International Journal of Obesity (2010) 34, 1480–1486

0307-0565/10
www.nature.com/ijo

PEDIATRIC HIGHLIGHT

Child-care use and the association with body mass index and overweight in children from 7 months to 2 years of age

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Objectives: Studies regarding the association of child-care use with body mass index (BMI), overweight or obesity development show contradictory results. This study examined the relationship between child-care use and BMI *z*-scores and overweight, as well as associates of child-care use in children up to 2 years old.
Methods: Longitudinal data originated from the Dutch KOALA Birth Cohort Study. Questionnaires assessed child-care use at ages 7 months and 1 and 2 years ($N = 2396$). Height and weight assessed at 1 and 2 years were used to calculate BMI *z*-scores. Overweight was defined as a BMI *z*-score of $\geqslant$85th percentile. The influence of child-care use on weight development was tested using backward linear and logistic regression analyses. Outcomes were: (1) BMI *z*-score at 1 and 2 years; (2) change in BMI *z*-score between 1 and 2 years; (3) overweight vs non-overweight at 1 and 2 years; and (4) change from normal weight to overweight vs remaining normal weight between 1 and 2 years. The association between child-care use and parental background characteristics was tested using backward logistic regression analyses.
Results: Child-care use (no/yes) at 1 and 2 years positively predicted BMI *z*-scores at age 2 years, as well as change in BMI *z*-score between 1 and 2 years. These associations were adjusted for various covariates (for example, parental working hours). Furthermore, child-care use significantly increased the odds of being overweight at age 1year. There were few differences in BMI or overweight between intensive (>16 h per week) and limited child-care use ($\leqslant 16$ h). Child-care use was positively associated with various parental characteristics, including parental working hours and maternal educational level.
Conclusion: The findings suggest a small influence of child-care use on weight development in very young children. The child-care setting could have an important role in preventive interventions against overweight and obesity development in young children.
International Journal of Obesity (2010) **34,** 1480–1486; doi:10.1038/ijo.2010.100; published online 25 May 2010

Keywords: child care; day care; kindergarten; overweight; parent; preschool child

Introduction

Childhood overweight prevalence is increasing globally.[1] Overweight children are at risk for various chronic conditions, such as cardiovascular diseases and type 2 diabetes mellitus.[2] Moreover, they often develop into overweight or obese adolescents and adults.[3,4] Among the most important determinants of childhood overweight development are an unhealthy diet and low levels of physical activity.[5] Dietary and physical activity habits are often formed at a young age, and once established, are mostly maintained throughout life.[6,7]

Child care is a setting in which young children today spend increasing amounts of time. In Europe, a quarter of the infants and over three-quarters of the children up to school age attend some form of child care or education facilities.[8,9] This setting could therefore potentially have an

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Received 10 November 2009; revised 10 March 2010; accepted 17 March 2010; published online 25 May 2010

important role in the prevention of overweight and obesity development in young children.[10] Previous research has underlined the influence of the child-care setting on both dietary intake[11,12] and physical activity among children.[13,14] However, studies examining the relation between child-care use and overweight or obesity have been scarce, and have shown mixed results. A recent study by Benjamin *et al*.[15] found that adiposity at ages 1 and 3 years was significantly and positively related to child-care use during the first 6 months of life. Kim and Peterson[16] found that child care by a relative, but not centre-based or non-relative child care, was associated with significantly more weight gain in the first 9 months of life when compared with no child care. Another study found that obesity at kindergarten entry was predicted by previous child-care use, with children attending at least 10 h of child care a week more often being overweight than those who attended child care for <10 h a week.[17] In contrast, Lumeng *et al*.[18,19] indicated that child-care use was protective against overweight and obesity, although this protective effect was only present with limited child-care use (<15 h a week). Extensive child-care use ($\geqslant 15$ h a week) did not result in a significant difference in overweight compared with no child-care use.[19] Other studies found no significant relation between child-care use and either childhood or adult body mass index (BMI) and overweight.[20–22]

Child-care use, in turn, has been found to be predicted by several parental factors, including higher income,[19] longer duration of employment[23] and higher educational level.[22–24] More child-care use was also associated with a more stimulating and supporting home environment.[19,23] Other factors that predicted child-care use were residential environment (with more child-care use in towns and cities compared with villages),[22] ethnicity[19] and family structure (less use of child-care with an increasing number of siblings).[22–24] Because of these many associates of child-care use, disentangling the effect of child-care use on overweight development requires longitudinal analysis, controlling for these background variables.

