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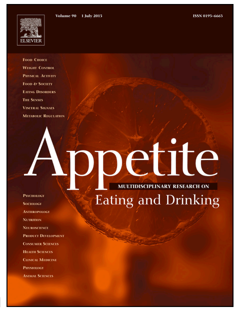

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Abstract

Background: Healthy dietary and physical activity behaviours are established early in life where children learn by observing their parents. Therefore, parents can act as role models and influence their children toward a healthier lifestyle. Besides a strong association between parental and child health behaviours, parents also influence their children's health behaviours through socio-cognitive processes, where perceived self-efficacy is the central component.

The objective was to examine if parental self-efficacy among Swedish mothers was associated with their four-year-old children's dietary and physical activity behaviours.

Methods: This cross-sectional study was based on information from control participants that took part in the Swedish primary prevention trial of childhood obesity (PRIMROSE) (n=420 mother-child pairs). Linear regression models were used to examine the associations between parental self-efficacy (Parental Self-Efficacy for Promoting Healthy Physical Activity and Dietary Behaviours in Children Scale) and children's dietary intake (parent reported) and levels of physical activity (accelerometer) with adjustments for potential confounders.

Abbreviations

AIC	Akaike Information Criterion
BMI	Body mass index
CI	Confidence interval
CPM	Counts per minute
FFQ	Food frequency questionnaire
MVPA	Moderate-to-vigorous physical activity
PA	Physical activity
PSE	Parental self-efficacy
PSEPAD	Parental Self-Efficacy for Promoting Healthy Physical Activity and Dietary Behaviours in Children Scale
SE	Perceived self-efficacy
SES	Socio-economic status
SSB	Sugar sweetened beverages
V_m	Vector magnitude

Results: Mothers' efficacy beliefs in promoting healthy dietary or physical activity behaviours in their children were associated with a slightly higher consumption of fruit and vegetables among their children (β: 0.03 [95%CI: 0.01; 0.04] P<0.001) and slightly higher levels of moderate-to-vigorous activity (β: 0.43 [95%CI: 0.05; 0.81] P=0.03). Mothers' belief in their ability to limit unhealthy dietary and physical activity behaviours was inversely associated with children's intake of unhealthy snacks (β: -0.06 [95%CI: -0.10; -0.02] P<0.01).

Conclusion: Our cross-sectional study suggests weak positive correlations between maternal self-efficacy and healthy dietary and physical activity behaviours, and weak inverse associations between maternal self-efficacy and unhealthy dietary and physical activity behaviours among their children.

Keywords: self efficacy; child; diet; physical activity; health behavior

Abbreviations

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Background

Overweight and obesity have been an increasing public health concern during the last decades (Ebbeling, Pawlak, & Ludwig, 2002; Lobstein, 2006) and is a major health concern worldwide. In total 41 million children under the age of five years were overweight or obese in 2014 (Wold Health Organization, 2016) and these numbers are expected to increase during the following years (Wold Health Organization, 2014).

Preschool children are dependent on their parents to provide them with almost all basic needs including food, entertainment and comfort (Bandura, 1997). Parents therefore act as role models and have a great potential to influence their young children's behaviour towards exhibiting a healthy lifestyle. Social-cognitive processes in parents may affect their children's health behaviours, including children's eating and PA behaviours. A central component is perceived self-efficacy (SE) which was introduced by Bandura (Bandura, 1977; Bandura, 2004). This construct refers to self-assessment of one's own ability to complete tasks and reach goals, and it has been shown to predict health behaviours (Bandura, 1997). Recently it has been suggested that parental SE (PSE) may have an important role for a positive development in health behaviours of preschool children (Scaglioni, Arrizza, Vecchi, & Tedeschi, 2011; Hodges, Smith, Tidwell, & Berry, 2013).

