Only children or siblings: who has higher physical activity and healthier weight?

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Research article

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Abstract

Background

The influence of parents on physical activity (PA) and body weight of their children is confirmed by scientific studies and accepted by the professional community. However, it is not known whether only children or those with siblings have a higher level of PA and healthier body weight. Therefore, the aim of this study is to assess whether there are any differences in the daily step counts (SC) and the prevalence of obesity between only children and children with siblings, and whether the achievement of the daily SC recommendation by children/parents and parental obesity influence obesity in children with and without siblings.

Methods

The analysis included 566 families (10.6%/89.4% with single child/two or more children) with complete data of family members on weight status and ambulatory PA monitored with a Yamax pedometer during regular school/work week during spring and autumn between 2013–2019. The cut-point values of the daily SC recommendation amounted to $\geq 13,000/\geq 11,000$ steps/day for 5–12 years old sons/daughters and $\geq 10,000$ steps/day for 12–16-year-old adolescents and adults. The Chi-Square (χ^2) test series was used to compare the achievement of the daily SC recommendation and the prevalence of normal body weight, overweight and obesity between only children and those with siblings. Logistic regression models (Enter method) were used to investigate whether the achievement of the daily SC recommendation by children/parents and parental obesity were associated with obesity in offspring in single-child families and families with more children.

Results

A significantly higher proportion of children with siblings ($p < 0.01$) achieved the recommended daily SC (51.8% vs. 31.7%) and showed a lower prevalence of overweight (16.2% vs. 20.0%) and obesity (7.1% vs. 20.0%) compared with only children. The achievement of the daily SC recommendation in children significantly ($p < 0.05$) decreased the odds ratio (OR) of obesity (OR = 0.22–0.34). Children with siblings had lower odds (OR = 0.41–0.54) of obesity than only children, but significantly ($p < 0.05$) only in mother-child dyads. Overweight/obesity of mothers significantly increased ($p < 0.05$) the odds of obesity (OR = 2.07) in their children.

Conclusion

Children from families with siblings have a higher amount of daily PA and healthier body weight than single-child families.

Background

Childhood obesity arises as a result of the interaction between a complex of genetic, environmental and psychosocial determinants that lead to excessive food intake and insufficient physical activity (PA) [1, 2]. Behavioural individual or family-based energy balance-related changes in diet and PA are currently the primary tools for modifying lifestyle and preventing childhood obesity. However, they show a rather small, short-term effect and a high heterogeneity [3, 4]. The solution to childhood obesity epidemic can no longer be achieved through a simplified reduction in caloric intake and increased PA. It is inevitable to consider the complex relationships between genetic factors, diet, sport participation, physical and sedentary behaviour, sleep, circadian rhythm, environment and intestinal microbiome [1, 2]. For example, sufficient sleep time was among the most important correlates reducing the risk of obesity in a randomized group of Czech 11–15-year-old adolescents besides regular weekly vigorous PA and participation in sport [5]. Thus, from a public health perspective, there is still a relevant demand for identifying the determinants and correlates of childhood obesity to formulate preventive recommendations and design effective interventions.

Naturally, research on children's energy balance-related behaviours frequently focuses on the family lifestyle and environment. Family is the setting where the first long-term formation of dietary and PA patterns of children occurs, and family-based lifestyle interventions are still the cornerstone of weight management in children [6]. Many family-related determinants and correlates of childhood obesity have been uncovered in genetics (e.g. parental overweight), lifestyle (e.g. parental stress, maternal smoking or breastfeeding status) or sociology (e. g. socioeconomic status of families) [7–10], but there are still incomplete and inconsistent findings regarding the family environment and parenting styles in relation to childhood obesity [11–13]. One of the reasons for the inconsistency between some parental variables and childhood obesity may stem from a change in the structure of families with children in economically developed countries over the past two decades – increasing mother's age at first pregnancy and the growing number of single-child families [14–17].

Evidence-based reasons explaining the sociological phenomenon of single-child families include higher age of parents when starting a family, increased financial demands of families [15, 18], but also housing in rural areas, family caregiving, one or both parents having grown up in a single-child family [15], time pressure inherently related to giving birth [19] and political reasons [16, 20, 21]. Single-child families can be, in addition to parenting child-centeredness [20], and no sibling rivalry, an appreciation of the child being the only recipient of parents' emotional and financial resources [22]. They are regularly investigated in psychosocial research [15, 16, 21, 22] but rarely in public health related research [23].

