

ORIGINAL ARTICLE

Age, income and sleep duration were associated with outcomes in children participating in weight management

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Abstract

Aim: To explore associations between baseline factors and weight-related outcomes among participants enrolled in a paediatric obesity trial.

Methods: We included children aged 6–12 years participating in a 2-year multidisciplinary family programme who attended a postintervention follow-up 36 months from baseline ($n = 62$). Outcome measures were change in body mass index standard deviation score (BMI SDS), reduction in BMI SDS ≥ 0.25 and change in waist circumference (WC). Independent variables included in linear and logistic regression models were age, sex, household income, parents' education, sleep duration, screen time and physical activity.

Results: Altogether, 26 children (42%) attained a reduction of BMI SDS ≥ 0.25 . Higher family income and longer sleep duration were associated with greater change in BMI SDS (-0.05 per 100.000 NOK, $p = 0.02$, and -0.24 per hour, $p = 0.02$, respectively). Higher age was associated with greater change in WC (-2.1 cm per year, $p = 0.01$) but lower odds of attaining a reduction in BMI SDS ≥ 0.25 (OR per year 0.70, $p = 0.04$). There was a borderline statistically significant trend towards greater increase in WC with longer daily screen time ($p = 0.05$).

Conclusion: Age, family income and sleep duration at baseline were associated with weight-related outcomes 1-year postintervention.

KEYWORDS

childhood, family income, lifestyle intervention, obesity, sleep duration

1 | INTRODUCTION

Childhood obesity has well-documented adverse consequences for physical and psychological health.^{1–3} According to systematic reviews, multidisciplinary family treatment has resulted in moderate improvements in weight-related measures in children and adolescents.^{4,5} Such treatment is considered safe and typically involves combinations of diet, physical activity and behavioural

interventions. However, high variability in weight-related effects has often been observed. Reduction in body mass index standard deviation score (BMI SDS) varied from 0.05 to 0.42 according to one review.⁶ This suggests that some children respond better to weight management than others. Exploring patient characteristics and social factors associated with treatment outcome is, therefore, an important area of research. Age, gender and degree of overweight at baseline are reported to be both positive and negative predictors

Abbreviations: BMI, body mass index; SDS, standard deviation score; SES, socioeconomic status; WC, waist circumference.

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for therapeutic benefit.⁷⁻¹⁰ Baseline poor family functioning and self-concept predicted poor 6 months overall outcome in one study.¹¹ The association between low socioeconomic status and obesity is well-documented.^{12,13} There is, however, a substantial lack of information on how these factors can influence paediatric obesity treatment.¹⁴ There is growing evidence that sleep duration and childhood obesity are associated,¹⁵ but the role of sleep duration as a possible predictor for treatment success is less clear.

The Finnmark Activity School trial was a collaborative initiative between primary and specialist care designed to treat childhood obesity in Finnmark County, Northern Norway, a region with a high prevalence of overweight and obesity in children.¹⁶ In the present study, we wanted to explore whether patient characteristics such as age, gender, degree of overweight, household income parents' education and lifestyle factors reported at baseline were associated with weight-related outcomes 1 year after the intervention was finished.

2 | METHOD

The Finnmark Activity School was a single-blinded randomised controlled study with two parallel arms, conducted at the Paediatric Department at Hammerfest Hospital. In 2009–2010, the study included a total of 97 children aged 6–12 years with BMI corresponding to $\geq 27.5 \text{ kg/m}^2$ in adults and $\geq 98^{\text{th}}$ percentile according to the IOTF and UK reference, respectively.^{17,18} They were recruited consecutively from seven municipalities in Finnmark and Troms county, Norway, through media coverage and information at the local public health centre. The exclusion criteria were diseases hampering participation in physical activity and social adjustment difficulties incompatible with group-based activities. No children were excluded based on these criteria. The children were randomised to either individual family or group intervention. The intervention lasted for 2 years, and a postintervention follow-up was performed 1 year after the intervention was finished. Data were collected at baseline, and at 3, 12, 24 and 36 months after the study start through questionnaires, blood samples, clinical examination and anthropological measurements. Drop-out with respect to primary outcome measures was 19% ($n = 18$ children) at 24 months and 36% ($n = 35$ children) at 36-month follow-up (Figure 1). Further details on the methods and results of the original study have been reported earlier.¹⁹⁻²¹

For the present study, we included participants from both study arms who attended both baseline and 36-month follow-up ($n = 62$). Outcome measures were change in body mass index standard deviations score (BMI SDS), waist circumference (WC) and whether the child achieved a reduction in BMI SDS ≥ 0.25 from study start to 36 months or not.

