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ORIGINAL ARTICLE

Parent–child dyads and nuclear family association in pedometer-assessed physical activity: A cross-sectional study of 4-to-16-year-old Czech children

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Abstract
The main aim of this study is to examine familial aggregation in pedometer-assessed physical activity (PA) and proxy-reported screen time (ST) with estimating which of the parents' lifestyle indicators help their offspring achieve step count (SC) recommendations under daily life conditions. The analysis included 773 parent–child dyads (591 mother–child, 182 father–child) and 511 nuclear family triads (mother-father–child) with data ambulatory PA monitored with a Yamax pedometer during a regular school/working week during the spring and autumn between 2013 and 2019. Based on Logistic regression analysis, an achievement of 10,000 steps a day by the mothers significantly ($p < 0.001$) increases the odds ratio of their children reaching the recommended daily SC in the parent–child dyads. Obesity/overweight of mothers (fathers) significantly ($p < 0.05$) increases (reduces) the chance of their children reaching the recommended daily SC in the analysis of the nuclear family triads. For both overweight/obese and non-overweight children, the odds of reaching the recommended daily SC are significantly ($p < 0.05$) increased by their regular participation (≥ twice per week) in organised leisure-time PA (analysis of the nuclear family triads) and non-excessive entertainment ST (≤2 h per day) in the mother–child and nuclear family triads. Despite the different mother-/father–child behavioural associations, SC of parents are positively associated with SC of their children (Linear regression analysis). The involvement of children in regular participation in organised leisure activities (at least twice a week) and limiting their excessive entertainment ST might be important factors contributing to the achievement of the recommended daily SC by children.

Keywords: *Physical activity, step counts, entertainment screen time, parent–child dyads, nuclear family triads*

Highlights
- Step counts of parents are positively associated with daily step counts of their children.
- Children with regular organized leisure time physical activities (at least twice a week) are more likely to meet the recommended daily step counts.
- Non-excessive entertainment screen time may increase the rates of children meeting the recommended daily step counts.

Introduction

Parents are considered as gatekeepers of children's health-related behaviours, because they spend a substantial part of their childhood in shared living quarters (Rhodes & Lim, 2018). To identify the correlates of the intricate web of parent–child physical activity (PA) relationships is an important research objective in the process of designing interventions to promote PA at population level. In objective monitoring of the usual PA and sedentary behaviour of families (at least parent–child dyads), closer mother–child than father–child relationships (Bringolf-Isler et al., 2018; Jacobi et al., 2011) and closer relationships at weekends than on school/working days (McMurray et al., 2016) have been repeatedly identified. Although mothers do not strongly prefer either daughters or sons in relation to PA, fathers have a closer relationship with their sons' PA, compared to

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the PA of their daughters (Bringolf-Isler et al., 2018; Yao & Rhodes, 2015).

The parental influence on the PA of their offspring generally includes two concepts – parental modelling (performing PA themselves), in which parents form the main role for their children (Rhodes & Lim, 2018) and parental support (facilitation of children's PA) (Pyper, Harrington, & Manson, 2016; Rhodes et al., 2019). Parental support is an important predictor of children's and young people's PA behaviour (Rhodes et al., 2019) and could have greater significance for children's PA than that of parent–child PA (Erkelenz et al., 2014; Gustafson & Rhodes, 2006). In parental support, we can distinguish four categories: motivational, instrumental, conditional, and regulatory (Beets, Cardinal, & Alderman, 2010; Pyper et al., 2016). All of these supportive behaviours have been proved to be correlates of child PA (Beets et al., 2010; Sallis, Prochaska, & Taylor, 2000) with no clear supportive behaviour being more important than any other. Parents play an important role in the health-related behaviour of their children, for instance, in terms of screen time (parental modelling, parental rules), as well as leisure-time PA and organised PA (Rodrigues, Padez, & Machado-Rodrigues, 2018; Xu, Wen, & Rissel, 2015). Parental correlates are well described in the literature (Gustafson & Rhodes, 2006; Sallis et al., 2000; Xu et al., 2015; Yao & Rhodes, 2015). However, the parental role in meeting children and adolescent PA recommendations is still not well understood, especially in Central and Eastern Europe. Following the previously confirmed correlates or indicators of parent–child-related active lifestyle behaviour in Czech preschool children (Sigmundová et al., 2017), in this study we primarily focus on parental PA, screen time, and overweight/obesity, for which we expected an effect on adherence to the PA recommendations of children and adolescents previously seen in preschool children.

European countries from the former Communist bloc (such as the Czech Republic) appear to tend to replicate the 'negative' health-related behaviour patterns related to obesity, which had previously been witnessed in Western European countries (Knai, Suhrcke, & Lobstein, 2007). Among others, this concerns a decrease in moderate-to-vigorous PA and an increase in screen time (ST) (Inchley, Currie, Jewell, Breda, & Barnekow, 2017).