From a psychosocial point of view (psychological distress, susceptibility to negative peer pressure, self-reported school performance, and problem behaviours), only children do not diverge from children with siblings and might even have some advantages over 'laterborns' regarding school-related outcomes [16, 21]. However, there are possible indications of differences in the level of PA depending on the number of siblings [23]. In general, there is a positive correlation between parent-child body weight status and the

risk of child obesity when their parents are obese [24, 25]. Similarly, positive associations between PA of parents and their preadolescent children [26–28], as well as parent-child sedentary behaviour [29, 30], have repeatedly been observed. However, findings on parent-child relationships in PA and obesity relative to the number of children in the family are scarce. Such analysis is desirable in view of the increasing number of single-child families in economically developed countries. This study attempts to bridge the research gap with information concerning a comparison of lifestyle indicators between single-child families and families with multiple children. Therefore, the aim of this study is to find out (i) whether there are any differences in the daily SC for school/workdays and weekends and the prevalence of obesity between only children and children with siblings, (ii) what the relationship between daily SC of parents and children is, and (iii) whether the achievement of the daily SC recommendation by children/parents and parental obesity is related to obesity in children with and without siblings.

Methods

Participants and inclusion/exclusion criteria

Participants were recruited by means of two-stage stratified random sampling. In the first stage, nine out of 14 administrative regions, three of each in the lowest, middle, and highest terciles for gross domestic product in the Czech Republic, were randomly selected. In the second stage of sampling, the selection of kindergarten ($n = 10$) and primary public and private schools ($n = 41$) respected the distribution of the urban-rural population in Czechia [31].

A total of 2,389 families were addressed in writing with an invitation to participate in the cross-sectional study, of whom 65.3% agreed to take part in the research (written informed consent received). The participating children and their parents were predominantly white Caucasian ($> 98\%$), which is representative of the ethnic demographics of the Czech Republic [32]. Family dyads consisted of a mother-child or father-child couple. The participation of at least one family dyad was a necessary precondition for being included in the research. In the initial stage of the study, information meetings were held to describe the process of the research. Figure 1 provides a detailed flowchart of the inclusion of the participants in the study. The analysis included 566 families (10.6% with single child ($n = 60$) and 89.4% with children ($n = 506$)) with complete data of family members on weight status and ambulatory PA monitored with a Yamax pedometer during a regular school/work week during spring and autumn between 2013 and 2019 (Fig. 1).

Figure 1

Procedures and measurement

After recruitment and submission of a written consent, each family received a self-monitoring package including: 1) a letter describing the study design and the ethical approval, 2) a family logbook for recording anthropometric and PA data of all family members, 3) the Yamax Digiwalker SW-200 pedometers for each participating child and parent, 4) a detailed and illustrated guide describing how to

operate the pedometer, 5) an explanatory letter to the teachers/coaches about the study explaining why a pedometer is worn by children during lessons/trainings, 6) an illustrated instruction leaflet for home measurement of body weight and height of family participants.

The participants were asked to wear the pedometer attached to the right hip for 8 consecutive days for at least 8 hours per day and record daily SC and possible active participation in organized leisure-time sport in the family logbook provided along [33]. The SC data from the first day of PA monitoring were not included in the final analyses due to the novelty of wearing the pedometer, which could have affected the level of the participants' PA [34, 35]. Inclusion of participants in the analyses was subject to a record of valid PA data for at least 6 days including both weekend days. The parents and children were instructed to wear the pedometer throughout the whole day (during transportation to school/employment, during classes and breaks and during participation in organized leisure-time sport or leisure organizations) except dressing, personal hygiene, and showering/bathing. Seasonal differences sought to be eliminated by choosing spring and autumn months in weeks without excessive examinations in schools, without multi-day school holidays and public holidays. The Yamax Digiwalker SW-200 pedometer is an unobtrusive, simple, valid, and reliable quantifier of all-day ambulatory PA across a wide population of children, adolescents [34, 36] and adults [37] designed for an analysis of the relationship between daily SC and health outcomes [38].

The parents were asked to fill in anthropometric data (date of birth of child/children, age of parents, gender, body height/weight (with 0.5-cm/kg accuracy)) of all participating family members to the family logbook before the start of the 8-day SC monitoring. The parents were thoroughly instructed how to measure their own body height and weight, as well as the height and weight of their offspring according to the illustrated instruction leaflets for home measurement. Parental home measurement of children's and adolescents' body height and weight [39–42] is considered to be sufficiently valid for calculating the BMI for a subsequent identification of childhood obesity [39, 40]. The chronological age of all family members was calculated from the date of birth until the starting day of the PA monitoring.