In this study, we examined the longitudinal influence of child-care use on subsequent weight development up to the age of 2 years, controlled for various relevant covariates. Outcomes were: (1) BMI *z*-score at 1 and 2 years of age; (2) the change in BMI *z*-score between ages 1 and 2 years; (3) overweight vs non-overweight at age 1 and 2 years; and (4) change from normal weight to overweight vs remaining normal weight between 1 and 2 years of age. In addition, we examined associates of child-care use in children aged between 7 months and 2 years, to identify which parents take their child to child care instead of caring for them at home.

Materials and methods

Respondents and procedure

The KOALA Birth Cohort Study is a prospective cohort study in the Netherlands, which started in the year 2000. KOALA is the Dutch acronym for Child, Parent and Health: Lifestyle and Genetic Constitution. Healthy pregnant women participating in a study of pregnancy-related pelvic girdle pain were recruited at 34 weeks of gestation for the study (conventional recruitment group). In addition, women were recruited through 'alternative lifestyle' recruitment channels (for example, anthroposophist midwives and general practitioners, Steiner schools and organic food shops).[25] This alternative recruitment group (17.3%) had an alternative lifestyle in terms of aspects such as dietary habits (for example, using organic foods) or child rearing, and we further refer to this group using the variable 'parental alternative lifestyle'. Written informed consent was obtained from all participants, and ethical approval was obtained from the Maastricht University/University Hospital Maastricht medical ethics committee. In total, 2834 women participated, and completed questionnaires during pregnancy and after their child was born.

Questionnaires

Questionnaires at several ages were used to assess various characteristics of the children and their parents. In this study, data of questionnaires at the ages of 7 months and 1 and 2 years were analysed. The total number of questionnaires returned was 2614 (91.9%) at 7 months, 2566 (90.2%) at 1 year and 2578 (90.6%) at 2 years. There were 2396 (84.2%) children for whom questionnaires were returned at all three ages, and who were included in the analyses. Drop-out analyses were executed to examine selective drop-outs regarding background characteristics (that is, number of hours of employment and overweight of mother and of father, parental alternative lifestyle, maternal educational level, age and country of birth). Logistic regression analyses showed that participants who provided data at all three ages did not differ on any of these factors from participants who did not provide complete data.

Child characteristics

Child-care use at the ages of 7 months, and 1 and 2 years was assessed by asking parents whether their child attended formal child-care facilities outside the home, and if so, for how many hours. Answering options were: no child-care attendance, 1–8, 9–16, 17–24, 25–32, 33–40 or >40 h per week. Child-care use was categorized in two ways. Children were first categorized into attending child care (1) or not (0), and those attending child care were then categorized into intensive (1) versus limited (0) use, using a median split (>16 vs $\leqslant 16$ h per week). Informal child-care arrangements, such as child care by a family member, were not included in this study.

Parents were asked to report the height and weight of their child at 1 and 2 years, as assessed during the periodical assessments at infant welfare centres, under the Dutch preventive health care system. Weight and height were used

to calculate BMI (that is, weight (kg)/(height (m))^2), which was then recoded into BMI *z*-scores compared with the national reference population (that is, the Fourth Dutch National Growth Study, 1997).[26] Children with a BMI *z*-score of $\geqslant$85th percentile were considered overweight.[27] In addition, children's absolute birth weight (in grams) and gender were recorded, and parents reported the duration of breast feeding (in months) in the first year of the child's life.

Parental characteristics

Parents were asked to indicate their own *post partum* weight and height, which we used to calculate their BMI. A BMI $>25\,kg\,m^{-2}$ was regarded as overweight. In addition, maternal country of birth, age at delivery of the child, highest completed education and the number of hours that each of the parents worked per week were assessed. Maternal education was categorized using median split, into lower (including elementary school, lower general secondary education, and lower and intermediate vocational education) and higher educational level (including higher general secondary education, higher vocational education, college-prep and university).