A sufficient level of PA is commonly evaluated by adherence to predefined PA recommendations. However, there is a large number of different recommendations for PA in the literature (Gelius et al., 2020; Tudor-Locke, Craig, Beets, et al., 2011; Tudor-Locke, Craig, Brown, et al., 2011). Many European countries have already developed, or have been developing, their own national PA recommendations, with a general tendency to adapt the basic WHO recommendations in relation to national needs (Gelius et al., 2020). A globally used PA recommendation for children and adolescents is at least 60 min of moderate-to-vigorous PA daily (World Health Organization, 2006). This generally corresponds to an average of 13,000–15,000 steps per day in school-aged boys, and 11,000–12,000 steps per day for school-aged girls (Rowlands & Eston, 2005; Tudor-Locke, Craig, Beets, et al., 2011). For adolescent boys and girls, the achievement of 10,000–11,700 steps per day is associated with the fulfilment of the recommendation of 60 min (Tudor-Locke, Craig, Beets, et al., 2011). In contrast to the wide variability in determining the cut-off for the SC recommendation in children and adolescents, there is agreement that reaching 10,000 steps a day is a sufficient level for PA for healthy adults (Tudor-Locke, Craig, Brown, et al., 2011).

It is noteworthy that previous studies investigating the relationship between the indicators of lifestyle behaviours of parents and their children were limited to a short range of age of children, included only dyads (mother–child, father–child) separately (Craig, Cameron, & Tudor-Locke, 2013; Stearns et al., 2016), or did not combine objective monitoring of PA with entertainment ST (Craig et al., 2013). In order to identify health-related determinants of children's lifestyle or to develop health-enhancing programmes, it is necessary not only to determine simple relationships but also to assess whether the level of parent–child relationships in PA and sedentary behaviour helps children achieve the recommended level of daily PA. That is why the main aim of this study is to examine familial aggregation in pedometer-assessed PA and proxy-reported ST by estimating which of the parental lifestyle indicators (daily PA and entertainment ST, weight status, and participation in organised leisure-time PA) and also children's lifestyle indicators help their offspring achieve the age-categorized daily PA recommendations under the conditions of daily life. Next, we investigated whether there is a difference between the SC on weekdays and weekend days and aimed to find out whether children's and adolescents' correlates of achieving the daily step recommendations vary in the analysis of family dyads (mother–child or father–child) and nuclear family triads (mother-father–child).

Methods

Participants

A couple and their child/children who share living quarters were defined as nuclear family triads participating in the study. Family dyads consist of a mother–child or father–child couples. The participation of at