Ethics

The study design, all procedures, measurement and method of feedback were approved by the Ethics Committee of the Faculty of Physical Culture, Palacký University Olomouc separately for families with preschool children (ref. No.: 57/2014 on 21 December 2014), families with 6–11-year-old children (ref. No.: 20/2012 on 12 December 2012) and families with 12–15-year-old adolescents (ref. No.: 14/2018 on 21 February 2018). The parents' written consent was obtained prior to the start of data collection. Parents of the children have given parental consent to participate in this study. Participation in the project was voluntary and without financial incentives.

Data management and statistical analysis

All data management and statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) for Windows, v.22 (IBM Corp. Released 2013. Armonk, NY, USA). Childhood BMI categories (normal weight, overweight or obese) were derived using the age- and gender-specific WHO

growth charts [43, 44]. Overweight and obesity in children was represented by BMI from 85th to 97th and > 97th percentile of the WHO growth charts, respectively [43, 44]. Overweight and obesity in parents was classified using a BMI from 25 kg/m² to 29.9 kg/m² and greater than or equal to 30 kg/m², respectively [45]. The daily step count variable represented the mean difference between the morning (pedometer turned on) and evening (pedometer turned off) step counts on the monitored days of the week. Daily SC values below 1,000 and above 30,000 were truncated to these recommended values, respectively [35, 46], and included in the analyses. If step counts were recorded during four weekdays, the data for the one missing weekday based on the participant's personal mean scores were added. The participants whose step count data were missing for more than one day were excluded from the analysis. The average daily SC was calculated separately for school/workdays and for weekends as the sum of the individual daily SC divided by the number of days. The daily SC recommendation was set at a value of $\geq 13,000$ / $\geq 11,000$ steps/day for 5–12-year-old sons/daughters and $\geq 10,000$ steps/day for 12–16-year-old adolescents [47] and adults [48]. The percentage of achievement of the recommended daily SC by individual family members was quantified separately for school/workdays, weekends, and the whole week. The Chi-Square (χ^2) test series was used to compare the prevalence of obesity, overweight, and normal body weight, achievement of the daily SC recommendation, and frequency of participation in organized leisure-time sport between single-child and sibling children. The One-way analysis of variance was used to compare the daily SC between single-child and sibling children, as well as their mothers and fathers. The parent-child daily SC (or BMI) relationship was quantified using Pearson's r_p correlation coefficient. Logistic regression models (Enter method) were used to investigate whether the achievement of the daily SC recommendation by children/parents and parental obesity were associated with obesity of offspring in single child families and families with siblings (separately for mother-child and father-child dyads). The results of the logistic regression analyses were expressed using the odds ratio (OR) and 95% confidence interval (95% CI). The alpha level of significance was set at the minimum value of 0.05.

Results

Children living in families with at least one sibling had a significantly higher rate of achievement of the recommended daily SC ($p < 0.01$) at weekends and on a weekly average compared with only children (Table 1). Children with siblings had a healthier body weight than children from single-child families. Especially, children with siblings showed a lower prevalence of overweight and obesity ($p < 0.01$) and, analogically, a higher proportion of normal body weight ($p < 0.05$) than only children (Table 1).

Table 1

Comparison (χ^2) of achievement of daily recommended step counts (SC)[#] and body weight levels (%) for children from single-child families and families with at least two children

Families	Meeting daily SC recommendations			Body weight level		
	week	workdays	weekends	normal	overweight	obesity
single-child (n = 60)	31.7%	46.7%	23.3%	56.7%	20.0%**	20.0%**
≥ 2 children (n = 506)	51.8%**	56.3%	43.1%**	71.1%*	16.2%	7.1%
χ^2 – Chi Square test; SC – step counts; [#] daily step counts recommendation represents ≥ 13000/≥11000 steps/day for 5–12-year-old boys/girls and ≥ 10000 steps/day for 12–16-year-old adolescents [45]; *p < 0.05, **p < 0.01						

Table 1

Children with a sibling significantly ($p < 0.05$) exceed only-children in the weekend's daily SC. Similarly, in mothers of children with siblings a significantly higher daily SC at weekends was observed compared with mothers of only-children (Fig. 2). The absence of participation in organized leisure-time sport was recorded in 40.7% of single children and 34.7% of children from families with siblings.

Figure 2

A closer relationship concerning the daily SC was revealed between parents and children with siblings on workdays and weekend days than single-child families. These closer relationships were found in both fathers and mothers (Table 2).

