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Clustering of energy balance-related behaviours and parental education in European preschool children: the ToyBox study

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Abstract

Energy balance-related behaviours (EBRB) are established in childhood and seem to persist through to adulthood. A lower parental educational level was associated with unhealthy behavioural patterns. The aim of the study is to identify clusters of EBRB and examine their association with preschool children's BMI and maternal, paternal and parental education. A subsample of the ToyBox study (*n* 5387) conducted in six European countries was used. Six behavioural clusters ('healthy diet and low activity', 'active', 'healthy lifestyle', 'high water and screen time; low fruits and vegetables (F&V) and physical activity (PA)', 'unhealthy lifestyle' and 'high F&V consumers') emerged. The healthiest group characterised by high water and F&V consumption and high PA *z* scores ('healthy lifestyle') was more prevalent among preschool children with at least one medium- or higher-educated parent and showed markedly healthier trends for all the included EBRB. In the opposite, the 'unhealthy lifestyle' cluster (characterised by high soft drinks and screen time *z* scores, and low water, F&V and PA *z* scores) was more prevalent among children with lower parental, paternal and maternal education levels. OR identified that children with lower maternal, paternal and parental education levels were less likely to be allocated in the 'healthy lifestyle' cluster and more likely to be allocated in the 'unhealthy lifestyle' cluster. The 'unhealthy lifestyle' cluster was more prevalent among children with parents in lower parental educational levels and children who were obese. Therefore, parental educational level is one of the key factors that should be considered when developing childhood obesity prevention interventions.

Key words: Clustering: Energy balance-related behaviours: Preschool children: Parental education levels

Childhood obesity is an important public health issue, as it affects health, educational attainment and long-term quality of life[1]. In addition, childhood obesity seems to track into later life[1–3]. It is estimated that 40–70 % of the variation in BMI is heritable according to classic genetic analyses[4]. Environmental contribution, however, seems to also have a major role in the obesity epidemic[5].

Weight gain has been associated with various lifestyle behaviours related to diet, physical activity (PA) and sedentary behaviours, referred to collectively as energy balance-related behaviours (EBRB)[6]. Such behaviours are established in early childhood and persist into adulthood[7–9]. A systematic review of the association between EBRB and overweight and obesity in preschool children reported a strong inverse association between total PA and being overweight and a moderate positive association between sedentary behaviour (especially television viewing) and overweight but provided insufficient evidence for the association between dietary behaviours and overweight[10]. Consumption of sugar-sweetened beverages

Abbreviations: EBRB, energy balance-related behaviours; F&V, fruits and vegetables; PA, physical activity.

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(SSB)[11] is proposed to be related to increased body weight whereas the opposite is observed for fruits and vegetables (F&V)[12,13], dairy products[14] and water consumption[15,16]. In addition, short sleep duration is associated with overweight and obesity in preschool children[17,18].

Clustering is a combination of behaviours that are more prevalent than expected from the prevalence of the separate behaviours[19]. Several studies have examined the co-occurrence or 'clustering' of EBRB in school-aged children and adolescents[20], but evidence in younger children is scarce. Dietary clusters were reported in 2- to 3-year-old children from low-income US families[21] and in 4-year-old children of south-west England[22], reflecting behavioural combinations that contribute either positively or negatively to the energy balance. An inverse association between television viewing and time spent being physically active was found in 3- and 4-year-old American children[23].