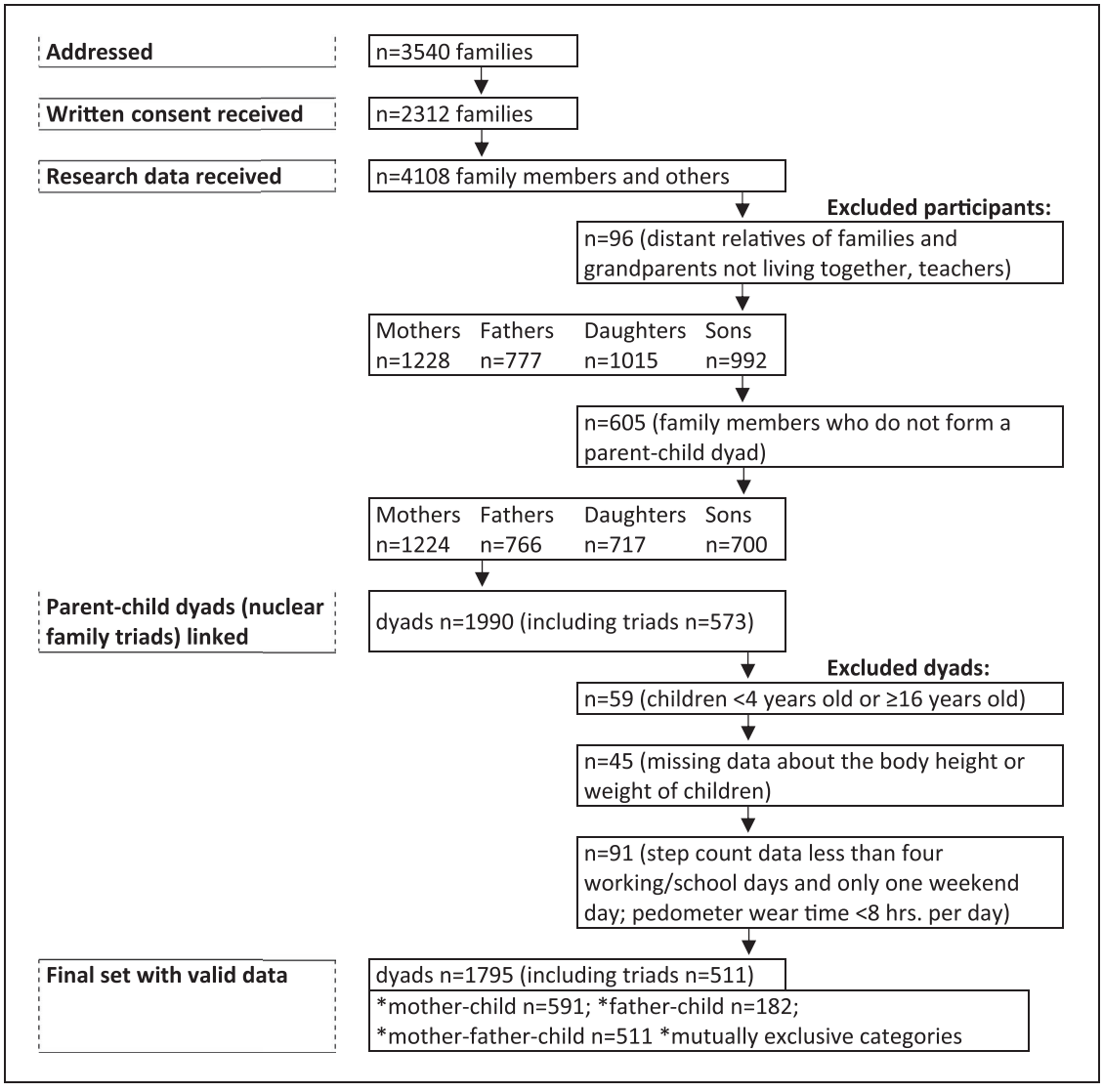

Figure 1. Flowchart of participants' inclusion in the study.

least one family dyad was not a necessary condition for starting the research. A total of 3540 families from the Czech Republic were addressed to participate in this cross-sectional study, of which 65.3% agreed to take part in the research (written informed consent received). The families were addressed through children and adolescents from 51 schools and 10 kindergartens that were selected randomly and, where information meetings were also held to describe the process/course of the research. Figure 1 provides a detailed description of the representation of the participating family members.

The analysis included 773 parent–child dyads (591 mother–child, 182 father–child) and 511 nuclear family triads (mother-father–child) with complete data for the family members on ambulatory PA monitored with a Yamax pedometer during regular school/working weeks during the spring and autumn between 2013 and 2019 (Figure 1) The data collection took place in four waves. In 2013, the study started with monitoring in families with children aged 9–10 years; in the 2014–2016 period, families with children aged 4–10 were included in the study; in 2017, the study was expanded by adding families with children aged 11 years, and the families with adolescents (aged 12–15 years) were measured during the last stage, in 2018–2019. Descriptive anthropometric characteristics of the final set of participants are presented in Table I.

The study design (measuring tools, protocols, procedures, and feedback format for respondents) was approved by the Institutional Ethics Committee No. 50/2012 for participation of school-aged children and adolescents and No. 57/2014 for pre-schoolers.

Table 1. Descriptive anthropometric characteristics – number; percentages (95% CI); means (standard deviations) of participants.

	Daughters			Sons				
	4–7.9 years	8–11.9 years	12–15.9 years	4–7.9 years	8–11.9 years	12–15.9 years	Mothers	Fathers
N	186	281	188	176	294	159	1102	693
Age (years)	6.5 (1.1)	10.0 (1.2)	13.6 (1.1)	6.4 (1.0)	9.9 (1.2)	13.5 (1.0)	39.5 (4.6)	42.1 (5.5)
Weight (kg)	22.9 (4.9)	35.3 (8.8)	51.3 (10.0)	23.6 (4.9)	35.7 (8.1)	55.2 (13.5)	66.8 (11.1)	88.1 (13.1)
Height (cm)	120.8 (9.1)	142.2 (10.2)	161.4 (8.0)	122.1 (8.2)	142.2 (8.9)	164.2 (11.0)	167.5 (6.1)	181.1 (7.1)
BMI (kg/m^2)	15.6 (2.6)	17.3 (2.7)	19.6 (2.9)	15.7 (2.0)	17.5 (2.9)	20.3 (3.5)	23.8 (3.8)	26.8 (3.5)
Overweight[a,c]	10.8% (6.3–15.3)	15.3% (11.1–19.5)	13.3% (8.4–18.2)	10.8% (6.1–15.4)	16.7% (12.4–20.9)	25.2% (18.3–32.0)	22.5% (20.0–25.1)	51.2% (47.4–55.0)
Obesity[b,d]	8.1% (4.1–12.0)	6.0% (3.3–8.9)	3.2% (0.7–5.7)	9.1% (4.8–13.4)	12.6% (8.8–16.4)	9.4% (4.8–14.0)	8.2% (6.6–9.9)	17.2% (14.4–20.1)

N– number of participants; BMI – Body Mass Index; [a]overweight or [b]obesity in children represents BMI from the 85th to 97th percentile of the WHO growth charts (World Health Organization, 2007); [c]overweight or [d]obesity in parents represents a BMI from 25 kg/m^2 to 29.9 kg/m^2 or greater than or equal to 30 kg/m^2 (World Health Organization, 2014).