Table 2

Parent-child associations (r_p) in daily step counts and Body Mass Index for children from single-child families and families with two or more children

Families	Daily step counts						Body Mass Index	
	week		workdays		weekends		mother	father
	mother	father	mother	father	mother	father		
single-child (n = 60)	0.12	0.20	0.11	0.12	0.11	0.20	0.26	0.36*
≥ 2 children (n = 506)	0.23**	0.29**	0.19**	0.25**	0.27**	0.28**	0.25**	0.27**
r_p – Pearson's r_p correlation coefficient; BMI – Body Mass Index; *p < 0.05, **p < 0.01								

Table 2

Figure 3

Positive relationships between the BMI of parents and their children were found in both single-child families and families with multiple children. In addition, children from single-child families had the negative correlation between mean daily SC for week-long monitoring and BMI nearly twice as big ($r_p = -0.25$ $p < 0.05$) as children from sibling families ($r_p = -0.13$ $p < 0.01$). The achievement of the recommended daily SC by children was associated with significantly lower odds of obesity in all presented models (Fig. 3). The odds of obesity occurring in children with siblings were half that of only children; this was however significant only for mother-child dyads in the PA model not adjusted for parents' weight. An excessive body weight of mothers doubled the odds ratio of occurrence of obesity in their children (Fig. 3).

Discussion

The present study reveals the fundamental differences in the prevalence of overweight, obesity and daily PA between children with siblings and only children. Children from families with siblings have a "healthier" body weight and more often achieve the recommended all-day PA than only children. However, in all children, it was found that the odds of their obesity significantly reduced the achievement of the recommended all-day SC. In families with siblings closer relationships were found between the PA of parents and their children than in single-child families, however, higher PA of parents was not significantly associated with the chance of obesity in their offspring.

PA represented by daily SC is higher for all family members on school/working days than on weekend days, regardless of the number of children in the family. However, a greater decrease in the amount of PA on weekend days compared with school days is observed in the members of single-child families (child: -1,776 steps per day; mothers/fathers: -2,270/-764 steps per day). Although it seems that it should be easier for single-child families to organize and implement PA to a greater extent than for families with more than one child, this is not the case. This reasoning is supported by the lower correlation coefficients between parent-child daily SC found in single child families compared with families with more than one child. The school regime together with participation in organized leisure-time sports for children and paid employment regime for parents co-create all-day PA on school/working days similarly for all participants, but weekend days show a critical decrease in PA, especially among members with single-child families.

As in similar studies from Belarus [49], Canada [24] or the United States of America [25, 50], a positive relationship between the BMI of parents and their children as well as an increased risk of obesity in children in the case of their parents' obesity [24, 25, 49], has been confirmed in both single-child families and families with at least two children. Given the significantly lower chances of obesity in children achieving the recommended daily SC regardless of the number of children in the family, sufficient PA is still an effective preventive factor in the development of childhood obesity. Thus, in accordance with a previous study [51], weekend days still have underutilized potential for stimulating family PA-enhancing programmes. In addition, family PA enhancement programmes do not necessarily need to be long per occasion but regular and long-term. Even replacing 10 minutes of sedentary time in adolescents with 10 minutes moderate-to-vigorous PA (MVPA) daily has a positive effect on waist circumference reduction

(0.5-1%), and a long-term replacement of 60 minutes of sedentary time with MVPA daily exercise can bring waist circumference reduction up to 3 cm [52].

Suitable opportunities for the realization of MVPA can be seen in higher participation in organized leisure-time sport or leisure organizations, as most children declared no participation in organized leisure-time sport or interest organizations. The use of multi sports facilities and centres offering a variety of physical activities for the whole family would be a suitable complement to the increase in habitual PA in case of low admission fees. Based on the closer relationship between parent-child daily SC in families with more children, as well as the lower chance of obesity in children from families with more children than single-child families, PA-enhancing programmes with an aspiration to reduce excessive body weight of children would be encouraged by the participation of all family members, or classmates or neighbourhood children in the case of single-child families,. However, it should be noted that parental positive social control or overall parental support may be ineffective in children with higher BMI who are in need to increase their PA [53]. In addition, it is also documented that parenting style is associated with childhood obesity – authoritarian and negligent parenting is associated with increased likelihood of childhood obesity [12], while warm parenting is associated with a decline in or stable child BMI during the family-based weight control programme [54]. Therefore, from a public health perspective, it is necessary to shed light on existing parental influences on the incidence of obesity in their offspring, as well as the behaviour of family members accompanying family-based energy balance-related programmes.

Although siblings are described as the building blocks of the family structure and the key players in family dynamics [55], their role has been relatively neglected in exploring family PA and sedentary behaviour. The results of public-health related research suggest a positive influence of older siblings on the motor development of younger siblings [56, 57] and a positive factor of higher weekend MVPA [23]. Given the higher PA found in families with siblings and closer linking to the PA of their parents than in single-child families, further studies should illuminate the mediating and moderating mechanism by which parents may influence sibling PA.