Data analysis

All statistical analyses were conducted using SPPS 15.0 (SPSS Inc., Chicago, IL, USA). First, the distribution of demographic background variables was explored. In all analyses with BMI *z*-scores, overweight or change in BMI or overweight as dependent variables, children who were underweight (BMI *z*-score $\leqslant$5th percentile)[27] were excluded, because an increase in BMI would be desirable for these children. This regarded 131 children (5.7%) at age 1 year, and 118 children (5.4%) at age 2 years. The influence of child-care use on BMI *z*-scores and overweight was tested using linear and binary logistic regression analyses, respectively. In a separate step, the various background characteristics of the children and their parents (number of hours of employment and overweight of mother and of father; maternal educational level, age and country of birth; parental alternative lifestyle; child's birth weight; breast-feeding duration) were included and backward deleted in order of their significance. Dependent variables were (1) BMI *z*-score at 1 and 2 years of age; (2) the change in BMI *z*-score between ages 1 and 2 years; (3) overweight vs non-overweight at age 1 and 2 years; and (4) change from normal weight to overweight vs remaining normal weight between 1 and 2 years of age. The analyses with weight status change as dependent variable (4) included only children at risk of becoming overweight (children who were already overweight at age 1 were excluded, $N=347$).

Additional linear and logistic regression analyses were performed within the group of children who attended child care, comparing the influence of intensive versus limited child-care use on (1) BMI *z*-score, (2) BMI *z*-score change, (3) overweight and (4) weight status change. To adjust for the above-mentioned covariates, they were included in the analyses in a separate step and backward deleted. In all analyses, *P*-values of <0.05 were considered statistically significant, and *P*-values of <0.10 were interpreted as indicating a trend.

To examine predictors of child-care use, the individual association between parental background variables and child-care use (yes/no) at 7 months, and 1 and 2 years was assessed using various univariate binary logistic regression analyses. In addition, all parental background variables were simultaneously included in multivariate backward binary logistic regression analyses to examine the influence of each of the variables on child-care use, adjusted for the influence of the other variables. Nonsignificant independent variables were deleted from these analyses in order of their significance, starting with the least significant.

Results

Questionnaires regarding 2396 children were returned at all three ages. Background information regarding these children and their parents can be found in Table 1. About a third of the children attended child care at various ages, for an average of approximately 20 h per week. A total of 628 children attended child care at all three ages. Approximately 15% of the children were overweight at ages 1 and 2 years.

Influence of child-care use on BMI development

Table 2 shows the association between child-care attendance and (1) BMI *z*-scores at 1 and 2 years; and (2) change in BMI *z*-scores between these ages. Child-care attendance was positively associated with BMI *z*-score at 2 years. The association with BMI *z*-score at 1 year was not significant when adjusting for covariates. Child-care attendance at age 1 year was further positively associated with the change in BMI *z*-score between 1 and 2 years of age: children attending child care showed an increase in BMI *z*-score, whereas children not attending child care showed a decrease.

Within the group of children using child care at each age, there were no statistically significant differences in the influence on BMI *z*-scores between limited ($\leqslant$16 h a week) and intensive ($>$16 h a week) child-care use after adjustment for covariates. The unadjusted analyses did show a significant difference between limited and intensive use at age 2 with regard to the association with BMI *z*-score at the same age (mean BMI *z*-scores for limited vs intensive child-care use: 0.07 vs 0.21, $P<0.05$). Mean BMI *z*-score was positive in both groups because underweight children were excluded.

Influence of child-care use on overweight development

Table 3 shows the association between child-care attendance and (3) overweight vs normal weight at 1 and 2 years; and

Table 1 Descriptive information of background characteristics ($N=2396$)

	Mean ± s.d.	*Prevalence (%)*
Child		
Gender		Male: 51.5%
		Female: 48.5%
Birth weight (g)	3526 ± 505	
Child-care attendance (hours per week[a] and yes vs no)		
7 months	20.0 ± 7.3	31.6%
1 year	20.1 ± 7.4	33.2%
2 years	19.5 ± 8.0	38.6%
BMI z-score		
1 year	−0.02 ± 1.03	
2 years	−0.04 ± 1.05	
Overweight (BMI z-score ⩾85th percentile)		
1 year		15.2%
2 years		14.4%
Maternal		
Employment (hours per week)	18.6 ± 12.0	
Educational level[b]		High: 62.1%
		Low: 37.9%
Age at birth of child (years)	32.1 ± 3.7	
Country of birth		NL: 96.5%
		Other: 3.5%
Alternative lifestyle[c] (yes vs no)		19.1%
Overweight (BMI $>25\,kg\,m^{-2}$)		31.6%
Paternal		
Employment (hours per week)	39.7 ± 10.1	
Overweight (BMI $>25\,kg\,m^{-2}$)		45.9%

Abbreviation: BMI, body mass index. [a]Hours per week child-care attendance reflects the average within the group who attend child care. [b]High is >median, and low is ⩽ median. [c]Recruited through alternative channels versus through conventional channels.