2.1 | Measurements and data collection in the original study

Height and weight were measured by trained nurses and rounded off to the nearest 0.1 cm and 0.1 kg, respectively. BMI kg/m^2 was

Key Notes

- Higher family income and longer sleep duration at baseline were associated with a reduction in body mass index standard deviation score (BMI SDS) 1 year after the intervention.
- Lower age was associated with higher odds of attaining a reduction of BMI SDS of 0.25 or more while higher age was associated with a decrease in waist circumference.
- There was a borderline statistically significant trend towards greater increase in waist circumference with longer screen time.

calculated, and BMI SDS was extracted from a calculator based on the British reference population.¹⁷ Two nurses measured WC at baseline and follow-up; we used the mean values of their measurements at baseline and follow-up, respectively. Both parents were invited to answer the questionnaires considering household income (Norwegian kroner, NOK), parents' education level, the child's sleep duration, amount of physical activity and screen time.

2.2 | Data in the present study

The actual dataset was extracted from the Finnmark Activity School database, anonymized and without information on treatment allocation. As potential predictors of treatment effect, we included the household income, parent level of education, the child's sleep duration, time spent in physical activity and screen time reported at baseline.

The parent with the highest level of education was chosen to represent the family in the analysis. Response categories were primary school, lower secondary school, upper secondary school, university and higher education ≤ 4 years and university and higher education > 4 years. Few families reported primary school or lower secondary school as the highest level of parental education (Table 1). Primary school, lower secondary school and upper secondary school were therefore regrouped in one category. Sleep duration was calculated as hours spent in bed, subtracting the time before falling asleep. Screen time was measured as time spent in front of the TV, iPad or computer after school. Possible response categories were 'never', '<½ an hour a day', '½-1 h', '2-3 h', '4 h' and 'more than 4 h'. Few cases responded 'never' and 'more than 4 h' (Table 1). The two lowest and the two highest groups were merged in the analysis. Response categories for physical activity were 'never', '½ an hour', '1 h', '2-3 h', '4-6 h' and '7 or more hours' weekly. Again, due to small numbers in some categories, we merged 'never', '½ an hour' and '1 h', and '4-6 h' and '7 or more hours', leaving three groups for analysis.

In cases where both the mother and the father had turned in questionnaires ($n = 3$), the mean was calculated for continuous variables. For variables collected as ordinal scale values, the mother's answer