Description of procedures and measures

The same research assistants organised informative meetings for children, teachers, and parents about the research objectives, the measurement tools used, the measurement procedure, and the anonymized feedback format for each participant at all the schools that agreed to participate in the research. The research assistants showed the participants how to use the pedometer, and provided the parents/children with oral and written instructions on how to record their step counts (SC) and those of their offspring and the duration and type of sedentary behaviour into the family log book. All the potential participants were able to test the operation of the Yamax Digiwalker SW-200 (Yamax Corporation, Tokyo, Japan) practically and add the data to a family log book. The parents and children were assured of the anonymity of data processing and other ethical principles of the 1964 Helsinki Declaration and its later amendments, as well as of the safety and hygiene of the measurement tools used. Written informed consent was received from both the parents and children who decided to participate in the research. Advice was given to both the parents and child participants to follow their usual PA routine during the research. The data collection began shortly (in the following week without public/school holidays) after the informative meeting of participants at the given school.

The parents were asked to complete the anthropometric data (date of birth of offspring, age of parents, gender, body height/weight (with 0.5-cm/kg accuracy) of parents and offspring) of all participating family members in the first section of the family log book before the start of the one-week monitoring of PA/sedentary behaviour. The parents were thoroughly instructed how to measure their own body height and weight at home, as well as the height and weight of their offspring. The parental home measurement of the body height and weight of their preschool and school-aged offspring (Chai, Collins, May, Holder, & Burrows, 2019) is considered to be sufficiently valid for calculating the Body Mass Index (BMI) for the subsequent identification of excessive body weight in children (Chai et al., 2019).

The PA under daily life conditions of all family members was monitored by a Yamax pedometer attached to the right hip of the participants for a continuous period of eight days. Data from the first monitoring day was not included in the analysis because of potential reactivity. The parents and their offspring were instructed to wear a pedometer all day except during time used for personal hygiene, swimming, or bathing. Every morning, after personal hygiene, the parents reset the pedometers, attached them to the right hip (their own and those of their offspring), and recorded the time at which the pedometer was attached in the second part of the family log book. In the evening, the parents took the pedometers off and, together with their offspring, recorded the time and daily SC of all participating family members in the log book. In addition, the parents could also record in the family log book whether they or their children were actively involved in organised leisure-time PA on that day. Organised leisure-time PA (e.g. sports training) did not include lessons of physical education during school/kindergarten hours. The Yamax Digiwalker SW-200 hip-worn pedometer-based monitoring of

PA is a valid and unobtrusive method providing a reasonable assessment of the total amount of all-day PA during free-living conditions without requiring a precise determination of its intensity in preschool (McNamara, Hudson, & Taylor, 2010) and school-aged children (McNamara et al., 2010), as well in adults (Kooiman et al., 2015). The mean daily step count was calculated for each person separately on the basis of the sum of his/her steps recorded on seven days of the week, five working days and two weekend days divided by the number of given days (7, 5, and 2, respectively). The daily SC recommendation represents an average daily value of ≥13,000/≥11,000 steps for 4–12-year-old boys/girls and ≥10,000 steps/day for 12–16-year-old adolescents (Tudor-Locke, Craig, Beets, et al., 2011) and adults (Tudor-Locke, Craig, Brown, et al., 2011).

The sedentary behaviour (duration of seven separate sitting/lying patterns of behaviour) of all participants was proxy-reported by the parents in the third part of the family book each evening. The parents were instructed to record the duration of all sedentary items with an accuracy of 10 min. Entertainment ST represents the sum of two items of sedentary behaviour (sitting/lying watching TV (DVDs, videos) and sitting/lying in front of a PC (notebook, tablet, or smartphone) for purposes other than school/work). Excessive entertainment ST was defined as more than 60 min per day for four-year-olds. For children older than five years and adults it was set as more than 120 min per day (Tremblay et al., 2017, 2011).

