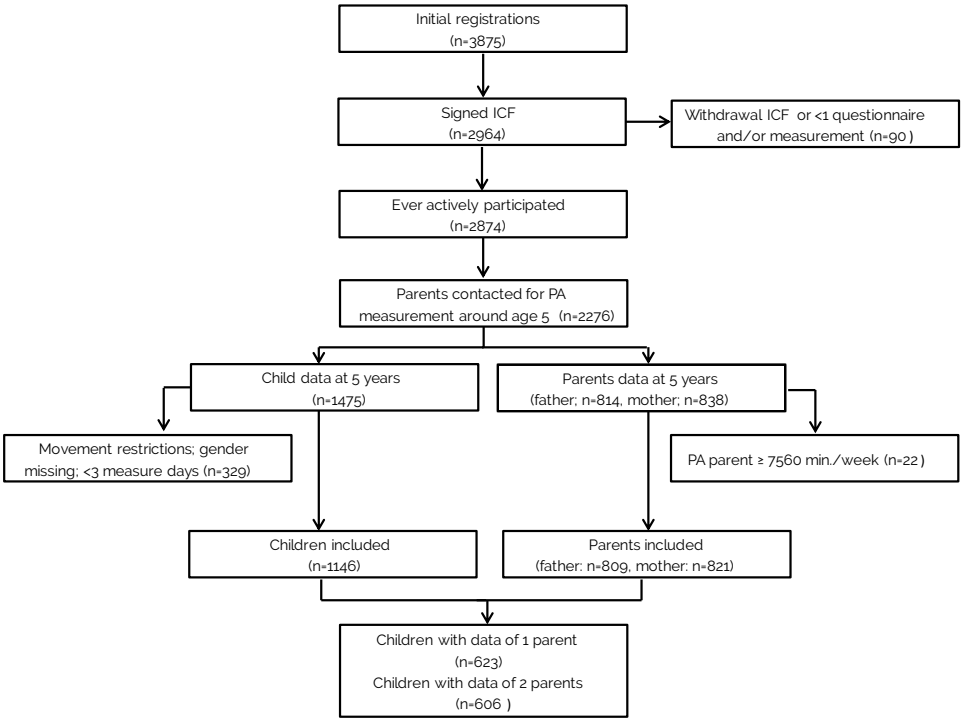

FIGURE 1. Flowchart of the participants

Statistics

Data are presented as means with standard deviations, as rates in N and percentages or, if data were skewed, as the median with 25th to 75th percentile. Because most PA variables were more or less skewed, Spearman correlations were used to assess the association between parental and child PA on different intensities. Since the parental

influence may be modified by education level, and both parental and child activities may be influenced by income level, education and income were investigated as potential modifiers in linear regression models. Dependent skewed variables were ln-transformed for linear regression. For clarity, only the most relevant PA domains of the SQUASH were presented in Tables 2 and 3. The influence of gender was investigated by stratification. Finally, it was investigated whether families with two active parents had more active children than families with no active parents. For this, parents were stratified to gender-specific tertiles based on MVPA and then regrouped into three categories: two active parents (both highest tertile), two inactive parents (both lowest tertiles) and all other combinations. Statistical analyses were carried out using IBM SPSS Statistics 22 for Windows (SPSS Inc., Chicago, IL).

RESULTS

In total parents of 2,276 children were contacted for PA measurements and 1,475 of these children were measured for PA. As shown in **Figure 1**, in total 623 children had valid ActiGraph data and PA data for at least one parent. From 606 of these children, data of both parents was available. Children included in the analyses were between 4.7 and 7.4 years of age. Age and BMI were comparable between boys and girls but as expected, boys were more active than girls. They spent about 16 minutes more in MVPA ($p<0.001$) daily and thereby more often fulfilled the guideline for physical activity (**Table 1**). When comparing children included in the analyses to children lacking parental data, the total PA (TPA) was comparable. Also the other way around, when comparing parents with child PA data to parents without valid child PA data, parental TPA was comparable (data not shown).