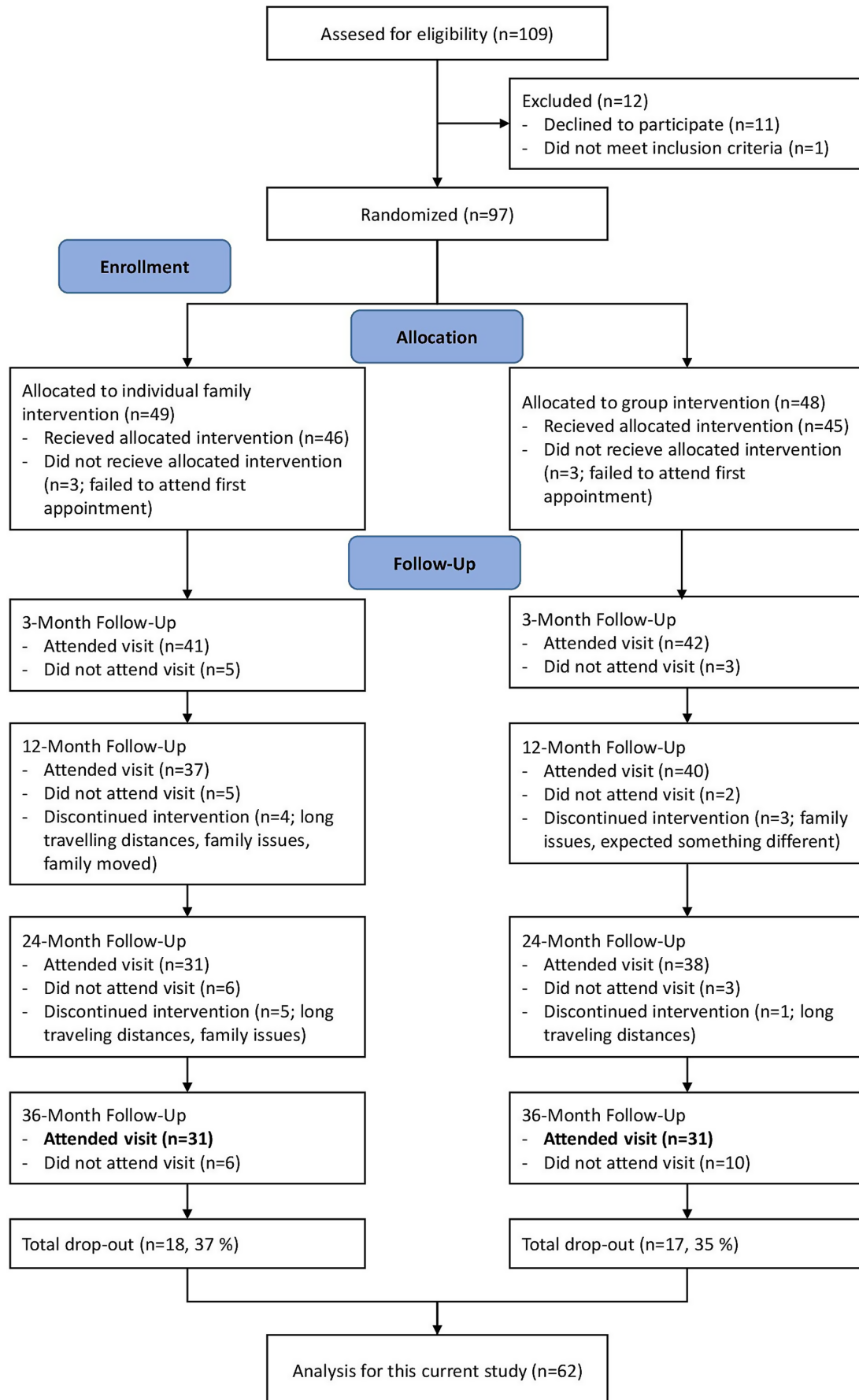


FIGURE 1 Flow of participants in the Finnmark Activity School*. *Revised flowchart from the original study by Kokkvoll et. al 2019

was preferred because the great majority of the questionnaires were answered by mothers ($n = 60$). Analyses were also carried out with fathers' answers prioritised, without any effect on the results.

We tested the hypotheses that household income, parent level of education, the child's sleep duration, physical activity and screen time were associated with weight-related outcomes. Linear regression was used for change in BMI SDS and change in waist circumference, and logistic regression for the dichotomous outcome of

attaining BMI SDS reduction of 0.25 or more. Multivariable analyses were carried out to adjust for age, gender and group allocation. Analyses were also carried out for age, gender and BMI SDS as independent variables. In this case, linear regression was used for change in BMI SDS and WC, and logistic regression was used for the dichotomous BMI SDS outcome. In these analyses, we adjusted for group allocation. STATA/IC 17 was used to perform the statistical analysis. p -values <0.05 were considered statistically significant. The study was approved by Regional Committee for medical and health research ethics (24078). Written consent was provided by all parents; children ≥ 12 years gave their assent.

TABLE 1 Baseline characteristics of children participating in a weight management programme

	Mean (standard deviation) or N (%)
Age (years)	10.3 (1.6)
Proportion female (n/n, %)	31/62 (50%)
BMI SD score at study start	2.81 (0.60)
Household income (NOK)	650,000 (31,000)
Parental education (n, %)	
Primary school	1 (1.6%)
Lower secondary school	4 (6.6%)
High school	25 (41.0%)
Higher education of 4 years or less	17 (27.9%)
Higher education of more than 4 years	14 (23.0%)
Sleep duration (hours)	9.5 (0.7)
Daily time spent in front of the TV, computer, iPad, etc. after school (n, %)	
<0.5 h	1 (1.7%)
0.5–1 h	16 (27.1%)
2–3 h	31 (52.5%)
4 h	6 (10.2%)
More than 4 h	5 (8.5%)
Weekly time spent at physical activity after school (n, %)	
No physical activity	6 (9.8%)
About 0.5 h	5 (8.2%)
About 1 h	13 (21.3%)
About 2–3 h	23 (37.3%)
About 4–6 h	11 (18.0%)
7 h or more	3 (4.9%)