Whilst PSE has been shown to be associated with early feeding as well as with dietary intake or PA habits in school children, research focusing on maternal SE and health behaviours among preschool children is limited. This is particularly the case in regard to the mother's ability to promote healthy dietary and PA behaviours in the child, and regarding the potential association between her ability and food intake and PA levels in preschool children. The few existing studies report that PSE seems directly associated with children's fruit and vegetable intake (Koh et al., 2014; Campbell, Hesketh, Silverii, & Abbott, 2010) and inversely associated with children's intake of unhealthy food items (Bohman, Nyberg, Sundblom, & Elinder, 2014). Additionally, a few studies also indicate that a higher PSE seems associated with preschool children spending less time in sedentary activities (Bohman, Rasmussen, & Ghaderi, 2016; Jago, Sebire, Edwards, & Thompson, 2013; Campbell et al., 2010). Thus, PSE is potentially an important factor in the prevention of obesity among preschool children. However, the majority of previous studies relied on self-reported measures of PA, though research shows that self-reported PA does not correlate well with objective measures of PA (Kavanaugh, Moore, Hibbett, & Kaczynski, 2014). Thus, more research using objective PA measures i.e. accelerometers is needed.

In addition to a possible association between PSE and child dietary and PA behaviours, studies have shown that mothers may also influence their children's food preferences not only through feeding practices, but also through their own food preferences (Birch, 1999; Hansson et al., 2016). For example, research suggest a strong correlation between parental and child fruit and vegetable intakes (Cooke et al., 2004). This parent-child association in food intake has also been seen in relation to PA, where the child's PA level seems to reflect parental PA level (Ruiz, Gesell, Buchowski, Lambert, & Barkin, 2011). Finally, previous research has shown that children from socially disadvantaged families have a more unhealthy life style potentially also leading to an increasing risk of overweight and obesity (Danielzik, Czerwinski-Mast, Langnase, Dilba, & Muller, 2004). Therefore, maternal health behaviours and socio-economic status are potential confounders which should be taken into account when analysing the association of PSE with child dietary and PA behaviours.

The objective of the present study was therefore to examine if maternal SE, i.e. if mothers' own belief in their ability to influence their children's dietary and PA behaviours, was associated with their four-year-old children's dietary intake and levels of PA.

Methods and materials

This cross-sectional study was based on data collected from control participants that took part in the Swedish primary prevention trial of childhood obesity called "PRIMROSE" (Doring et al., 2014).

PRIMROSE

In brief, this population-based trial was initiated in 2008 and completed in 2015. It was conducted among first-time Swedish mothers visiting child health care centres in mid-Sweden. The aim was to prevent the development of obesity among Swedish preschool children by promoting healthy eating and PA. In total, 59 child health care centres from 8 Swedish counties (Stockholm, Uppsala, Södermanland, Örebro, Gävleborg, Västernorrland, Västmanland and Jämtland) participated, of which 31 were randomly allocated to an intervention arm and 28 to a control arm. The trial included 1.355 families with 1.369 young children. The design of the "PRIMROSE" trial has been described in detail elsewhere (Doring et al., 2014) (Trial registry: ISRCTN, Trial number: 16991919,).

Study population

A total of 768 control children participated in the "PRIMOSE" trial. There were 563 mothers who had valid data on SE at follow-up at age four. A further 143 children were excluded because of missing information on the specific outcomes of dietary intake and PA or because there were missing information on one of the potential confounders (counties, maternal body mass index [BMI], maternal education, child BMI, sex and maternal dietary intake and PA habits). Therefore, the analytic study population consisted of 420 mother-child pairs.

Measures

Maternal self-efficacy

Information on SE was collected at follow-up when the children were four years of age. Mothers were asked to evaluate their belief in own ability to influence their four-year-old children's dietary and PA habits. This was done using the Parental Self-Efficacy for Promoting Healthy Physical Activity and Dietary Behaviours in Children Scale (PSEPAD) (Bohman, Ghaderi, & Rasmussen, 2013). In the present study, a revised version of the PSEPAD was used (Bohman et al., 2013). The PSEPAD is a self-report measure of PSE and the revised version consists of 14 items (table 1), divided into three subscales (corresponding to factors) concerning PSE for promoting healthy dietary behaviours in children (factor 1; items 1-6), PSE for limit-setting of unhealthy dietary or PA behaviours (factor 2; items 10-14) and PSE for promoting healthy PA behaviours in children (factor 3; items 7-9). Total score ranges from 0 to 140 with a high score indicating high PSE. Factor 1: PSE for promoting healthy dietary behaviours in children with score range from 0 to 60, factor 2: PSE for limit-setting of unhealthy dietary or PA behaviours in children with score range from 0 to 50, and factor 3: PSE for promoting healthy PA behaviours in children with score range from 0 to 30.