Data processing and statistical analysis

All the data processing and statistical analyses were completed using the Statistical Package for the Social Sciences (SPSS) for Windows v.22 software (IBM Corp. Released 2013. Armonk, NY, USA). The final data set, with valid anthropometric, step count, and screen time data, was checked for extreme values. The Body Mass Index (BMI) was calculated as body weight (kg) divided by body height (m) squared. Body weight status (non-overweight, overweight, obesity) was determined in accordance with the WHO's gender-specific BMI-for-age growth charts (World Health Organization, 2007). Overweight and obesity in children were represented by the 85th–97th percentile and > 97th percentile, respectively, on the gender-specific BMI-for-age growth charts (World Health Organization, 2007). Overweight and obesity in parents are represented by a BMI from 25 kg/m^2 to 29.9 kg/m^2 or greater than or equal to 30 kg/m^2 (World Health Organization, 2014). The children were divided into three age groups (4–7.9 years; 8–11.9 years; 12–15.9 years), which represented a third of the children's age range in the present study. Descriptive characteristics were calculated for anthropometric variables for the mothers and fathers, and three age categories of their offspring separated according to the daily SC recommendation for children and adolescents (Tudor-Locke, Craig, Beets, et al., 2011). Descriptive characteristics are presented as percentages, means, and standard deviations. The daily SC data is expressed as the mean and 95% confidence interval (CI). Linear regression analyses (stepwise selection method) were used to describe the associations of the lifestyle-related family-based behaviour indicators of parents (BMI, mean daily SC, mean daily ST, weekly frequency of organised leisure-time PA) and their children's SC (BMI, mean daily SC, mean daily ST, weekly frequency of organised leisure-time PA, age). Crude (unadjusted) logistic regression models (Supplemental Table 1) were ran as preliminary analyses and then the logistic regression models (using backward stepwise selection method based on the likelihood ratio tests) were used to investigate which of the lifestyle-related family-based behaviour indicators of the parents (non-overweight status, ≥10,000 SC/day, ≤120 min of ST/day, participation in organised leisure-time PA) and their offspring (non-overweight status, ≤60 min of ST day for 4 years old children and ≤120 min of ST/day for children 5–16 years old, participation in organised leisure-time PA, and the age category and gender of the children) are associated with reaching the daily SC recommendation in children. Expected relationships of variables for selected regression analyses are presented in Supplemental Figure 1. Ordinary single-level regression was used because the initial analyses were not significantly altered by the clustering of data by school/kindergartenThe non-parametric Wilcoxon signed rank test for related samples was used to assess the differences in SC between working days and weekends. The alpha level of significance was set at the minimum value of 0.05.

Results

The average daily number of steps for all age categories of daughters and sons exceeded 10,000 steps per day on weekdays and weekend days (Table II). All age categories of daughters and sons showed higher PA on school days than on weekend days, with a statistically significant difference in the daily SC between weekdays and weekend days, except for 12–16 – year-old boys. Significant difference in SC between weekdays and weekend day was also confirmed in mothers (Table II).

Table 2. Pedometer daily step counts (SC) and meeting SC guidelines in the different parts of the week in the family participants; means (95% confidence interval).

Daily SC	Daughters			Sons				
M (95% CI)	4–7.9 years	8–11.9 years	12–15.9 years	4–7.9 years	8–11.9 years	12–15.9 years	Mothers	Fathers
Week	10,881 (10,409–11,354)	11,124 (10,670–11,579)	10,941 (10,338–11,543)	12,114 (11,523–12,705)	11,864 (11,352–12,375)	10,924 (10,242–11,605)	10,335 (10,108–10,562)	10,106 (9820–10,392)
Weekdays	11,207*** (10,714–11,700)	11,428*** (10,968–11,889)	11,162** (10,538–11,787)	12,293* (11,668–12,919)	12,297*** (11,771–12822)	11,074 (10,363–11,785)	10,613*** (10,373–10,852)	10,197 (9892–10,502)
Weekends	10,066 (9437–10,696)	10,366 (9779–10,953)	10,387 (9619–11,154)	11,664 (10,923–12,405)	10,782 (10,140–11,423)	10,546 (9712–11,381)	9640 (9358–9922)	9879 (9534–10,223)
Meeting SC guidelines^{+} *(%)*		Daughters			Sons		Mothers	Fathers
	4–7.9 years	8–11.9 years	12–15.9 years	4–7.9 years	8–11.9 years	12–15.9 years		
Week	47.8	45.9	54.8	47.7	34.4	52.8	50.3	48.1
Weekdays	50.5	48.0	58.5	49.4	42.2	54.7	53.7	47.8
Weekends	39.2	37.7	48.9	43.8	28.2	50.9	40.7	45.6

Legends: + *Meeting SC guidelines* represents a value ≥13,000/≥11,000 steps/day for 4–12-year-old boys/girls and ≥10,000 steps/day for 12–16-year-old adolescents (Tudor-Locke, Craig, Beets, et al., 2011) and ≥10,000 steps/day for adults (Tudor-Locke, Craig, Brown, et al., 2011); Wilcoxon test for differences in SC between weekdays and weekends day $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

Boys show a slight decrease in PA with an increase in the age category of children and adolescents on school and weekend days. Mothers outperform fathers in their daily SC on weekdays and on average for the whole week (Table II). More than 50% of the mothers reach the recommendation of 10,000 steps a day on weekdays as well as the weekly average, compared with less than 48% among the fathers.