TABLE 2 Regression analysis: associations between and age, gender, BMI SDS and weight-related outcomes

	Change in BMI SDS β (95% CI) ^a	BMI SDS reduction of 0.25 or more OR (95% CI) ^b	Change in WC β (95% CI) ^a
Age	0.06 (−0.02, 0.13) $p = 0.14$	0.70 (0.50, 0.98) $p = 0.04$	−2.1 (−3.5, −0.6) $p = 0.01$
Gender	−0.01 (−0.26, 0.24) $p = 0.95$	0.94 (0.33, 2.65) $p = 0.91$	−4.0 (−9.0, 1.0) $p = 0.11$
BMI SDS at study start	−0.04 (−0.24, 0.16) $p = 0.70$	0.91 (0.39, 2.11) $p = 0.82$	2.12 (−2.1, 6.3) $p = 0.31$

^aLinear regression adjusted for group allocation.

^bLogistic regression adjusted for group allocation.

3 | RESULTS

Among the 62 children, the mean BMI SDS at baseline was 2.81 (SD = 0.60, range 1.52–4.33), which is equivalent to the BMI 99.4th percentile. The mean waist circumference was 88.96 cm at the study start (SD 10.41 cm) and is beyond 95 percentile for both genders at 10 years of age according to both the British and Norwegian reference.^{22,23}

The median household income was 650,000 NOK, which is similar to the Norwegian median level of household income.²⁴ In 51% of the families, at least one of the parents had higher education (Table 1). At baseline, the majority of the children slept 9–11 h per night and had at least 2 h of daily screen time. Only three children reported weekly physical activity corresponding to 60 min of daily vigorous activity as recommended by the World Health Organization²⁵ (Table 1).

At 36 months, the children had a mean BMI SDS 2.60 (SD = 0.75) and a mean reduction of 0.21 (SD = 0.48). A total of 26 (42%) children attained a reduction in BMI SDS of 0.25 or more. Four children attained a waist circumference below the 95 percentile after 36 months. The mean change in waist circumference was an increase of 2.5 cm (SD 9.3 cm).

Higher age at baseline was associated with lower odds of attaining reduction in BMI SDS of ≥ 0.25 (OR per year 0.70, 95% CI 0.50–0.98). On the other hand, higher age was associated with a greater reduction in WC (β −2.1 cm per year of age, 95% CI −3.5 to −0.6) (Table 2). Higher household income was significantly associated with a reduction in BMI SDS (−0.05 per 100,000 NOK, 95% CI −0.10 to −0.01) (Table 3). The probability for attaining a reduction of BMI SDS

≥ 0.25 increased with higher income (OR 1.27 per 100.000 NOK), but the trend was of borderline statistical significance (95% CI 1.00–1.61, $p = 0.048$) (Table 4). There was no significant association between household income and change in WC (Table 5).

Longer sleep duration was associated with a greater reduction in BMI SDS ($\beta -0.24$ per hour, 95% CI -0.44 to -0.04). The association to increased odds of attaining BMI SDS reduction ≥ 0.25 was of borderline significance (OR 2. 2.65, 95% CI 1.00–6.99, $p = 0.049$). There was no association between sleep duration and change in WC.

There was a borderline statistically significant trend towards a greater increase in waist circumference with longer daily screen time (Table 5). Screen time was not significantly associated with either of the BMI-related outcomes. No associations were detected between gender, BMI SDS at baseline, parent education and any of the outcome measures.

4 | DISCUSSION

In a cohort of children participating in a weight management programme, lower age, higher family income and longer sleep duration at baseline were associated with improvements in BMI-related outcomes 1-year postintervention. Higher age was associated with a greater change in WC. An association between a higher level of screen time and an increase in WC was of borderline statistical significance. We

TABLE 3 Linear regression analysis: predictors of change in BMI SDS^a

	β (95% CI) ^b	<i>p</i> -value
Household income (100.000 NOK)	-0.05 (-0.10, -0.01)	0.02
Parent's education ^c	0.06 (-0.09, 0.22) ^d	0.43
1 = Primary, lower secondary and/or high school		
2 = Higher education of 4 years or less		
3 = Higher education of more than 4 years		
Sleep duration (hours)	-0.24 (-0.44, -0.04)	0.02
Screen time ^c	0.12 (-0.06, 0.30) ^d	0.18
1 = 1 h or less		
2 = 2–3 h		
3 = 4 h or more		
Physical activity ^c	-0.05 (-0.22, 0.12) ^d	0.58
1 = 1 h or less		
2 = 2–3 h		
3 = 4 or more hours		

^aCalculated by subtracting BMI SDS at study start from BMI SDS at 36-month follow-up.