Table 1: The revised PSEPAD items (Bohman et al., 2013)

How confident are you that you can…..?

1. Promote healthy eating habits for your child?
2. Arrange eating regular meals together in the family?
3. Restrict consumption of soft drinks by your child to no more than twice a week?
4. Make possible for your child to eat meals according to the plate model?
5. Have your child eat fruit and vegetables every day?

6. Limit visits at fast-food restaurants to maximally 1-2 times a month?
7. Get your child engaged in physical play indoors and outdoors?
8. Limit your child's inactivity in front of computer or TV?
9. Arrange opportunities for you and your child to be physically active together, for example, play outdoors?
10. Set limits for your child in everyday life, for example, the number of servings of ice creame per week or the duration your child may watch TV?

11. Set limits at visits at grandparents or other relatives, for example, about eating candy?
12. Set limits for your child if it is influenced by advertisement for unhealthy food and heavily insist that you buy something he or she has seen on TV?
13. Set limits against negative influence from your child's peers, for example, peers who may eat cookies in front of the TV at dinner time?
14. Resist your child's nagging, for example, about frequently buying candy, ice crème, cookies, ect.?

Note: PSEPAD: Parental Self-Efficacy for Promoting Healthy Physical Activity and Dietary Behaviours in Children Scale
Factor 1: PSE for promoting healthy dietary behaviours in children (items 1-6), Factor 2: PSE for limit-setting of unhealthy dietary or PA behaviours in children (items 10-14), and Factor 3: PSE for promoting healthy PA behaviours in children (items 7-9)

Dietary intake

The children's dietary intake was measured using a semi-quantitative food frequency questionnaire (FFQ) completed by the parents. The FFQ has been validated against an 8-

day food diary, with correlations in the medium to high range (Doring et al., 2014). It included information on habitual dietary intake on certain food items (fruit, vegetables, fish, French fries, sugared drinks and snacks) as well as information on regularity of meals. Possible answers on children's intake frequency of these and many other items were: how many times per month (0-3 times), week (1-6 times) or day (1, 2 or 3 or more times) (Hansson et al., 2016). Information on dietary intake was obtained only at home and not at day care. Information on "fruit and vegetables" was categorized into a single variable because the Swedish national recommendation refers to total intake per day of fruit and vegetables combined (National Food Agency, 2016). Moreover, information on soft drink, concentrated fruit syrup added to water and chocolate milk was categorized into "sugar sweetened beverages (SSB)" and savoury snacks, sweets, chocolate, pastries, cake and ice cream were categorized in to "snacks". Fruits and vegetable outcomes were presented as times per day and SSB and snacks were presented as times per week. Definition of food groups were based on recommendations from the Swedish National Food Agency, as these food items reflect diet quality and indicate unhealthy or healthy dietary patterns (Sepp, Ekelund, & Becker, 2004).

Maternal dietary intake was measured by the same questions and response categories. Information on "fruit and vegetables", "SSB", and "snacks" were categorized and presented in the same way as for the children's dietary intake.