Based on linear regression analyses (Table III), there are positive significant associations of parental daily SC with their children's daily SC (in parent–child dyads). Furthermore, we observed negative association of children's time spent by entertainment ST and positive association of children's participation in organised leisure-time PA with children's daily SC. Next, frequency of fathers' organised PA was negatively associated with daily SC of their children.

There are different associations between mothers and fathers among the parental correlates of reaching the daily SC recommendation in their offspring (Table IV). While parental overweight/obesity does not significantly affect reaching the recommended amount of daily SC of their children in the parent–child dyads models, in the case of the analysis of the nuclear family triads, the children of overweight (including obese) mothers are more likely to meet the recommended daily SC.

In analysis parent–child dyads, higher PA of mothers (≥10,000 steps per day), non-excessive entertainment screen time (of mothers and also children) and mother's participation in leisure-time organised PA significantly increases their offspring's odds of reaching the recommended daily SC. In the analysis of the nuclear family triads, the higher PA of the fathers is significantly associated with their children achieving the recommended daily SC. The rest of the parental lifestyle indicators are not significantly related to children's PA expressed in daily SC (Table IV).

The children's odds of reaching the daily recommended SC, regardless of their body weight level, are significantly increased by regular participation (≥2 times per week) in organised leisure-time PA ($p < 0.001$) and non-excessive entertainment ST (≤2 h per day) in the analysis of the mother–child dyads and nuclear family triads ($p < 0.05$) (Table IV). Adolescents are significantly ($p < 0.01$) more likely to achieve the age-related SC recommendations than 4–7.9-year-old children.

Discussion

The present study attempts to address the role of parents' modelling of the PA of their offspring through objective monitoring of weekly PA supplemented by proxy-reporting of entertainment ST under daily life conditions. Family-aggregated PA/ST patterns are revealed through an extensive set of families with children aged four to 16 years. Another original feature of this study is a separate analysis for the mother/father–child dyads and family nucleus triads.

First, the results seem to indicate decreasing differences in the daily SC between girls and boys in all given age groups of children and between school and weekend days. Unlike other studies (Farooq et al., 2018; Jacobi et al., 2011), there is no decrease in objectively monitored PA with an increase in the age of the children and adolescents. These findings may be caused by the relatively high proportion of children in all age categories with regular (at least twice a week) participation in organised leisure-time PA (daughters/sons – 30.2%/34.0% in 4–7.9-year-old offspring, 44.6%/50.4% in 8–11.9-year-old offspring, and 39.3%/41.1% in 12–15.9-year-old offspring). Furthermore, the recommendations for PA vary according to the children's age; for adolescents the PA cut-offs are lower compared to younger children and thus, despite the lower absolute value of the number of steps, they can meet the recommendations for PA (Tudor-Locke, Craig, Beets, et al., 2011). In addition, the Hawthorne effect exists (Kerlinger, 1972) and the fact that more active families tend to be involved in research could have affected these results.

Different mother/father–child associations are found regarding the odds ratio of their children achieving the recommended daily SC. However, in line with other studies (Jacobi et al., 2011; Stearns et al., 2016), our findings support the claim that there is a positive association among PA of parents and their children. However, the positive effect on the odds of achieving the recommended daily SC in children is significantly increased by the higher PA in mothers in analysis of parent–child dyads and also in fathers in the analyses of nuclear family triads. A peculiarity is the different association of the weight status of mothers with the PA of their offspring, when the children of mothers with excessive body weight are significantly more likely to meet the recommended daily SC. It seems as if mothers with excessive body weight are more aware of the importance of physical activity for the healthy development of their offspring than mothers with non-overweight status. This is a rather an unprecedented finding, thus further research on the topic is warranted.

Besides the direct relationship of parents to the PA of their offspring, the participation of children in organised leisure-time PA in relation to the PA of their parents is also repeatedly highlighted (Bringolf-Isler et al., 2018; Erkelenz et al., 2014; Rodrigues et al., 2018). The present study discovered the

Table 3. Linear regression analysis for children's mean daily step counts and related factors.