Few studies have examined cross-behavioural clustering (dietary intake and PA) in preschool European children[24–26]. Lioret *et al.*[24] reported 2 EBRB clusters in 3- to 6-year-old children, namely, the 'varied food and physically active' and the 'snacking and sedentary' pattern. Gubbels *et al.*[25] reported the 'sedentary-snacking' cluster, characterised by high screen time, snacking and SSB consumption, and the 'fibre' cluster, composed of vegetables, fresh fruits, and brown bread consumption in 5-year-old children. Recently, Leech *et al.*[26] identified three clusters (the 'most healthy', the 'energy-dense consumers who watch television' and the 'high sedentary behaviour/low moderate-to-vigorous PA) in a study of Australian children aged 5–6. In addition, a study of children from eight European countries identified six clusters. A high proportion of children with low socio-economic status were allocated in the cluster with the highest SSB consumption. In addition, children in the clusters with the highest mean sedentary time had statistically significant higher BMI[27]. In the same direction, Fernandez-Alvira *et al.*[28] found that clusters with high sugared drinks consumption, high screen time and low sleep duration were more prevalent in the group of children with lower educated parents. There are also studies addressing clusters of eating routines, in addition to various dietary intake behaviours. Specifically, Gubbels *et al.*[29] reported four lifestyle patterns in 5-year-old children in the Netherlands, such as the 'television – snacking', the 'sports – computer', the 'fast food' and the 'traditional family' patterns, whereas Kontogianni *et al.*[30] reported a pattern (characterised by high breakfast consumption and high eating frequency in children, in combination with a Mediterranean diet) that was negatively associated with BMI in Greek children and adolescents aged 3–18 years.

Dietary and PA habits are established in early childhood and may persist through to adulthood[7,8], and the same seems to apply with sedentary behaviours[9]. However, there is limited research on the clustering of EBRB in children younger than 5 years. Moreover, several EBRBs' patterns have been associated with various background characteristics. Specifically, a low parental educational level is positively associated with unhealthy behavioural patterns and negatively with healthy patterns[22,25,26,29]. Thus, in order to prevent obesity, it is important to identify the related behavioural patterns already in early childhood and understand how these clusters differ by socio-demographic indicators. The aim of the study was to identify cross-behavioural clusters of EBRB and explore their association with parental education and child's BMI in a sample of preschool children of 6 European countries (Belgium, Bulgaria, Germany, Greece, Poland and Spain) participating in the ToyBox study.

Methods

Study design

The ToyBox study (www.toybox-study.eu) is a cluster-randomised study aiming to prevent overweight and obesity in preschool children from six European countries, namely, Belgium, Bulgaria, Germany, Greece, Poland and Spain[31]. The ToyBox intervention targeted four lifestyle behaviours: water consumption, healthy snacking (promoting water and F&V consumption), PA and limiting/interrupting their sedentary behaviour by improving children's physical and social environment both at the kindergarten and at home[31]. Recruitment and baseline data collection occurred from May 2012 until June 2012. In total, 309 kindergartens and 7056 children aged 3·5–5·5 years were recruited[32]. In this study, 5387 preschool children were included, which were the children for which all required questions were completed. All questionnaires were completed by parents/legal guardians who gave written informed consent. Ethics approval was obtained from the research ethics authority of each participating centre: in Belgium, by the Medical Ethics Committee of the Ghent University Hospital; in Bulgaria, by the Ethics Committee of the Medical University of Varna; in Germany, by the Ethics Committee of the Ludwig Maximilian University of Munich; in Greece, by the Bioethics Committee of Harokopio University and the Greek Ministry of Education; in Poland, by the Bioethics Committee of the Children's Memorial Health Institute and the Department of Information and Publicity of the Polish Ministry of Education; and in Spain, by the Clinical Research Ethics Committee and the Department of Consumers' Health of the Government of Aragón.

Data collection

Information regarding preschool children's EBRB (questions regarding PA, screen time and sleep time), socio-demographic and socio-economic characteristics were obtained via the primary caregivers' questionnaire specifically developed and tested for the purposes of the study[33,34].

Socio-economic variables

The questionnaire included a set of indicators/determinants out of which educational level, in particular, maternal educational level, was identified as one of the best proxy indicators of socio-economic status[35]. Maternal and paternal education levels (the years of education) were obtained as five categories: <7 years, 7–12 years, 13–14 years, 15–16 years and more than 16 years of education. Thereafter, the variables were

re-categorised into three categories: <7–12 years, 13–16 years and more than 16 years of education. Parental education was considered as the highest education level of both parents.