Physical activity

PA was measured using the Actigraph GT3X+accelerometer, which has been validated in young children (Santos-Lozano et al., 2012). The accelerometer was sent by mail to the families, along with detailed information on how to use it. The children wore the accelerometer on their right hip at all wakening hours for seven consecutive days. We analysed vector magnitude (V_m) activity counts, calculated as ($VM=\sqrt{(X^2+Y^2+Z^2)}$). A pragmatic approach (Colley, Brownrigg, & Tremblay, 2012) was used to remove sleep time, where all hours between 12 a.m. and 6 a.m. were excluded from the analyses. Swedish four-year old children have previously been shown to sleep during these hours (Palmstierna, Sepa, & Ludvigsson, 2008). Non-wear time was defined as 60 consecutive minutes with no counts, allowing for two-minute interruptions with non-zero counts (Choi, Liu, Matthews, & Buchowski, 2011). The cut-off points used to categorize different intensity-levels of PA were: sedentary ≤ 820 counts per minute (cpm), light PA 821-3.907 cpm and moderate-to-vigorous PA (MVPA) ≥ 3.908 cpm (Butte et al., 2014). Measurements of PA were considered valid if children had worn the accelerometer for a minimum of three days with at least ten hours of wear time per day (Cain, Sallis, Conway, Van, & Calhoon, 2013).

Information on maternal PA level was obtained with the use of the Baecke questionnaire (Baecke, Burema, & Frijters, 1982), which covers three dimensions of PA (sports activity, leisure activity and work activity). The response options range from 1 to 5 where 1 is lowest level of activity and 5 highest level of activity. The questionnaire has been shown to have good validity when compared to energy expenditure measurement using the doubly labelled water method (Philippaerts, Westerterp, & Lefevre, 1999).

BMI

Children's and their mothers' height and weight were measured on validated scales and stadiometers by nurses at the Swedish child health care centres at follow-up and were used to calculate child and maternal BMI. For some children BMI was not measured at exactly four years of age. Growth curve modeling, using nonparametric regression (kernel smoothing) was therefore applied to estimate their BMI at that age. For pregnant women their self-reported pre-pregnancy weight was used.

Maternal Education

Information on mothers' highest level of education (proxy for socio-economic status) was reported in seven categories at baseline and categorized into two groups: primary/secondary" (preschool, primary school, upper secondary school) and "post-secondary" (higher education shorter than 3 years, higher education 3 years or more and post graduate programmes).

Ethics approval and consent to participate

Ethical approval (2006/525-31/2) was obtained from the Ethical Review Board in Stockholm, Sweden. Informed consent was obtained both from nurses and parents.

Statistical analyses

Multiple linear regression models were used to examine the associations between maternal SE (total score, scores for factors 1-3) and children's PA and dietary behaviours with adjustment for the following potential confounders; child BMI and child sex, counties, maternal BMI, maternal education, maternal dietary and PA habits. The analyses were conducted in four steps with the first model being an unadjusted model, including only the exposure (PSE) and the outcome (dietary intake and levels of PA). The second model included adjustments for counties, maternal BMI, maternal education, child BMI and child sex. A third model further investigated how maternal dietary and PA habits may influence the association between PSE and children's dietary and PA behaviour. Finally, a fourth model was added including all three PSE factors (when assessing factor 1 as an exposure, adjustments for factor 2 and 3 were included) to investigate if a combined model explained more of the variation in children's dietary and PA behaviours. To identify the "best" statistical model in the sense of a low prediction error the Akaike Information Criterion (AIC) was used and the model with the smallest AIC was chosen as the best model. Only results from the best fitting model is presented below, but additional results from all models can be found in **supplementary table 1**.

Given the small number of pregnant mothers (n=36) participating in the study, we chose to conduct a sensitivity analysis where the pregnant mothers were excluded. Furthermore, analyses of non-participants were performed to investigate if participants differed from non-participants with regard to child sex, age, BMI, PA levels, dietary intake, maternal SE, education, BMI and age.

Associations were considered statistically significant at $P<0.05$. All statistical analyses were performed using Intercooled version Stata 14.0 (StataCorp LP, College Station, Texas; www.stata.com).

Results

Children's characteristics, such as, sex, age, BMI, dietary intake and levels of PA are shown in table 2. Moreover, maternal age, maternal BMI, maternal education and PSE are also presented in table 2.