^bAdjusted for age and gender. Every line in the table is carried out as a single analysis and is not adjusted for any of the other independent variables listed in the table.

^cOrdinal scale, coding indicated below the variable name.

^d β for linear trend across the ordinal categories.

found no associations between gender, degree of overweight at baseline (BMI SDS), parent education and physical activity and any of the weight-related outcomes.

4.1 | Results in relation to other studies

4.1.1 | Age

Age at baseline was associated with somewhat conflicting results in the present study depending on whether BMI or WC was used as the outcome. Previous studies have reported a greater effect of lifestyle interventions in the younger participants compared with older children.^{7,8,26} Although these studies included a wider age range, the same trend was detected in our study with respect to BMI SDS. One could argue that change in weight status is easier to detect in young and small bodies because BMI SD scores change more for a given change in mass (kilogram) and diet, and physical activity patterns may be less established.²⁶ In some studies, however, older children had better outcomes in weight management programmes.¹⁰

In this dataset, higher age was associated with a decrease in WC. Even though WC is frequently reported as a secondary outcome in childhood obesity programmes, this outcome is less often reported in systematic reviews due to the variation in use and precision.⁴ The authors have argued for WC as the primary outcome measure in weight management targeting physical activity (as in our original study) since BMI does not distinguish fat mass from lean mass.²⁷ There is a risk that a reduction in fat mass may be masked by a rise in lean mass, while WC is a measure of abdominal fat, independently of body lean mass. We can speculate whether this effect may be even more important in older children due to pre- and pubertal growth. However, due to the small sample size, more research is needed in order to explore WC change in relation to age in childhood obesity treatment.

4.1.2 | Household income and parents' education

The association between low socioeconomic status (SES) and obesity is well-documented.¹² Different genetic, biological and lifestyle pathways connected with poverty and stress could be underlying mechanisms behind these findings.²⁸

Authors have reported an increase in weight gain among school children during summer. The mechanisms suggested are disrupted family routines, sleep dysregulation, limited access to out-of-school activities and healthy food in periods when school is closed, factors particularly affecting vulnerable groups, including families with low SES.²⁹ When participating in weight management, families need to make significant lifestyle changes in their home environment. With a good household income, at least cost barriers such as increased expenses for healthier food³⁰ and sports equipment are easily overcome. However, while some studies have reported associations

TABLE 4 Logistic regression analysis: predictors of attaining a reduction in BMI SDS ≥ 0.25

	OR (95% CI) ^a	p-value
Household income (100,000 NOK)	1.27 (1.00, 1.61)	0.05
Parent's education ^b	0.71 (0.36, 1.41) ^c	0.33
1 = Primary, lower secondary and/or high school		
2 = Higher education of 4 years or less		
3 = Higher education of more than 4 years		
Sleep duration (hours)	2.65 (1.00, 6.99)	0.05
Screen time ^b	0.75 (0.33, 1.69) ^c	0.48
1 = 1 h or less		
2 = 2–3 h		
3 = 4 h or more		
Physical activity ^b	1.19 (0.58, 2.46) ^c	0.64
1 = 1 h or less		
2 = 2–3 h		
3 = 4 or more hours		

^aAdjusted for age and gender. Every line in the table is carried out as a single analysis and is not adjusted for any of the other independent variables listed in the table.

^bOrdinal scale, coding indicated below the variable name.

^cOR for linear trend across the ordinal categories.

between socioeconomic status and treatment outcome,^{14,31,32} others have not.^{8,33,34}

Interestingly, no association was observed between parents' length of education and treatment outcome in this current study, which is in line with Moens et al.³⁴ We might speculate that highly educated parents have less to gain from informational aspects of weight management programmes. However, others have found that higher parental education was associated with a change in BMI-related outcomes.³¹

4.1.3 | Sleep

The association between sleep duration and overweight in children is well-documented,³⁵ and the causality between the two is thought to be multifactorial.¹⁵ Lack of sleep contributes to increasing appetite through its impact on leptin and ghrelin levels and neural reward processing mechanisms, which may lead to increased food intake.^{28,36,37} Sleep deprivation can lower energy expenditure, both through predisposing for sedentary activity and changes in metabolism (e.g. insulin and glucose metabolism).³⁶ Successfully changing habits of sleep in children can have a positive impact on BMI, physical activity level and nutrition.³⁸ This corresponds well to the findings in our study.