Anthropometric measures

Anthropometric measures were performed by trained researchers according to standardised protocols[34]. Body weight was measured in underwear and without shoes using an electronic scale (Type SECA 861 or SECA 813) to the nearest 0·1 kg, and body height was measured with a telescopic height instrument (Type SECA 225 or SECA 214) to the nearest 0·1 cm. The intra- and inter-observer reliability for weight and height was excellent (>99 and 98 %) in all participating countries[36]. BMI (kg/m^2) was calculated[37].

Diet assessment

Food and beverage consumption was assessed using a 37-item semi-quantitative FFQ[34]. The questionnaire was based on a previously developed and validated FFQ for Flemish preschool children by Huybrechts *et al.*[38] and was adapted and validated for the purposes of the ToyBox study. Low-moderate relative validity was observed, which varied by food and beverage group (0·52–0·79), and estimate correlations ranged; however, for some of the 'key' foods/drinks targeted in the ToyBox intervention (e.g. water and soft drinks), the validity was good (unpublished results). In the current study, three food groups/items, reflecting the aims of the study, were selected and analysed: 1 – water, 2 – sugar-sweetened and light beverages (soft drinks), and 3 – F&V consumption, expressed in portions per d. The selection of these food groups was based on the fact that they are some of the goals of the ToyBox intervention.

Physical activity

PA was assessed by a questionnaire and pedometers. However, in this study, only PA assessed via sports participation (number of hours per week that children participated in one or two sports) was included. The assessment of PA through 'sports participation' was identified in previous European studies as showing the highest correlation with the moderate-to-vigorous PA as measured with accelerometers[39].

Screen time

Screen time (i.e. television and computer time) was assessed, both for week and weekend days, by two questions: (1) minutes spent watching television (including video and DVD) and (2) minutes spent on computer activities per day. Responses included were 'never', '<30 min/d', '30 min to 1 h/d', '1–2 h/d', '3–4 h/d', '5–6 h/d', '7–8 h/d', '8 h/d' and 'more than 8 h/d'. To obtain the daily screen time, the average minutes per day, both for week and weekend days, were summed up and divided by 7 d.

Sleep duration

Parents reported the number of hours and minutes the child slept per night on average; they were reported separately for weekdays and weekend days and were then summed up and divided by 7 d to calculate average daily sleep duration.

Statistical analysis

All statistical analyses were performed using the Predictive Analytics Software (IBM SPSS Statistics for Windows) version 20. The analyses were done with the overall sample due to the lack of sex differences analysed using a t test for continuous variables and χ^2 test for categorical variables. The EBRB variables (soft drinks, F&V, water intake, PA, screen time and sleep duration) were chosen because they were the key messages in the ToyBox intervention objective in order to promote water, F&V consumption, PA and limit/interrupt the sedentary behaviour. Before clustering, the variables were standardized into their z scores. A combination of hierarchical method and k-means cluster analysis was used to identify clusters with similar lifestyle behaviours[40]. In the first step, a hierarchical cluster analysis was carried out using Ward's method based on the Euclidean distances. As Ward's method is sensitive to the influence of univariate outliers (more than 3 SD), extreme values were omitted from the subsequent analyses; additionally, individuals with multivariate outliers (high Mahalanobis values) were omitted. We performed Ward's method to obtain clusters of a meaningful size. In the second step, an iterative non-hierarchical cluster k-means clustering procedure was applied in which initial cluster centres based on Ward's hierarchical method were used as non-random starting points. To examine the stability of the obtained clusters, the sample was randomly split into halves and the full two-step procedure (Ward, followed by k-means) was then applied to each half. The elements of each half of the sample were assigned to a new cluster based on their Euclidean distances to the clusters centres of the other half of the sample. These new clusters were then compared for agreement with the original by means of Cohen's κ[41] and excellent concordance was found (Cohen's κ values = 0·95). Analysis of variance tests with *post hoc* Bonferroni tests were used to investigate differences between each cluster on all indices adjusted for child's BMI and maternal and paternal education. χ^2 tests were performed to investigate differences in cluster distribution by country, child's BMI category, and maternal and paternal education level. Odds ratios for specific clusters of maternal, paternal and parental education levels were also calculated (adjusting for age, sex and child's BMI). All statistical tests and corresponding P values lower than 0·05 were considered statistically significant.