Tables 2 and 3 show the associations between parental PA and child PA. For mothers, more leisure time activity or more sports, was associated with lower sedentary behaviour in children. Furthermore less active commuting in mothers was associated with lower sedentary behaviour in children. More maternal leisure time PA was related to more MVPA in children (**Table 2**), especially for girls (**Table 3**). In general, maternal PA was more significantly related to PA levels of daughters, whereas paternal PA was more related to PA of sons. Looking more in detail at daughters, they were more active if mothers had high vigorous PA (VPA), high sports activities and high leisure time PA.

TABLE 1: Descriptive characteristics of children and parents in the GECKO Drenthe cohort

Child factors	**N**	**Girls**	**N**	**Boys**	**P-value**
Age at PA measurement (years)	299	6.1 ± 0.5	324	6.1 ± 0.5	0.93
Ethnicity (%)	282		304		0.32
Dutch		94.7		96.4	
Non-Dutch		5.3		3.6	
Highest household income, N (%)	267		279		0.22
≤€1150		11 (4)		6 (2)	
€1151-€3050		179 (67)		173 (62)	
€3051-€3500		51 (19)		69 (25)	
≥€3501		26 (10)		31 (11)	
BMI (kg/m²)	262	16.0 ± 1.5	277	16.0 ± 1.2	0.57
Physical activity	299		324		
TPA (counts/minute, cpm)		764 ± 197		839 ± 241[a]	**<0.001**
Sedentary (hrs./day)		6.41 ± 0.92		6.27 ± 0.96	0.053
LPA (hrs./day)		4.28 ± 0.61		4.31 ± 0.62	0.58
MPA (min./day)		40 (31; 48)		48 (40; 61)[a]	**<0.001**
VPA (min./day)		16 (11; 24)		20 (14; 28)	**<0.001**
MVPA (min./day)		55 (43; 72)		71 (54; 90)	**<0.001**
Adherent to PA guideline, N (%)		132 (44)		215 (66)	**<0.001**
Parent factors	**N**	**Mothers** (n=621)	**N**	**Fathers** (n=608)	
Age (years)	620	37.1 ± 4.4	579	40.0 ± 5.0	
BMI at PA measurement (kg/m²)	417	24.6 ± 4.0	372	25.4 ± 3.1	
Overweight and obesity, N (%)	417	164 (39.3)	372	178 (48.0)	
Education level (%)	595		578		
Low/middle		348 (58.5)		378 (65.4)	
High (higher vocational)		247 (41.5)		200 (34.6)	
Physical activity	621		608		
TPA (hrs./day)		8.0 (6.3 - 10.3)		7.9 (6.6 – 9.4)	
LPA (hrs./day)		6.5 (4.7 - 8.4)		6.0 (2.7 - 7.4)	
MPA (hrs./day)		1.14 (0.57-2.50)		0.93 (0.29 - 4.14)	
VPA (hrs./day)		0.00 (0.00-0.26)		0.14 (0.00-0.43)	
MVPA (hrs./day)		1.29 (0.71-2.77)		1.32 (0.57-4.56)	
Sports (hrs./day)		0.14 (0.00 -0.36)		0.14 (0.00 – 0.43)	
Leisure time PA (hrs./day)		0.79 (0.43-1.38)		0.89 (0.50 - 1.53)	
Household activities (hrs./day)		3.57 (2.29 – 6.00)		1.00 (0.29 – 2.00)	
Active commuting (hrs./day)		0.00 (0.00-0.10)		0.00 (0.00-0.07)	
Active work (hrs./day)		3.43 (2.14-3.86)		5.71 (4.57 – 6.07)	

Data is presented as means ± standard deviations or as median with 25th and 75th percentile or as percentages when noted. **Bold:** p<0.001 for boys vs. girls.