Table 2 Association between child-care use (no/yes) and BMI *z*-scores at ages 1 ($N=2156$) and 2 years ($N=2086$), and change in BMI *z*-score between 1 and 2 years ($N=1922$), resulting from univariate (unadjusted) and backward multivariate (adjusted for covariates) linear regression analyses

Child care	*No (0)*	*Yes (1)*	*Unadjusted B*	*Adjusted B*
	Mean BMI z-score			
BMI z-score 1 year				
7 months	0.07	0.18	0.11**	0.02
1 year	0.08	0.17	0.09*	−0.02
BMI z-score 2 years				
7 months	0.04	0.17	0.12**	0.08†
1 year	0.04	0.17	0.13**	0.12*
2 years	0.04	0.15	0.11**	0.12*
BMI z-score change 1 to 2 years				
7 months	−0.02	0.03	0.05	0.02
1 year	−0.04	0.06	0.10*	0.10*

Abbreviation: BMI, body mass index. †$P<0.10$; *$P<0.05$; **$P<0.01$. The numbers deviate from total sample size due to exclusion of underweight children (BMI *z*-score ⩽5th percentile).

(4) change to overweight vs remaining normal weight between these ages. Although the percentage of overweight children was consistently higher in the group attending child care (all odds ratios >1), these differences were not significant. However, after adjustment for significant covariates, child-care attendance at 7 months significantly increased the odds of being overweight at age 1 year (odds ratio 1.32, confidence interval 1.04–1.69). There was a trend ($P<0.10$) for children in child care to have higher odds of becoming overweight between the ages of 1 and 2 years.

At age 1 year, 15.9% of the children making limited use of child care (⩽16 h a week) at 7 months were overweight, whereas 21.8% were overweight in the group that used child care intensively (>16 h a week). This difference was significant ($P<0.05$; odds ratio 1.81, confidence interval 1.12–2.92).

Table 3 Association between child-care use (no/yes) and overweight (BMI *z*-score ⩾85th percentile) at ages 1 ($N=2156$) and 2 years ($N=2086$), and change in weight status between 1 and 2 years ($N=1576$), resulting from univariate (unadjusted) and backward multivariate (adjusted for covariates) binary logistic regression analyses

Child care	*No (0)*	*Yes (1)*	*Unadjusted OR (CI)*	*Adjusted OR (CI)*
	Percentage overweight			
Overweight 1 year				
7 months	14.8%	18.8%	1.06 (0.79–1.42)	1.32* (1.04–1.69)
1 year	15.2%	18.1%	1.05 (0.79–1.40)	1.23† (0.97–1.57)
Overweight 2 years				
7 months	14.3%	16.8%	1.07 (0.79–1.44)	1.18 (0.89–1.57)
1 year	14.4%	16.3%	1.09 (0.81–1.46)	1.17 (0.88–1.55)
2 years	14.1%	16.5%	1.17 (0.88–1.57)	1.19 (0.93–1.53)
Changed from normal weight to overweight 1 to 2 years				
7 months	8.3%	11.0%	1.25 (0.84–1.88)	1.36† (0.95–1.94)
1 year	8.2%	11.0%	1.23 (0.83–1.85)	1.37† (0.96–1.95)

Abbreviations: CI, confidence interval; OR, odds ratio. †$P<0.10$; *$P<0.05$. The numbers deviate from total sample size due to exclusion of underweight children (BMI *z*-score ⩽5th percentile). The number for weight status change further deviates from total sample size because only children at risk for becoming overweight (that is, normal-weight children) were included.

Associations between parental background characteristics and child-care use

Child-care use was associated with various parental background characteristics (see Table 4). The average number of hours that the mother worked per week was positively and significantly associated with child-care use at all ages: for each additional hour the mother worked, the probability of child-care use increased by 6–8%. The association between child-care use and the father's work was positive, but much weaker and only became significant after adjustment for covariates at 7 months and 1 year. Children of highly educated mothers were more than twice as likely to be in child care than children of mothers with a lower educational level. Children of older mothers were also more likely to attend child care. Having an alternative lifestyle was associated with less child-care use at the age of 7 months, but the association was not significant at older ages. The country of birth of the mother was unrelated to child-care use.