Table 2: Characteristics of the children and mothers

	n	%	Mean (SD)	Min/max
CHILDREN				
Sex	*420*			
Boys	*242*	*58*		
Girls	*178*	*42*		
Predicted BMI at 4 years (kg/m^2)	*420*		*16.1(1.5)*	*12.9/24.3*
Age (years)	*420*		*4.4(0.4)*	*3.9/6.1*
Dietary intake				
Fruit/vegetables (times/day)	*420*		*2.0(1.1)*	*0.0/6.0*
Sugar sweetened beverages (times/week)	*420*		*2.5(2.6)*	*0.0/16.0*
Snack (times/week)	*420*		*5.7(3.0)*	*0.7/22.2*
Physical activity	*420*			
Sedentary (mean min/day)	*420*		*340.8(61.9)*	*175/593.7*
Light PA (mean min/day)	*420*		*365.1(47.5)*	*197/471.8*
MVPA (mean min/day)	*420*		*50.9(20.4)*	*9.0/138.17*
Counties				
Stockholm	*111*	*26*		
Uppsala	*120*	*29*		
Sörmland	*79*	*19*		
Örebro	*42*	*10*		
Västernorrland	*20*	*5*		
Västmanland	*16*	*4*		
Jämtland	*19*	*4*		
Gävleborg	*13*	*3*		
MOTHERS				
BMI (kg/m^2)	*420*		*25.1(4.8)*	*17.3/48.1*
Age (years)	*420*		*33.4(4.7)*	*21.9/46.0*
Dietary intake				
Fruit/vegetables (times/day)	*420*		*2.4(1.3)*	*0.0/6*
Sugar sweetened beverages (times/week)	*420*		*1.8(2.6)*	*0.0/21*
Snack (times/week)	*420*		*6.3(4.3)*	*0.0/39.2*
Physical activity	*420*		*8.2(1.4)*	*4.6/12.4*
Maternal Education	*420*			
Primary/Secondary	*167*	*40*		
Post-secondary	*253*	*60*		
PSE				
Total scale[a]	*420*		*114.1(16.0)*	*32/140*
Factor 1[b]	*420*		*50.9(7.6)*	*0/60*
Factor 2[c]	*420*		*39.0(6.7)*	*16/50*
Factor 3[d]	*420*		*24.2(4.8)*	*0/30*

a: Total scale (score range from 0 to 140). b: Factor 1: PSE for promoting healthy dietary behaviours in children (score range from 0 to 60), c: Factor 2: PSE for limit-setting of unhealthy dietary or PA behaviours in children (score range from 0 to 50), d: Factor 3: PSE for promoting healthy PA behaviours in children (score range from 0 to 30).

Results showed that maternal SE for promoting healthy dietary behaviours (factor 1) was associated with a slightly higher intake of fruit and vegetables in children (β: 0.03 [95% Confidence interval (CI): 0.01; 0.04] P<0.001) (table 3). This means that each 1 score increase in maternal SE for promoting health dietary behaviours was associated with 0.03 time higher intake of fruit and vegetables per day. Furthermore, maternal SE for limit-setting of unhealthy dietary or PA behaviours in children (factor 2), was inversely associated with children's intake of snacks (β: -0.06 [95%CI: -0.10; -0.02] P<0.01), indicating that each 1 score increase in maternal SE was associated with -0.06 time lower intake of snacks. No significant associations were observed between maternal SE for limit-setting of unhealthy dietary or PA behaviours in children (factor 2) and SSB and light PA, respectively (table 3). When investigating the association between maternal SE and PA, maternal SE for promoting healthy PA behaviours in children (factor 3) was associated with slightly higher MVPA (β: 0.43 [95%CI: 0.05; 0.81] P=0.03), indicating that each 1 score increase in maternal SE was associated with 0.43 increase in MVPA. No significant associations were observed between maternal SE for promoting healthy PA behaviours in children (factor 3) and sedentary behaviour.