Study Strengths And Limitations

The formulated conclusions reflecting the results of the study supported by its strengths must respect the methodological limitations of the study. The greatest strength of the study is the involvement of all family members in all-week monitoring of all-day PA including school hours, leisure time and both weekend days. Wearing a pedometer for at least eight hours allows relevant capture of all-day PA.

One limitation of the study is the use of a waist-worn spring-suspended pendulum pedometer. Although suspended pendulum pedometers are considered to be sufficiently valid to summarize all-day free-living PA optimally during continuous seven-day monitoring [34], they are limited in detecting the intensity or pattern of PA [36]. However, despite PA monitoring constraints, daily SC from the pedometer are a suitable, easily imaginable and interpretable marker of daily PA allowing it to be compared between children, adolescents and adults [38, 58]. Although the ideal location for accurate step determination

seems to be the ankle or foot, a waist strap fastened pedometer is accurate enough and can yield useful information on the relationship between daily SC and health outcomes (including body weight) [38]. Another possible limitation is the intentional non-inclusion of holidays or winter/summer seasons in the period of PA monitoring, which could affect the level of PA [59, 60]. However, our aim was to capture the habitual family PA regime, including both weekend days, which prevail during the school year. Finally, it is necessary to accept the possible influence of social desirability, reactivity or competitiveness in monitoring free-living PA of children and adolescents through display wearable devices. However, none of the participants was given the cut-off of the recommended daily SC, no reactivity was detected on 6 or more days of PA monitoring [35, 61], and no differences were found in SC measured using sealed and unsealed pedometers [62].

Another potential limitation could be the home measurement of body weight and height of family members. However, parental home measurement of their children's weight and height according to researchers' instruction sheets are sufficiently accurate compared with laboratory measurement [40] for subsequent BMI calculations and classification of overweight and obesity [63], for example according to the WHO percentile growth charts. Moreover, none of the family members was given the cut-off values to classify body weight levels according to the WHO percentile growth charts for obesity classification. Although this is a cross-sectional study whose design does not allow the detection of causality between input and output variables, verified theoretical models [64, 65] point to the prevailing influence of obesity/PA of parents on their child's obesity/PA, not vice versa.

Conclusions

Children from families with siblings significantly more often reach the recommended amount of daily SC at weekends and on average for the whole week and have a lower incidence of overweight and obesity than children from single-child families. Achieving the recommended amount of daily SC in children significantly reduces their chances of obesity. Children from families with siblings have a lower chance of obesity than only children, but significantly only in the mother-child model. Maternal overweight/obesity more than doubles the chance of obesity in her offspring.

Abbreviations

BMI, Body Mass Index; CI, Confidence interval; kg, kilogramme; m, metre; MVPA, Moderate-to-vigorous physical activity; OR, Odds ratio; PA, Physical activity; Ref., Reference group; r_p , Pearson's correlation coefficient; SC, Step counts; SPSS, Statistical Package for the Social Sciences; WHO, World Health Organization

Declarations

Ethics approval and consent to participate

The study design, all procedures, measurement and method of feedback were approved by the Ethics Committee of the Faculty of Physical Culture, Palacký University Olomouc separately for families with preschool children (ref. No.: 57/2014 on 21 December 2014), families with 6–11-year-old children (ref. No.: 20/2012 on 12 December 2012) and families with 12–15-year-old adolescents (ref. No.: 14/2018 on 21 February 2018). Parental written consents were obtained prior to data collection. Parents of the children have given parental consent to participate in this study. The participants were allowed to quit the monitoring at any time without being sanctioned by the investigators. A possible loss of or damage to the pedometers was not to be reimbursed by the participants. All family members with valid data were provided with individual feedback on the research results.

Consent for publication

Not applicable.

Availability of data and material

The datasets analysed during the current study are not publicly available regarding the rules for funded projects but are available from the corresponding author ES upon reasonable request.

Competing interests

The authors declare that they have no conflict of interest.

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Authors' contributions

ES conceptualized and designed the study and drafted the initial manuscript. DS carried out the data analysis and interpreted the results. DS critically read the initial manuscript and commented on all parts of the text. All authors have read and approved the manuscript.

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Figures

Figure 1

Study flow of participants and basic somatic characteristics of family members

Figure 2

Comparison of parents' and children's pedometer-determined daily step counts (mean and 95% confidence intervals) on weekdays and weekend days between family members in families with at least one sibling and single child (* $p < 0.05$ - one-way analysis of variance)

Figure 3

Association (odds ratio and 95% confidence intervals) of family lifestyle indicators with obesity of family offspring