Table 4 Associations of parental background variables with child-care use ($N=2396$)

	Child-care use (no = 0/yes = 1)					
	7 months		1 year		2 years	
	OR (95% CI)		OR (95% CI)		OR (95% CI)	
	Unadjusted[a]	Adjusted[b]	Unadjusted[a]	Adjusted[b]	Unadjusted[a]	Adjusted[b]
Employment of mother (hours per week)	1.08*** (1.07–1.09)	1.08*** (1.07–1.09)	1.08*** (1.07–1.09)	1.08*** (1.07–1.09)	1.07*** (1.06–1.07)	1.06*** (1.05–1.07)
Employment of father (hours per week)	1.00 (0.99–1.01)	1.02** (1.00–1.03)	1.00 (0.99–1.01)	1.01* (1.00–1.02)	1.00 (0.99–1.01)	—[c]
Educational level of mother (low = 0/high = 1)	2.92*** (2.39–3.58)	2.38*** (1.90–2.98)	3.17*** (2.59–3.88)	2.44*** (1.96–3.03)	2.64*** (2.18–3.18)	2.06*** (1.68–2.51)
Age of mother at birth of child (years)	1.05*** (1.02–1.07)	1.06*** (1.03–1.09)	1.05*** (1.03–1.07)	1.06** (1.03–1.09)	1.04** (1.02–1.06)	1.04** (1.01–1.07)
Mother's country of birth (The Netherlands = 1/other = 0)	1.52 (0.92–2.53)	—[c]	1.25 (0.78–2.03)	—[c]	1.42 (0.89–2.28)	—[c]
Alternative lifestyle (no = 0/yes = 1)	0.77* (0.61–0.96)	0.72* (0.55–0.94)	0.88 (0.71–1.10)	—[c]	1.02 (0.83–1.26)	—[c]

Abbreviations: CI, confidence interval; OR, odds ratio. [a]OR from the univariate binary logistic regression analyses with child-care use at various ages as dependent variables. [b]OR from the multivariate backward binary logistic regression analyses, adjusted for the influence of each of the other independent variables, with child-care use at various ages as dependent variables. [c]Variable not included in the final backward regression model (NS). $^{*}P<0.05$; $^{**}P<0.01$; $^{***}P<0.001$.

Discussion

This study showed that child-care attendance at the child's age of 1 and 2 years was positively associated with BMI *z*-scores at 2 years, and a greater increase in BMI *z*-score between these ages. In addition, to a limited extent, child-care use increased the odds of being overweight at age 1 year, and developing overweight between the ages of 1 and 2 years. These findings are in line with those of some previous studies.[15–17] However, other studies have reported protective effects of child-care use against overweight or obesity,[18,19] or found no effect.[20,21] These conflicting findings might be explained by differences between the study populations. For instance, several previous studies included low-educated or low-income populations.[18,23] In our current sample, the majority of the mothers (62.1%) had a high educational level. As educational level has been shown to be positively associated with the quality of mothers' parenting practices,[28,29] child-care use could possibly be beneficial for children of low-educated mothers, but might have no protective effect for children of highly educated mothers. Another difference between the study populations is with regard to the age of the children. All studies of child-care use in young children (<3 years), including the current study, found a positive relationship between child-care use and overweight.[15,16] In contrast, the studies among older children (⩾3 years) showed conflicting results.[17–22] Possibly, child care is specifically unfavourable for young children, but not so much for older children. Moreover, the various studies differ regarding their study designs and methods (for example, some studies are cross-sectional whereas others are longitudinal), which might explain the conflicting findings. An alternative explanation for the conflicting findings of different studies might be that the child-care centres attended in the various studies differed in terms of their 'obesogenicity'. Previous research has shown that various aspects of the child-care environment influence dietary intake and physical activity.[11–14] Unfortunately, no information regarding the quality of the child-care centres was available in the current or previous studies. In addition, differences in the overall child-care systems in the different studies and countries (for example, different opening hours, different policies), might have influenced the findings.

In addition to child-care-related factors being responsible for an association between child-care use and BMI, the relationship found between the two might also be confounded by factors associated with both child-care use and BMI. For instance, Kim and Peterson[16] found that child care by a relative was associated with both unfavourable infant feeding practices, such as lower breast-feeding rates, and more weight gain in the first 9 months of life. Although the association between child-care use and BMI remained significant after adjustment for factors such as breast-feeding duration in the current study, and secondary analyses did not reveal a significant association between child care and breast feeding, other factors that were not assessed might

also have confounded this relationship. An example of such a factor is infectious diseases. Children who attend child care are more likely to be infected with several communicable diseases.[30] These diseases and the medication taken for them might influence children's weight and/or height.