	Children's weekly step counts and related factors						
	Parent-child dyads#				Family nucleus triads#		
	Mother in model		Father in model		Both parents in the model		
	B	95% CI	B	95% CI		B	95% CI
PARENTS:							
Step counts	0.24***	0.17–0.31	0.17*	0.04–0.31	Mother	NS	
					Father	0.33**	0.15–0.51
Organised PA (in how many days parent's participate in organised PA)	NS		NS		Mother	NS	
					Father	−533.04*	−979.68–−86.40
CHILDREN:							
Entertainment ST (min/week)	−11.03***	−14.76–−7.29	−10.36*	−18.42–−2.30		−14.53*	−25.90–−3.17
Organised PA (in how many days children's participate in organised PA)	229.19**	61.99–396.40	548.32**	217.83–878.80		683.43**	247.12–1117.75
R^2	0.113		0.163			0.305	

Linear regression analysis, Stepwise method; B – unstandardised coefficients; 95% CI – confidence interval; R^2 – coefficient of determination; organised PA – structured leisure-time physical activity (e.g. sports training), which does not include lessons of physical education during school/kindergarten time; Entertainment ST – screen time during sitting/lying while watching TV and sitting/lying in front of a PC (notebook, tablet, or smartphone) and not for school/work purposes; regression analyses were controlled for children's gender; parental BMI and entertainment ST, children's BMI and age were non-significant variables – excluded from the all models; NS – non-significant variable excluded from the model.

negative association between frequency of fathers' participation in organised PA and overall weekly step count of their children. The possible explanation is that fathers who are still engaged in sports at the competitive level might have less time to be physically active together with their children. This finding requires further attention in future because it is in contrast with the other studies showing that the children with at least one active parent show more frequent participation in organised sports than the offspring of inactive parents (Erkelenz et al., 2014; Rodrigues et al., 2018). High variability exists in the proportion of children meeting the PA recommendations across countries, as well as the assessment methods used and outcomes obtained (Van Hecke et al., 2016). In this study, about half of the children met the SC recommendation across the age categories. A lower PA level was found in adolescent Australian girls, with 40.3% of them achieving 10,000 steps/day (Schofield, Schofield, Hinckson, & Mummery, 2009). Likewise, only 14.5% of New Zealand high school students achieved at least 10,000 steps/day (Hohepa, Schofield, Kolt, Scragg, & Garrett, 2008). A Greek parent–child study confirmed different proportions of children achieving the recommendation of 10,000 steps/day on working days or at weekends (Voukia, Voutsina, Venetsanou, & Kambas, 2018), with 69% and 29.6% of the boys and only 26.6% and 11.5% of the girls achieving this recommendation on working days and at weekends, respectively. On the other hand, the majority of Irish primary school children (62.2% male, 74.7% female) was found to achieve the recommended SC level (Belton, Brady, Meegan, & Woods, 2010). The relatively high proportion of children and adolescents who achieved the daily SC recommendations (daughters/sons in family dyads: 49.0%/42.8%; daughters/sons in nuclear family triads: 56.0%/44.4%) in this study is strongly supported by regular participation in organised leisure-time PA. Finding that a significant positive association between children's leisure-time organised PA and their daily PA may appear to be a tautology. However, with a registered decrease in habitual PA with the increasing age of children (Farooq et al., 2018; Jacobi et al., 2011) and time spent outdoors (Bassett, John, Conger, Fitzhugh, & Coe, 2015), regular participation in organised leisure-time PA may not lead to the PA recommendations being met.

The health benefits of PA greatly outweigh the health risks and many of the health benefits increase with increased intensity, frequency, and duration of PA (Oja, Bull, Fogelholm, & Martin, 2010). Therefore, effective means are sought to increase the everyday extracurricular physical activity of children and adolescents, including active transport to school (Jones et al., 2019), outdoor play (Bento & Dias, 2017), and participation in organised leisure-time activities (Badura, Geckova, Sigmundova, van Dijk,

Table 4. Logistic regression analysis: odds ratios and 95% confidence intervals for meeting the daily step count (SC) recommendations in children and adolescents, separately for parent-child dyads and nuclear family triads.

