REGULAR ARTICLE

ACTA PÆDIATRICA
NURTURING THE CHILD WILEY

Hyperactivity is associated with higher fat-free mass and physical activity in Swedish preschoolers: A cross-sectional study

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Funding information The study received funding from the Swedish Research Council (project no. 2012-2883), the Swedish Research Council for Health, Working Life and Welfare (2012-0906), Bo and Vera Axson Johnsons Foundation, and Karolinska Institutet (all ML). The funder had no role in design, data analysis and interpretation, or in writing the manuscript.

Abstract

Aim: We investigated psychological strengths and difficulties in a Swedish population of preschool children and analysed how these behavioural variables were related to body composition, cardiorespiratory fitness, physical activity levels, sedentary behaviour and diet.

Methods: Three hundred and fifteen boys and girls were recruited during 2014-2015. Body composition was measured using air-displacement plethysmography, and anthropometric measures were taken. Parents responded to questions about age, sex and educational attainment, diet, physical activity levels and smoking habits, as well as the Strengths and Difficulties Questionnaire (SDQ). Regression models were created to analyse associations between psychological variables, body composition and health behaviours.

Results: Hyperactivity scores were positively related to fat-free mass ($\beta = 0.20$, $P = .001$) and moderate-to-vigorous physical activity ($\beta = 0.16$, $P = .003$) and negatively associated with sedentary behaviours ($\beta = 0.18$, $P = .001$), but showed no statistically significant associations with fat mass.

Conclusion: Our findings suggest that the adverse health consequences of hyperactivity on obesity and obesity-related health behaviours may be established after the preschool period. Questions about the time frame of contributing and modulating factors in obesity development are discussed.

KEYWORDS
body composition, body mass index, hyperactivity, physical activity, SDQ

1 | INTRODUCTION

Childhood obesity represents an enormous global health problem with far-reaching consequences for both affected children and society.[1] Although the escalating rise in prevalence seems to have slowed, the current rate is a significant source of public health concern.[2] In the last two decades, the number of children under the age of five with overweight or obesity has increased with one third and now count 38 million.[3] Obesity, established in early life, often remains into adulthood, and the presence of significant overweight affects nearly all aspects of health and well-being, from metabolic alterations to psychosocial functioning.[4] The long-term costs in terms of morbidity and mortality include increased risk of cardiovascular disease,[5] cancer[6] and a reduced life expectancy.[1] It is now widely recognised that childhood obesity is the combined result of numerous factors interacting dynamically.[7] Although the genetic component seems highly influential, the rapid rise of obesity during the last two decades reveals the importance of environmental factors.[7]

Psychological factors, emerging from the child's temperament, personal characteristics and emotional well-being, have historically remained in the periphery in models of childhood obesity pathogenesis.[8] However, evidence for associations between anxiety and depression, as well as for inattention and hyperactivity, and obesity has recently been firmly established.[9] Although the strength of these associations and underlying mechanisms remains uncertain, some researchers attribute the association to selection bias.[10] In contrast, others are likely overcontrolling for potential confounding factors and thus risking to misinterpret important effect modulators.[11] Another possible source of confusion is the frequent use of body mass index (BMI). BMI makes no distinction between fat mass and fat-free mass, making it an especially poor marker of fat mass in infants and preschool-aged children. For instance, Delisle-Nyström et al. showed that BMI was as strongly related to fat-free mass index as to fat mass index, demonstrating its limitation as a proxy of body fatness in preschoolers.[12] Psychological factors are of high importance since a significant proportion of children are afflicted by psychiatric problems. For example, around 5% of the global population of children have difficulties with hyperactivity above the threshold for an attention deficit hyperactivity disorder (ADHD) diagnosis. An additional 5% have substantial difficulties in the subclinical range.[13]

Studies of preschoolers are generally scarce, and to our knowledge, only one earlier study has used adequate measures of body composition and health behaviours.[14] Ebenegger et al showed, in a cross-sectional study, that 4- to 6-year-old children with inattention and hyperactivity problems were surprisingly associated with a lower percentage of body fat. These children also had higher levels of physical activity, spent less time in sedentary behaviours, but also had more screen time and less healthy eating patterns.[14] Important questions remain to be elucidated about the role and significance of psychological factors in childhood obesity, and answers to some of these questions could inform the development of much needed effective interventions.[8]

Key notes

- Evidence for the importance of psychological factors in obesity development is accumulating in the literature.
- We examined psychological strengths and difficulties, as well as body composition, physical fitness and health behaviours, among 305 Swedish preschoolers.
- Hyperactivity was associated with fat-free mass, physical activity levels and sedentary behaviour, suggesting that obesity-related negative health consequences of hyperactivity develop after the preschool period.