Child-care attendance showed a weaker association with BMI at 1 year than with BMI at 2 years, and the association at age 1 year even disappeared after adjustment for covariates in the analyses. The analyses with overweight as a dependent variable showed the opposite outcome: there was a significant association between child-care use and overweight at age 1 year, but not at age 2 years. It is unclear why this is the case, but the differences in eating and activity patterns between 1 and 2 year olds could have a role. For instance, 1-year-old infants drink more milk than 2-year-olds,[31] and spend more hours during the day sleeping.[32] The child-care environment may have differential influences on the different dietary and physical activity behaviours at different ages, leading to differences in the association between child-care use and weight status.

The only difference between intensive (>16 h per week) and limited use ($\leqslant 16$ h) was that intensive child care at 7 months led to more overweight at age 1 year. The absence of other significant differences indicates that child-care use in general is mostly associated with a higher BMI, regardless of the amount of time spent in child care. In line with the current findings, previous studies reported more intensive child-care use to be associated with a higher BMI when compared with limited use.[17] However, intensive child care has also been reported to be associated with either a weaker[19] or a stronger[18] negative association with BMI when compared with limited use.

In addition to examining the influence of child-care use on BMI and overweight, this study also explored correlates of child-care use itself. Various parental characteristics were significantly related to child care, including maternal age and parental working hours. In line with previous research,[22–24] children were found to be more than twice as likely to attend child care if they had a mother who had a high educational level, and were also significantly more likely to attend child care for each additional hour their mother worked. Although educational level and employment hours could both be seen as indicators of socioeconomic status, their associations with child-care use remained significant (although somewhat weakened) after adjustment for each other and other covariates. Educational level and employment are related to parental income (not assessed in this study), which could partly explain their association with child-care use, as parental income has previously been linked to child-care use.[19] Costs of child care are relatively high, and parents with a higher income are more likely to be able to afford it. In contrast to maternal working hours, father's working hours were found to have only minor influence on child-care use at 7 months and 1 year. This difference could be explained by the fact that fathers are traditionally less involved in child rearing and often work full time (39.7 h per week on average in the current sample). Children who do not attend child care are often cared for by their mothers at home, which explains the positive relationship between maternal employment and child-care attendance.

Some limitations should be taken into account in interpreting the results. A limitation of this study is that it only examined formal child-care arrangements, whereas some previous studies have shown the differential influence of different types of child care.[15–17,21] Furthermore, all data, including weight, height and child-care attendance, were reported by parents, and could therefore be biased. However, the questionnaires were completed shortly after visits to infant welfare centres, and parents were asked to take down the results of the anthropometric measurements made there. Although child anthropometric measures are probably more reliable when assessed by health-care professionals when compared with assessment by parents,[33] using this approach also introduces an additional error source: parents could makes mistakes when copying these data. BMI distribution in the study population was, however, similar to that in the reference population.[26] A strong point of this study is that data were gathered longitudinally, and hence recall bias and other weaknesses of retrospective research are less probable in this study. However, child-care use was only assessed at the time of the questionnaire, and child-care attendance between questionnaires was not asked.

Various researchers have indicated the important role that child care could have in the prevention of overweight and obesity (see, for example, Story *et al*.[10]). This study contributes to the still-limited evidence base supporting this proposition. Previous research has identified modifiable factors in the child-care environment that influence energy balance-related behaviours, such as staff behaviour and availability of facilities.[11–14] When combining this knowledge with the fact that children are spending increasing amounts of time in child care,[8,9] it would appear that interventions focusing on these factors could contribute to counteracting the childhood overweight and obesity epidemic. Although more research will be needed to specify the content of such interventions, recent interventions educating parents, staff and children showed promising results.[34]

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

The KOALA Birth Cohort Study's conception and follow-up to the age of 2 years was financially supported by the Triodos Foundation, Royal Friesland Foods, University Hospital Maastricht and funds unrelated to commercial organizations

(Iona Foundation, Phoenix Foundation, Foundation for the Advancement of Heilpedagogiek), all in The Netherlands. All research by JS Gubbels is financed by the NUTRIM School for Nutrition, Toxicology and Metabolism, Maastricht University Medical Centre, The Netherlands.

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