TABLE 2: Spearman's correlations between PA of mother and father with children's physical activity

	All children					
	TPA	**Sedentary behaviour**	**LPA**	**MPA**	**VPA**	**MVPA**
Mother						
TPA	0.018	-0.013	0.023	0.016	0.030	0.020
LPA	0.003	0.024	0.004	-0.023	0.003	-0.020
MPA	0.000	-0.070	0.042	0.041	0.007	0.035
VPA	0.047	-0.038	0.004	0.072	0.068	0.072
MVPA	0.019	-0.076	0.044	0.062	0.020	0.052
Sports	0.040	**-0.083**	0.070	0.058	0.066	0.064
Leisure time PA	0.052	**-0.082**	0.067	0.073	0.065	**0.079***
Active commuting	-0.050	**0.085**	-0.032	-0.048	-0.011	-0.030
Father						
TPA	0.010	0.013	0.078	-0.046	0.010	-0.022
LPA	-0.032	0.051	0.025	**-0.098**	-0.031	-0.079
MPA	0.027	-0.021	0.011	0.030	0.011	0.030
VPA	0.024	-0.014	0.038	0.066	0.056	0.064
MVPA	0.041	-0.028	0.019	0.056	0.035	0.056
Sports	-0.010	0.000	0.000	0.041	0.049	0.040
Leisure time PA	-0.002	-0.039	0.080	-0.021	0.015	0.001
Active commuting	-0.034	0.064	-0.024	-0.040	-0.038	-0.040

Bold: p<0.05, values indicate Spearman's rho.

In fathers, higher light PA (LPA) was correlated with lower moderate PA (MPA) of their children (**Table 2**). When fathers scored high on MPA and MPVA their sons also scores higher on MVPA. But when fathers had higher levels of LPA their sons scored higher on sedentary behavior. High levels in fathers for LPA was also associated with lower levels of MVPA in their sons (**Table 3**). None of the paternal activities from specific domains (sports, leisure time and active commuting, defined in the SQUASH questionnaires) were significantly associated with MVPA of boys. When comparing families with two active parents, families with one active parent and families with two inactive parents, no differences were found for PA in children (data not shown).

TABLE 3: Spearman's correlations between PA of mother and father stratified for sons and daughters.

	Sons		Daughters	
	Sedentary	**MVPA**	**Sedentary**	**MVPA**
Mother				
TPA	-0.062	0.000	0.040	0.078
LPA	-0.027	-0.038	0.076	0.035
MPA	-0.055	0.034	-0.085	0.057
VPA	0.026	0.007	-0.051	**0.159***
MVPA	-0.070	0.047	-0.080	0.078
Sports	-0.072	-0.003	-0.091	**0.133***
Leisure time PA	-0.080	0.059	-0.084	**0.127***
Active commuting	0.037	-0.054	**0.146***	-0.016
Father				
TPA	0.041	-0.092	-0.014	0.075
LPA	**0.122***	**-0.228****	-0.019	0.072
MPA	-0.079	**0.147***	0.038	-0.067
VPA	0.049	-0.027	-0.083	**0.141***
MVPA	-0.061	**0.132***	0.002	-0.003
Sports	0.069	-0.046	-0.073	0.103
Leisure time PA	-0.036	-0.002	-0.053	0.021
Active commuting	0.087	-0.080	0.045	-0.026

*p<0.05, ** p<0.01, values indicate Spearman's rho.

Income and education levels were not significantly related to PA levels of children, nor influenced income or education the association between parental PA and child PA (data not shown). This was also true for the mother-daughter association presented in **Table 3**. However, for fathers, the association between paternal LPA and sedentary behaviour in the son could be explained fully by educational level of the father in linear regression analyses, with high educational levels to be related to more sedentary time in sons, the B = 19 (95% CI 4-34) minutes per day. Regarding income, although no direct effect of income was found, fathers with a high LPA spent more time in occupational physical activity, which was mostly classified as light activity (office work, intermittent sedentary work) and had higher income.

DISCUSSION

The most interesting finding of this study is that the association between PA of parents and PA of their children is highly determined by the gender. Girls of mothers who spent more time in VPA from sports and leisure time had higher levels of MVPA, whereas boys scored higher on MVPA when their fathers scored higher on MVPA. These findings support the hypothesis that PA in parents is associated with PA in children. In this study, weak positive associations were found in particular with moderate-to-vigorous physical activity of children, and for mother-daughter and father-son relationships.