We found that socio-economic status, together with maternal dietary and PA behaviours did not seem to influence the association between maternal SE and child dietary intake and levels of PA (**Supplementary table 1).** However, the models including maternal dietary and PA behaviours were the best models to predict the association of maternal SE with child dietary and PA behaviours, expect for light PA (table 3). Overall the AIC analyses showed that the models containing the domain most directly related to children's behavioural outcomes were the best models to predict dietary intake and PA, respectively.

Moreover, adjusting for the two remaining factors of maternal SE did not add further to the predictive value of the models (**Supplementary table 1, model 4**). We also looked at the R-squared measure for the best model to explore how much variation the model explained. We found that for the association between factor 1 and fruit and vegetables intake, the R^2 revealed that model 3 explained 34% of the variation (0.03 [0.01; 0.04] P<0.001). Furthermore, we found that for the association between factor 2 and intake of snacks, the R^2 revealed that model 3 explained 34% of the variation (β: -0.06 [95%CI: -0.10; -0.02] P<0.01).

Sensitivity analyses conducted without pregnant women (n=36) gave essentially similar results (data not shown).

Analyses of non-participants showed slightly lower child mean age among participants (4.35 years) compared to non-participants (4.42 years) (P=0.03 (**Supplementary table 2)**). Further, a lower intake of SSB was observed among participants (2.50 times/week) compared to non- participants (3.07 times/week) (P=0.03). No statistically significant differences were observed between participants and non- participants with respect to children's sex, BMI, levels of PA and intakes of unhealthy snacks, fruit and vegetables. Moreover, no statistically significant differences were observed between participants and non- participants in relation to maternal age, BMI, education and SE (**Supplementary table 2)**.

Table 3: Association between PSE and children's dietary intake and PA level.

	PSE Total score	Factor 1[a]	Factor 2[b]	Factor 3[c]
	n=420 β [95% CI] P (AIC)			
Dietary intake				
Fruit/vegetables (times/day)[3]	*0.01 [0.01;0.02] P<0.001 (1171.17)*	*0.03 [0.01;0.04] P<0.001 (1166.02)*	*0.02 [0.004;0.04] P=0.01 (1174.86)*	*0.01 [-0.01;0.03] P=0.42 (1181.77)*
SSB (times/week)[3]	*-0.004 [-0.02;0.01] P=0.68 (1933.11)*	*-0.01 [-0.04;0.03] P=0.61 (1933.03)*	*-0.02 [-0.06;0.03] P=0.48 (1932.62)*	*0.01 [-0.04;0.07] P=0.66 (1933.12)*
Snack (times/week)[3]	*-0.01 [-0.03;0.003] P=0.11 (1959.89)*	*-0.02 [-0.05;0.02] P=0.35 (1961.56)*	*-0.06 [-0.10;-0.02] P<0.01 (1952.74)*	*0.02 [-0.03;0.06] P=0.52 (1962.15)*
Physical activity				
Sedentary (mean min/day)[3]	*-0.15 [-0.49;0.18] P=0.37 (4660.18)*	*-0.31 [-1.21;0.59] P=0.50 (4660.22)*	*-0.18 [-0.95;0.59] P=0.64 (4660.68)*	*-0.56 [-1.57;0.46] P=0.28 (4660.03)*
Light PA (mean min/day)[1]	*0.15 [-0.14;0.45] P=0.31 (4437.63)*	*0.23 [-0.30;0.75] P=0.40 (4438.21)*	*0.41 [-0.13;0.94] P=0.14 (4437.36)*	*0.34 [-0.50;1.19] P=0.43 (4438.24)*
MVPA (mean min/day)[3]	*0.07 [-0.05;0.19] P=0.25 (3688.58)*	*0.10 [-0.17;0.36] P=0.48 (3689.48)*	*0.07 [-0.20;0.34] P=0.63 (3689.84)*	*0.43 [0.05;0.81] P=0.03 (3685.25)*

Only the best models are presented. For overview of all models please see supplementary table 1.
[a]Factor 1: PSE for promoting healthy dietary behaviours in children, [b]Factor 2: PSE for limit-setting of unhealthy dietary or PA behaviours in children, [c]Factor 3: PSE for promoting healthy PA behaviours in children.
1: Model 1: Unadjusted model, only including exposure and outcome.
3: Model 3: Adjusted for counties, maternal BMI, maternal education, child BMI, sex, for maternal diet and PA habits.
The standard errors of the parameter estimates where calculated by bootstrapping.