Results

Table 1 shows the characteristics of the study population (n 5387). The mean age of the participants was 4·7 (SD 0·4) years. Approximately 35·3 % of the mothers and 29·8 % of the fathers were allocated in the high educational level; 41·9 % of the parents were allocated in the high educational level when considering their highest education attainment. The prevalence of overweight and obesity in studied preschool children were 10·2 and 3·6 %, respectively.

Fig. 1 presents the six EBRB clusters (mean z scores) derived from the cluster analysis. Cluster 1 was labelled 'healthy diet

Table 1. Descriptive characteristics of the total sample (Mean values and standard deviations; numbers and percentages)

	Mean/*n*	SD/%
Age (years)	4·74	0·44
Sex		
Boys	2826	51
Girls	2561	49
BMI status (kg/m^2)*		
Normal weight	4179	86·0
Overweight	514	10·2
Obesity	143	3·6
Maternal education (years)		
<7–12	1383	18·7
13–16	3055	41·3
>16	2607	35·3
Paternal education (years)		
<7–12	1873	25·4
13–16	2750	37·2
>16	2205	29·8
Parental education (years)		
<7–12	1153	23·7
13–16	2960	40·1
>16	3095	41·9
Country		
Belgium	1263	17·1
Bulgaria	917	12·4
Germany	1276	17·3
Greece	1768	23·9
Poland	1345	18·2
Spain	820	11·1

* BMI according to Cole's cut-off[37].

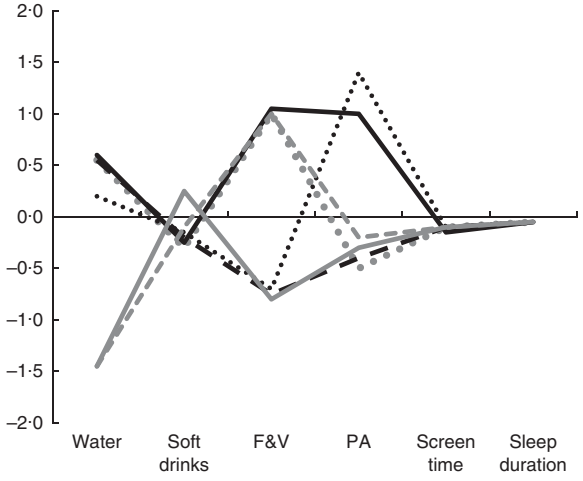

Fig. 1. Standard deviation scores of clusters on energy balance-related behaviours in boys and girls participating in the ToyBox study. F&V, fruits and vegetables; PA, physical activity; ····, Healthy diet and low activity; ·····, active; ——, healthy lifestyle; — —, high water and screen time; low F&V & PA; ——, unhealthy lifestyle; – – –, high F&V consumers.

and low activity', and it was characterised by high water and F&V z scores and low PA z scores. Cluster 2, labelled 'active', had high PA and water z scores and very low F&V z scores. Cluster 3 was labelled 'healthy lifestyle' and was characterised by high water, F&V, PA and sleep time z scores and low soft drinks and low screen time z scores. Cluster 4 was labelled 'high water and screen time; low F&V & PA' with high water z scores and screen time z scores combined with low F&V and PA. Cluster 5 was labelled 'Unhealthy lifestyle' as it was characterised by high soft drinks and screen time z scores, combined with low F&V, water and PA z score. Finally, cluster 6 was named 'high F&V consumers' as it was characterised by high F&V z scores and low water and low z scores of PA.

Table 2 presents the means and standard deviations of EBRB for each cluster. The smallest consumption of soft drinks was observed in the 'healthy lifestyle' cluster (cluster 3) and the highest was in cluster 5 ('unhealthy lifestyle'). All clusters were characterised by increased screen time, with the highest in the cluster 5.