	Meeting step counts recommendations: ≥13,000/≥11,000 steps/day for boys/girls and ≥10,000 steps/day for 12–16-year-old adolescents								
	Parent-child dyads#						Family nucleus triads#		
	Mother in model			Father in model			A – Mother B – Father		
Entered variables (step 1)	%	OR	95% CI	%	OR	95% CI	%	OR	95% CI
PARENTS:									
Weight status									
Non-overweight		NS			NS		A 70.5	Ref.	
Overweight/obesity							A 29.5	2.03*	1.13–3.66
Step counts									
< 10,000 steps/day	54.5	Ref.			NS		B 54.1	Ref.	
≥10,000 steps/day	45.5	2.79***	1.76–4.41				B 45.9	2.31**	1.38–4.07
Entertainment ST									
Excessive	31.3	Ref.			NS		A 31.8	Ref.	
Non-Excessive	68.7	1.87*	1.12–3.13				A 68.2	1.67	0.95–2.92
Organised PA									
0 times per week	62.2	Ref.							
at least 1 times per week	37.8	1.62*	1.01–2.62		NS			NS	
CHILDREN:									
Gender									
Boys		NS			NS			51.5	Ref.
Girls								48.5	1.64	0.99–2.73
Age category									
4–7.9 years		NS			NS			38.7	Ref.	
8–11.9 years								35.7	0.72	0.40–1.31
12–15.9 years								25.6	2.73**	1.36–5.49
Weight status									
Non-overweight		NS			NS			79.0	Ref.	
Overweight/obesity								21.0	0.58	0.30–1.11
Entertainment ST									
Excessive	30.1	Ref.		30.6	Ref.			22.9	Ref.	
Non-excessive	69.9	1.73*	1.03–2.91	69.4	2.05	0.90–4.69		77.1	1.95*	1.02–3.73
Organised PA									
0 times per week		NS		45.5	Ref.			32.1	Ref.	
1 times per week				23.1	0.67	0.29–1.57		20.0	1.73	0.95—3.14
≥2 times per week				31.4	2.07	0.79–5.39		47.9	4.82***	2.41–9.64
Nagelkerke R^2		0.16			0.07				0.26	

The analyses include mutually exclusive categories for each model; Entertainment ST – screen time during sitting/lying while watching TV and sitting/lying in front of a PC (notebook, tablet, or smartphone) and not for school/work purposes, Excessive entertainment ST was defined for children older than 5 years and adults as more than 120 min per day and as more than 60 min per day for 4 years old children (Tremblay et al., 2017, 2011); organised PA – structured leisure-time physical activity (e.g. sports training), which does not include lessons of physical education during school/kindergarten time; # – mutually exclusive categories; % – proportion of children in the given area; OR – odds ratio; 95% CI – confidence interval; Ref. – reference group; R^2 – Nagelkerke coefficient of determination, logistic model, Backward LR method; the statistical significance is expressed as $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$; NS – non-significant variable (with a threshold $p > 0.1$) excluded from the model.

& Reijneveld, 2015). However, for children and adolescents whose family is available, it will always be beneficial to promote daily PA through a supportive family background.

Limitations and future studies

The conclusions drawn from the results of the study should be seen in the light of the existing limits. Although neither the parents nor children were informed of the daily SC inclusion criteria or recommendations, the potential bias resulting from social desirability is always possible when a pedometer is worn. However, the participants were instructed to follow their usual weekly PA routine, and in accordance with the study of Rowe, Mahar, Raedeke, and Lore (2004), the data from the first day of PA monitoring was not included in the analyses. Furthermore, spring-levered pedometers do not allow the monitoring of water-based PA and their sensitivity is diminished when detecting the intensity of PA, which may result in underestimation

of daily SC or, generally speaking, PA. Next limitation is represented by a large time period of the data collection offering a space for change in lifestyle of young people (Inchley et al., 2017). Similarly, it may be difficult to accurately determine entertainment ST when multitasking has become a common phenomenon in adolescents (Brasel & Gips, 2011). However, the primary aim of this study was not to analyse overall daily SC/ST in detail, but mainly family dyads (mother–child or father–child) and nuclear family triads (mother-father–child) relationship in terms of SC/ST behaviour and its correlates.

The variables related to the socio-economic status of families (e.g. parental education, family income) were surveyed only for families with 12–15-year-old adolescents, and therefore these variables were not included in the current analyses. Given that parental education and income were previously shown to be associated with levels of PA in both adults and their children (Erkelenz et al., 2014; Määttä et al., 2018) future studies need to include this confounding factor in their analyses. Finally, because of the lower response rate (66%) and the experience that more active families are usually more likely to meet a seven-day objective of monitoring PA using pedometers successfully, we are hesitant to generalise our results, for instance, to less active families, even though the file size is large enough.

On the basis of the revealed family aggregation of PA helping the offspring to achieve the recommended daily SC, subsequent studies should quantify what increase in parents' PA under daily life conditions can be expected to increase SC in children and adolescents and whether this expected increase varies with respect to the indicators of the socio-economic status of families.

Conclusions

Despite the different mother/father–child behavioural associations, higher PA of parents is undoubtedly associated with the higher daily SC in their offspring. Regular involvement of children in organised leisure-time physical activities (at least twice a week) and limiting their excessive entertainment ST may increase the rates of children meeting the recommended daily SC as well as overall level of PA. The present study implies that the influence of the family on the physical behaviour of children depends mostly on factors associated with mothers' lifestyle or the lifestyle of both parents together. Future interventions focused on increasing children's PA should include support for fathers' physical activity, and also the accessibility of organised activities for children.

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Supplemental data

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