Discussion

The present study was designed to investigate if PSE, that is mothers' own belief in their ability to influence their four-year-old children's dietary and PA behaviours, was associated with their children's dietary intake and PA level. Our findings suggest that maternal SE may be associated with children's dietary intake and PA levels, but the associations seem rather weak. Our results showed that a strong belief in the ability to promote healthy dietary behaviours was associated with slightly higher consumption of fruit and vegetables. That is, if it is possible for mothers to increase their PSE by 20 scores, this would result in an increase of about half a portion of fruit and vegetables per day in their four-year old children. A stronger belief in the ability to promote PA behaviours was also associated with a slightly higher level of MVPA. Moreover, an inverse association was seen between maternal belief in their ability to limit unhealthy dietary or PA behaviours and their children's intake of snacks.

Only a few previous studies have investigated the association between PSE and dietary and PA behaviours in preschool children, but the findings in our study are consistent with these and indicate that PSE seems associated with a higher consumption of fruit and vegetables and a lower intake of unhealthy food, such as, concentrated fruit syrup added to water and cake in children (Campbell et al., 2010; Koh et al., 2014; Bohman et al., 2014). High PSE for promoting healthy PA behaviours in children was in our study significantly associated with a higher level of child MVPA. This finding is supported by results from a previous study by Adkins et al. (Adkins, Sherwood, Story, & Davis, 2004) who found that high PSE for supporting daughters to be active was associated with high

PA of daughters (assessed by accelerometer). However, in the study by Bohman et al where PA was assessed by accelerometer, no significant association was seen between PSE and children's PA (Bohman et al., 2014). Other studies (Campbell et al., 2010; Jago et al., 2013) have shown that an increase in PSE was associated with a decline in parental reported sedentary activity. A similar tendency was also seen in our study, though the association was not significant. By contrast, a study by De and colleagues found that only very few specific parenting practices and PSE were associated with parental reported PA and screen time of their children (PA assessed by the Flemish Physical Activity Questionnaire) (De, De, I, Cardon, & Verloigne, 2015). An explanation of the inconsistent findings between studies may be the different ways of measuring PSE and dietary and PA behaviours or the use of different cut-off for levels of PA.

Overall, we consider participants from the PRIMROSE study as a homogeneous group, however, we observed that children participating in the present study were slightly younger than those not participating. In general, the children included in the analysis had a lower intake of SSB and a tendency towards a lower intake of snacks than those not included. This may indicate that the participating children were from a healthier segment than those not participating which may have led to the observed associations between maternal SE and child dietary and PA behaviours.

In general, results from previous literature suggest that there may be a direct relationship between maternal food patterns, feeding practices and her child's food preferences, for example that a high maternal fruit intake is directly correlated with her child's intake of fruit

(Cooke et al., 2004; Birch, 1999). This is in line with our results. The model which also included maternal dietary and PA habits explained 34% of the variation in children's fruit and vegetable intake. Thus, it seems important to include maternal dietary intake and PA habits when studying children's dietary intake and physical activity levels. An interesting supplement to future studies may therefore be to include mothers' SE about their own dietary behaviours and how this may influence her child's dietary intake. Furthermore, it would be interesting to investigate if these maternal factors may moderate the association under investigation.

The use of validated measures of dietary intake and PA for the children and mothers as well as maternal SE is a strength of the present study. Especially the use of objective measures of PA as previous studies are based on self-reported measurements. It is also a strength to have used the PSEPAD, which is one of few validated PSE instruments covering both dietary and PA behaviour among children. In has previously been shown that the three factors were correlated with each other (Bohman et al., 2013), which was also the case in our analyses where all factors where combined in one model. In general, the model that included all three factors did not explain more of the variation in the children's dietary intake and PA level, than when only looking at one factor at the time, indicating that in future studies including PSE, domain specific approaches may be more beneficial.