Lower household income has been associated with impaired sleep in children.³⁹ To a child, both sleep deprivation and (parental worrying for) low household income can represent chronic stressors.

TABLE 5 Linear regression analysis: predictors of change in waist circumference^a

	Beta (95% CI) ^b	p-value
Household income (100,000 NOK)	-0.46 (-1.38, 0.46)	0.32
Parent's education ^c	1.19 (-1.69, 4.07) ^d	0.41
1 = Primary, lower secondary and/or high school		
2 = Higher education of 4 years or less		
3 = Higher education of more than 4 years		
Sleep duration (hours)	-3.37 (-7.12, 0.38)	0.08
Screen time ^c	3.29 (0.03, 6.55) ^d	0.05
1 = 1 h or less		
2 = 2–3 h		
3 = 4 h or more		
Physical activity ^c	-1.64 (-4.82, 1.54) ^d	0.31
1 = 1 h or less		
2 = 2–3 h		
3 = 4 or more hours		

^aCalculated by subtracting mean waist circumference at study start from mean waist circumference at 36-month follow-up.

^bAdjusted for age and gender. Every line in the table is carried out as a single analysis and is not adjusted for any of the other independent variables listed in the table.

^{c,d}Ordinal scale, coding indicated below the variable name.

Exposure to stress early in life is associated with obesity in adolescence.²⁸ Such stressors could also make it difficult to succeed in weight management programmes.

4.1.4 | Screen time and physical activity

Some studies have explored the association between habits of physical activity and inactivity at baseline and treatment effect with conflicting results.^{31,33} We found that both short sleep duration and increased screen time were associated with poorer weight-related outcomes, although the latter was of borderline statistical significance. Both bedtime and screen time are subject to parental control. We might speculate that lack of parental control and structure could contribute to poorer outcomes. However, our data do not allow for any conclusions in this respect.

4.2 | Limitations

A long-term follow-up is the main strength of our study, but there are important limitations. The sample size was limited, and the study may have been underpowered to detect important associations. Due to the small sample size, we refrained from including all available variables in the regression models to avoid overfitting.⁴⁰ Thus, our ability to adjust for potential confounders was limited as well. Our analytic strategy

involved multiple statistical testing, which increases the risk of false-positive findings. Some of our findings were close to the threshold for statistical significance and should be interpreted with special caution. Several of the potential predictor variables were based on self-report (from parents), not objective measures. Furthermore, the attrition rate was substantial (36%). Previous analysis comparing the children who met at 36 months with those who did not reveal any differences in baseline characteristics such as age, gender or degree of overweight (BMI SDS).²¹ Nevertheless, this is another potential source of bias. Finally, our participants may have been more motivated for change than the average child/family, which could hamper the external validity of our findings.

4.3 | Implications

Our findings suggest that baseline patient and family characteristics could be important for tailoring future weight management programmes to the individual child. In accordance with earlier studies, our findings suggest that interventions should start at an early age, as the youngest children may benefit more from weight management programmes. Our results also suggest that the family economy might have an impact on outcomes from weight management programmes. Politicians and clinicians may do well-considering this in the struggle for improving weight management among vulnerable children.

4.4 | Unanswered questions and future research

Our result suggests that older children may benefit from intervention with respect to WC. To our knowledge, information is limited and further research on how age may influence WC in weight management programmes is needed.

The foundation for understanding the role of social inequality in managing obesity in children is weak because we lack high-quality evidence.¹⁴ Interventions aimed at overcoming economic barriers to lifestyle changes are an important line of research.

Our findings suggest that active intervention aimed at sleep habits could be an important component in weight management programmes for children. Thus, studies targeting sleep duration per se may prove valuable.

5 | CONCLUSION

For children participating in a multidisciplinary family-based lifestyle intervention, higher family income, longer sleep duration and lower age at baseline were associated with a favourable change in BMI SDS-related outcomes 1-year postintervention.

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CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

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