Associations between the six clusters and socio-demographic variables (country, BMI and maternal, paternal and parental education level) are presented in Table 3. Significant differences in EBRB clusters were found by country, maternal and paternal education level. Moreover, the highest proportion of preschool children with increased F&V consumption (cluster 6) was observed in Germany, whereas in Greece, the highest proportion of increased water intake was observed (clusters 2 and 4). The majority of participants with low and medium parental education (17·7 and 43·2 %, respectively) were allocated in the unhealthy lifestyle cluster (cluster 5).

After exploring the associations of sex, country and BMI with the cluster distribution, OR were calculated for being allocated in a specific cluster by parental education level, adjusted for the other socio-demographic characteristics (Table 4). The results showed that preschool children with lower maternal, paternal, and parental education levels (OR: 0·55; 95 % CI 0·40, 0·75; OR 0·56; 95 % CI 0·43, 0·73; OR 0·48; 95 % CI 0·34, 0·68, respectively) were significantly less likely to be allocated in the healthy lifestyle cluster than those children with higher maternal, paternal, and parental education levels.

In the same direction, preschool children with lower maternal, paternal, and parental education levels (OR 1·55; 95 % CI 1·23, 1·96; OR 1·58; 95 % CI 1·25, 1·99; OR 1·70; 95 % CI 1·32, 2·16, respectively) were significantly more likely to be allocated in the unhealthy lifestyle cluster than those children with higher maternal, paternal, and parental education levels. Preschool children with medium maternal education level were also significantly more likely to be allocated in the cluster characterised by high consumption of water and low F&V (OR 1·52; 95 % CI 1·21, 1·91) than those children with higher maternal, paternal and parental education levels. In addition, preschool children with medium paternal and parental education levels (OR 1·52; 95 % CI 1·23, 1·88; OR 1·36; 95 % CI 1·13, 1·64, respectively) were significantly more likely to be allocated in the unhealthy cluster than those children with higher maternal, paternal and parental education levels.

Discussion

Six cross-behavioural clusters emerged in this study of preschool children participating in the ToyBox study. To the author's knowledge, this is the first study to identify cross-behavioural clusters of dietary behaviours, PA, sedentary behaviours and sleep duration in European preschool children.

The 'healthy lifestyle' cluster, characterised by high water and F&V intake, high PA and sleep duration, and low soft drinks

Table 2. Energy balance-related behaviours (EBRB) in the final clusters (C) obtained, ANOVA and results of Bonferroni test adjusted by maternal and paternal education and BMI
(Mean values and *z* Scores with their standard errors)

	Healthy diet and low activity (C1)		Active (C2)		Healthy lifestyle (C3)		High water and screen time; low F&V and PA (C4)		Unhealthy lifestyle (C5)		High F&V consumers (C6)		
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	*F*
Water (portions/d)	4·34	0·74	3·74	1·24	4·37	0·75	4·28	0·75	1·21	0·44	1·20	0·46	2 674 509*
z Score	0·57		0·19		0·59		0·54		−1·41		−1·42		
SE	0·47		0·79		0·47		0·47		0·28		0·29		
Soft drinks (portions/d)†	0·41	0·02	0·52	0·03	0·40	0·03	0·45	0·02	0·78	0·03	0·64	0·03	29 994*
z Score	−0·23		−0·10		−0·27		−0·15		0·16		0·06		
SE	0·11		0·19		0·43		0·07		0·15		0·18		
F&V (portions/d)	4·11	0·74	1·38	0·38	4·12	0·74	1·28	0·34	1·26	0·36	4·12	0·74	4973 593*
z Score	0·98		−0·79		0·99		−0·86		−0·87		0·99		
SE	0·48		0·25		0·48		0·22		0·24		0·48		
PA (min/d)	0·23	0·85	17·22	0·96	14·00	0·98	0·60	0·06	2·00	0·35	3·00	5·60	1930 091*
z Score	−0·51		1·41		1·03		−0·46		−0·31		−0·20		
SE	0·09		0·66		0·67		0·23		0·19		0·15		
Screen time (min/d)	103·74	0·47	104·00	2·82	84·00	2·73	116·00	1·98	127·00	2·88	110	1·71	15 212*
z Score	−0·06		−0·06		−0·07		−0·06		−0·06		−0·06		
SE	0·01		0·01		0·01		0·01		0·01		0·01		
Sleep duration (h/d)	9·89	0·07	9·87	0·04	10·00	0·04	9·80	0·16	9·91	0·15	9·88	0·02	4451*
z Score	−0·25		−0·25		−0·25		−0·25		−0·25		−0·25		
SE	0·01		0·01		0·01		0·01		0·01		0·01		