We do, however, also acknowledge some limitations to our study. For instance, even though dietary intake was assessed using a validated instrument, reporting bias cannot be excluded. Information on dietary intake was obtained by FFQ. This tool has a tendency to generally give higher estimates of diet intake compared to food records and recalls (Collins, Watson, & Burrows, 2010). Furthermore, for the foods included in our present paper except SSB, it was reported earlier that the FFQ overestimated fruit intake at higher levels of intake, while lower levels of vegetable intake was fairly well estimated (Doring et al., 2016). Moreover, mother's positive attitude to a healthy life-style might influence both her perception of her own ability to influence the child's behavior in a healthy direction and also her evaluation and reports on the child's behavior. This may have led to an inflation of the observed association between maternal SE and child dietary intake. Moreover, dietary intake was only assessed as times per day or week rather than as frequency together with amount of food consumed. This may have diluted the observed associations between maternal SE and the children's dietary behaviours and is a limitation of the present study. As children spent most of their day in daycare and information on dietary intake was obtained only at home, this may have led to an underreporting in general or of certain food items. However, since this study investigated the association between maternal SE and dietary intake we assume that missing information on dietary intake during daycare did not affect our results. PA was measured with a high-quality tri-axial accelerometer over seven days, thus accurately estimating habitual PA (Santos-Lozano et al., 2012). In addition, both the accelerometer wear protocol and data processing protocol followed best practices (De et al., 2015). The accelerometers may not have been removed at night in all children and we did not consider daytime naps in our analyses. Thus, the time when the child was sleeping outside 12 a.m. to 6 a.m. was considered sedentary time, and if the child was active at night, that activity was overlooked.

Furthermore, unmeasured factors could also be an explanation for the inconsistent results and is a limitation of the study. Research indicates that parenting style may affect children's eating behaviours (Farrow, Galloway, & Fraser, 2009; Wardle, Carnell, & Cooke, 2005; Birch, Fisher, & Davison, 2003; Jansen et al., 2012) and maternal SE may influence mothers' parenting style and the other way around (Kaplan, Sallis, & Patterson, 1993; Schaffer, 2005). Parenting style may therefore potentially confound the studied associations between maternal SE and child dietary and PA behaviours.

The PRIMROSE study only included Swedish-speaking families and previous research indicates that foreign-born parents and children have a higher prevalence of obesity than their Swedish-born counterparts (Lindstrom & Sundquist, 2005; Khanolkar, Sovio, Bartlett, Wallby, & Koupil, 2013). Moreover, the participating children were from a healthier segment than those not participating, again limiting generalisability. Therefore, the present results may not be representative of the general population of Swedish preschool children.

Our study indicates that maternal SE may play a role in establishing a healthy lifestyle among pre-school children. However, it is also important to bear in mind that our results were based on cross-sectional findings and that no causal inferences can be made. Longitudinal and intervention studies are therefore needed to clarify the exact causal relationship. If our findings can be supported in more studies, future obesity interventions might benefit from modifying maternal SE as a strategy to promote healthier dietary and PA behaviours among preschool children. However, it is important to acknowledge that dietary intake and PA habits of the child are affected by many other factors than maternal SE such as parenting style, family environment, parental dietary and PA habits, caregiver's others than parents, and thus, PSE is one of many factor in the development of healthy childhood dietary and PA behaviors.

Conclusion

In conclusion our cross-sectional study suggests weak direct correlations between PSE and healthy dietary and PA behaviours, and weak inverse correlations between SE and unhealthy dietary and PA behaviours. These findings imply that maternal SE can play a role in establishing a healthy lifestyle among pre-school children. However, more research is needed to establish a causal relationship between maternal SE and children's dietary and PA behaviours.

Availability of data and material

Data may be requested through contact with the principal investigator.

Competing interests

The authors declare that they have no competing interests.

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