Although many studies are published on the association between parental PA and child PA, only few used objective measurements (e.g. accelerometry) and distinguished between mothers and fathers[22]. Some of these studies used accelerometry only in children[41-44] and two studies also used accelerometry in parents[45,46]. Most previous studies reported that PA of parents is indeed associated with PA of their preschool children[41,45-47]. Two studies showed no clear association with parental PA, which may be explained by self-reported parental PA instead of objectively measured PA, or differences in socioeconomic status[42,43]. Additionally, in 431 children of 10-12 years old, Jago et al. did not find an association between parents' PA and children's PA despite the use of accelerometry for both[48]. The contrary results in that study might be explained by the older age since research focusing on social influence found that support for PA in adolescents is shifting more from parents to peers[49]. A more recent study from Jago et al. in 1,267 five and six year-olds showed a weak association between the MVPA of children and their parents[47]. In that study, both children's and parents' PA were measured with accelerometry. Other intensities of PA were not reported.

Overall, we found differences between the role of mothers' and fathers' PA on child PA. When looking at boys and girls together, maternal PA was more often and more significantly associated with physical activity and sedentary behaviour, compared to paternal PA. Previously, Taylor et al. showed that father's PA was more predictive of child's activity than mother's PA[45]. Sallis et al. only studied the role of maternal PA, and not paternal PA, on child's PA and showed no association[42]. In our previous study from the GECKO cohort at preschool age (3-4 years) it was found that maternal active commuting was associated with lower BMI Z-score, but not with the child's PA[50]. We then suggested that active commuting mothers may also actively participate with their children in daily physical activity more, which could contribute to a healthier BMI of their

children. Although BMI was not studied in our present analyses, the positive associations between VPA, sport hours and leisure time with higher activity of the children seems to support the above suggestion, that active mothers raise more active, and possibly, more healthy children. At older age this may not be effectuated by active commuting since the association between active commuting of the mother was associated with higher sedentary time in children in our current study.

More active fathers had more active sons. This positive correlation between fathers' and boys' PA was previously found[45], and also shown in a review of 150 mostly cross-sectional studies with subjective measurement of PA, i.e. questionnaires or observation[51]. Recently, Vollmer et al. also found a positive correlation between VPA of 150 fathers and VPA of their 3-5 year old children in one-on-one interviews[52]. Additionally, and more unexpectedly, we found that paternal LPA had a significant positive correlation with sedentary time and inverse association with MVPA of boys. When looking at the determinants of LPA, this was among others time spent in work (r = 0.23, P<,001). In this case, a low paternal LPA indicated lower offspring sedentary time. In our study, fathers with lower LPA were younger, had lower income and education, did less household activities and had higher BMI (data not presented). These fathers might have a lower socioeconomic status but also a different interaction with their boys than the older, lower BMI, higher educated and higher income fathers. Although children from parents with higher income are suggested to show more healthy lifestyle behaviours[53], fathers and sons of lower SES may not necessarily be less active. The determinants of children's sedentary behaviour may differ from those of children's MVPA. Their MVPA may be related to parental PA, while sedentary behaviour may be more linked to the environment.

Important strengths of this study were the representativeness of the study population and the large sample size. This study included 623 parent/child pairs, which is more compared to other studies in preschool age (n=33 to n=347)[41-43,45,46]. The selection bias was small, since parents were not recruited specifically for a PA study, but for the total observational birth cohort[31]. In addition, no differences were found in PA levels of children with and without parental data. The number of children that met the Dutch guideline for activity in children (MVPA > 60minutes per day) was 44% for girls and 66% for boys, which corresponded reasonably well with the national average of 50% in children 4-11 years between 2006 and 2012[54].

CONCLUSION

Mothers who were more vigorously active and spent more time in sports or leisure time activities had more active daughters. Fathers with more moderate PA had more active sons. In particular the moderate activities of children may be related to the physical activities of the parents, whereas sedentary activities may be dependent on other family-related factors. The outcomes of this study gives suggestions for the development of interventions focusing on stimulation of PA in parents to enhance the PA in children.

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