F&V, fruits and vegetables; PA, physical activity.
* $P < 0·001$ ANOVA and Bonferroni *post hoc* test, adjusted by maternal, paternal education and BMI.
† Sugar-sweetened and light beverages (soft drinks).

Table 3. Socio-demographic characteristics by cluster solution in boys and girls participating in the ToyBox study

	n	Healthy diet and low activity (%)	Active (%)	Healthy lifestyle (%)	High water and screen time; low F&V and PA (%)	Unhealthy lifestyle (%)	High F&V consumers (%)	χ^2
Country								
Belgium	821	14·9	17·7	14·9	19·3	25·6	15·4	701 184*
Bulgaria	623	16·2	10·9	9·6	13·5	15·9	12·5	
Germany	778	14·8	22·3	35·3	11·8	13·3	27·2	
Greece	700	11·9	28·9	12·9	21·8	10·3	4·1	
Poland	919	22·8	4·5	7·8	15·1	27·4	24·4	
Spain	712	19·4	15·7	19·5	18·5	7·6	6·4	
BMI status (kg/m^2)†								
Normal weight	3764	88·0	86·7	84·2	86·8	85·3	85·4	11 121
Overweight	461	9·4	11·0	12·8	9·7	11·0	12·4	
Obesity	131	2·6	2·4	3·0	3·5	3·8	2·2	
Maternal education (years)								
<7–12	781	14·4	16·5	12·5	21·5	22·9	14·4	116 803*
13–16	1861	41	50·4	43·4	44	41·9	32·4	
>16	1765	44·0	33·0	44·6	34·5	35·2	52·2	
Paternal education (years)								
<7–12	1092	23·3	20	18·5	27·9	29·4	19·7	116 715*
13–16	1714	35·8	43·2	36·7	39·8	44	34	
>16	1477	38·0	32·6	40·3	26·8	25·4	44·0	
Parental education (years)								
<7–12	728	11·4	11·6	8·5	17·2	17·7	12·1	127 125*
13–16	1789	36·3	41·5	37·2	42	43·2	27·7	
>16	2070	51·1	41·8	52	39·4	37·5	51·2	

F&V, fruits and vegetables; PA, physical activity.
* $P < 0·001$.
† BMI according to Cole's cut-offs[36].

intake and screen time, was observed in 17 % of the sample. To our knowledge, such pattern has not been previously identified in European preschool children. In a previous study of children aged 2–9 years, the 'healthy' cluster was characterised by high F&V and low SSB consumption and low time spent in sedentary behaviours; however, participation in sports activities was

Table 4. Logistic regression analyses between clusters of energy balance-related behaviours and education level in boys and girls participating in the ToyBox study†
(Odds ratios and 95 % confidence intervals)

	Low		Medium		
	OR	95 % CI	OR	95 % CI	High
Maternal education					
Healthy diet and low activity	0·68*	0·55, 0·84	0·86	0·74, 1·03	Ref.
Active	1·10	0·80, 1·40	1·52*	1·21, 1·91	Ref.
Healthy lifestyle	0·55*	0·40, 0·75	0·86	0·70, 1·06	Ref.
High water and screen time; low F&V and PA	1·66*	1·37, 2·00	1·31*	1·13, 1·52	Ref.
Unhealthy lifestyle	1·55*	1·23, 1·96	1·14	0·94, 1·38	Ref.
High F&V consumers	0·65*	0·49, 0·86	0·55*	0·44, 0·68	Ref.
Paternal education					
Healthy diet and low activity	0·82*	0·68, 0·99	0·80*	0·68, 0·94	Ref.
Active	0·75	0·57, 1·00	1·14	0·90, 1·45	Ref.
Healthy lifestyle	0·56*	0·43, 0·73	0·74*	0·60, 0·92	Ref.
High water and screen time; low F&V and PA	1·82*	1·52, 2·17	1·40*	1·19, 1·65	Ref.
Unhealthy lifestyle	1·58*	1·25, 1·99	1·52*	1·23, 1·88	Ref.
High F&V consumers	0·57*	0·54, 0·74	0·62*	0·50, 0·77	Ref.
Parental education					
Healthy diet and low activity	0·68*	0·54, 0·85	0·80*	0·69, 0·93	Ref.
Active	0·82	0·58, 1·15	1·30*	1·05, 1·62	Ref.
Healthy lifestyle	0·48*	0·34, 0·68	0·76*	0·62, 0·93	Ref.
High water; low screen time and F&V and PA	1·73*	1·43, 2·11	1·33*	1·15, 1·54	Ref.
Unhealthy lifestyle	1·70*	1·32, 2·16	1·36*	1·13, 1·64	Ref.
High F&V consumers	0·72*	0·53, 0·96	0·63*	0·51, 0·77	Ref.

F&V, fruits and vegetables; PA, physical activity; Ref., reference group: high maternal, paternal and parental education, respectively.
* $P < 0·001$.
† Analysis adjusted by BMI, sex, age and country.

low[27], and it did not include sleep duration as a variable. Moreover, Fernandez-Alvira *et al.* reported a similar cluster in older school children, aged 10–12 years, labelled the 'Active' cluster[28] characterised by *z* scores above 0 for PA and *z* scores below 0 for soft drink consumption and screen time. None of these studies assessed water consumption as in our study and furthermore, our cluster demonstrated notably healthy trends for all the included EBRB.

Our results showed that preschool children with a lower parental education level were more likely to be allocated in the 'unhealthy lifestyle' and 'high water & screen time; low F&V & PA' clusters. Apart from high water consumption, the remainder of the EBRB, as well as the associations with the different socio-economic indicators, were similar between both clusters. Similar results were found in other studies examining the effect of parental educational level on EBRB clusters in preschool children[22,25,29]. Northstone & Emmett[22] found that a 'junk' diet (high in high-fat processed foods) and snack foods (high in fat and/or sugar) were positively associated with decreasing levels of maternal education in young children. Results from the Child, Parent and Health: Lifestyle and Genetic Constitution (KOALA) Birth Cohort Study of 2-year-old children showed that low and medium maternal education levels were associated with high scores of the 'sedentary-snacking' cluster[25]. Similar to our study, Gubbels *et al.*[29] assessed both paternal and maternal education levels in relation to the clustering of activity-related behaviours and eating routines in 5-year-old children. They reported that both maternal and paternal educational levels were inversely associated with the 'television – snacking pattern' and a negative association existed between low paternal educational level and the 'sports – computer pattern' cluster. Unlike our study, however, this analysis did not consider the intake of specific food groups or sleep duration.

Parents seem to have a crucial role in the lives of preschool children, controlling the availability of food, determining food intake and activity patterns and being role models, thus influencing preschool children's EBRB and weight gain[42]. Low parental education level, either parental or maternal, seems to be associated with more unhealthy lifestyles in preschool children, whereas when examining parental and maternal education level separately, higher maternal education level seems to be related to healthier eating habits, whereas higher paternal educational level is mainly associated with high PA level. Our findings still need to be interpreted with caution, accounting for the country-specific representation.

Our findings are in line with findings in slightly older school children and adolescents[20,28]. The review by Leech *et al.* examined the clustering of diet, PA and sedentary behaviours in children and adolescents aged 5–18 years. Cluster patterns characterised by high PA/sports participation were significantly associated with a higher level of parental education, whereas high sedentary behaviours clusters were associated with low parental education[20]. A study of 10- to 12-year-old children[28] reported that children of highly educated parents were more likely to be allocated in the cluster with high PA level, whereas clusters with high sugared drinks consumption, high screen time and low sleep duration were more prevalent in the group with lower educated parents. Such findings could suggest that the relationship between clustering of EBRB and parental education possibly tracks into later life.

Moreover, we assessed the potential association of the clusters with preschool children's BMI status. Our findings showed that the 'unhealthy lifestyle' pattern was more prevalent

in obese preschool children, which could indicate that unhealthy behaviours affect children's weight status. Previous studies have also suggested that patterns characterised by high television and snacking behaviour[16,29], as well as patterns mainly characterised by high consumption of noncarbonated sweetened beverages, high sedentary behaviour and low consumption of water, are positively associated with being overweight in children 3–6 years old[24]. In the contrary, no association was found in the study of Gubbels *et al.*[25]. In addition, boys participating in the IDEFICS study had increased odds of high BMI *z* scores when in the cluster with the highest time spent in sedentary activities and low PA[27]. In older school children, the results are inconsistent, with some studies suggesting a higher prevalence of overweight/obesity in unhealthy clusters, whereas other studies reporting no association[20]. It is worth mentioning that in the study of Fernandez-Alvira *et al.* the highest proportion of overweight and obese children were in the cluster characterised by both low sleep duration and low PA[28]. Our data concur with the last systematic analysis[43] where the overweight and obesity prevalence in Europe was relatively low in this population in comparison with North America.

Moreira *et al.*[44] in a study performed in children (5–10 years old) reported that television viewing, lower maternal education and lower sleep duration were positively associated with a dietary pattern that included fat and sugar-rich foods. In a systematic review performed by Leech *et al.*[20], several studies were identified where cluster patterns characterised by high PA/sports participation were significantly associated with a high parental education level. Meanwhile, high sedentary behaviour clusters were associated with low parental education. In addition, there is evidence suggesting an association between low parental SES and being overweight in children[43,44]. Parents of low SES children from Belgium, Germany and Spain, reported more hours of television viewing compared with parents of medium/high SES. One possible explanation could be based on the fact that parents of low SES had no rules regarding watching television. For this reason, it is important to inform how their rules about sedentary time could impact their children's health. Alternatives for television viewing, setting rules, turning off the television or encouraging children to participate in organised sports activities should be proposed for changing the amount of television viewing.

The main strengths of our study include a large pool of examined EBRB in a large sample of preschool children from six European countries, collected using standardised and harmonised data collection procedures[34] and reliable and validated questionnaires[33]. In addition, the study population was at a critical period regarding lifestyle habit acquisition. In addition, the use of cluster analysis provides a global view of preschool children's behaviours that are very critical at this young age.

However, our study has some limitations that may hamper the generalisation of the results. Information regarding preschool children's EBRB was provided by their parents or caregivers based on self-reported questionnaires, which, although prone to over- or under-reporting, has been shown to provide acceptably accurate and reliable data concerning children's dietary and lifestyle information[45]. Moreover, given the cross-sectional nature of this study, it does not allow the establishment of causal relationships but only associations. The authors are aware that a number of socio-demographic and lifestyle variables and factors could affect observations.

Conclusion

This is the first study providing insights into EBRB clustering in European preschool children. Further longitudinal analysis is needed to confirm whether our results track into later life and is replicated in other populations. These results have important implications not only for future research but also for public health strategies. Specifically, the development of lifestyle intervention strategies targeting low SES population groups could possibly help to prevent chronic diseases as obesity in children. The lifestyle behaviours have been linked with the SES background; for this reason, social and political efforts should be oriented to the most unfavourable SES families. Current evidence can be used to provide information for school policies and interventions targeting the school environment.

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