This study aimed to investigate psychological factors in a Swedish population of preschool children and analyse how difficulties, including emotional problems and hyperactivity, were related to specific measures of body composition, cardiorespiratory fitness, physical activity levels, sedentary behaviour and diet.

2 | METHODS

Baseline data were derived from the MINISTOP trial (Mobile-based Intervention Intended to Stop Obesity in Preschoolers), which aimed to prevent obesity among preschool children by providing information and feedback on parents' health behaviours through a mobile application.[15] Participants were recruited from the general population during 2014 and 2015, and 315 children (46% girls and 54% boys) with a range in BMI from 12.8-24.5, and were not selected on the basis of any increased risk for developing obesity or hyperactivity.[12] At baseline, parents responded to questions about age, sex and mother's educational attainment, used as a proxy for the family's socioeconomic status. Parents also provided information about diet, physical activity levels and smoking habits. A total of 10 families had incomplete responses to questionnaires, and an additional 0-12 participants had not completed all outcome measures. Thus, the remaining number of participants available for statistical analyses was 305.

2.1 | Data collection

Psychological strengths and difficulties were assessed using the Strengths and Difficulties Questionnaire (SDQ). The psychometric properties of the questionnaire have recently been validated for preschool children.[16] The 25-item instrument was designed for screening for psychiatric disorders. The items are grouped into five subscales with separate scores, including emotional symptoms, conduct problems, hyperactivity and inattention, peer relationship problems and pro-social behaviours.[17]

Body composition was assessed using air-displacement plethysmography, the paediatric BodPod (www.cosmed.com), described in detail in an earlier publication.[18] Body volume measured via the

TABLE 1 Characteristics of children in the study

	All (n = 305)			Boys (n = 165)			Girls (n = 140)		
	n	Mean (SD)	Min-Max	n	Mean (SD)	Min-Max	n	Mean (SD)	Min-Max
Mothers education									
Primary school (%)	0 (0%)								
High school (%)	86 (28%)								
University degree (%)	219 (72%)								
Physical characteristics									
Age (y)	305	4.5 (0.1)	4.2-4.5	165	4.5 (0.1)	4.2-4.9	140	4.5 (0.2)	4.2-4.9
Height (cm)	305	107.5 (4.2)	96-119.5	165	108.0 (4.3)	98-118.1	140	107.0 (4.0)	96-119.5
Weight (kg)	305	18.3 (2.5)	12.8-30.4	165	18.5 (2.4)	12.8-28.6	140	18.0 (2.5)	13.0-30.4
BMI (kg/m^2)	305	15.8 (1.4)	12.8-24.5	165	15.8 (1.3)	13.2-21.2	140	15.7 (1.4)	12.8-24.5
Fat mass index (kg/m^2)	293	4.1 (0.9)	1.7-10.0	162	4.0 (0.8)	1.7-6.5	131	4.3.1 (1.0)	1.8-10.0
Fat-free mass index (kg/m^2)	293	11.6 (1.0)	9.6-14.8)	162	11.9 (1.0)	9.6-14.8	131	11.4 (0.9)	9.6-14.6
Shuttle run (laps)	297	5.8 (2.6)	1.0-18.0	159	5.6 (2.5)	2.0-18.0	138	6.0 (2.6)	1.0-16.0
MVPA (min/d)	303	101 (25)	33-204	165	102 (26)	47-204	138	100 (23)	33-171
Sedentary behaviour (min/d)	303	479 (52)	289-595	165	478 (52)	289-595	138	479 (53)	303-567
Fruits and vegetables (g/d)	305	209 (112)	2.5-591	165	202 (112)	2.5-591	140	216 (111)	13-552
Sugar-sweetened bev. (dL/d)	305	0.6 (0.7)	0-3.5	165	0.7 (0.8)	0-0.4	140	0.6 (0.6)	0-0.4
Strengths and difficulties scores									
Total difficulties	305	6.4 (3.9)	0-25	165	7.1 (4.1)	0-25	140	5.7 (3.5)	0-16
Emotional difficulties	305	1.4 (1.5)	0-7	165	1.5 (1.6)	0-7	140	1.3 (1.4)	0-6
Conduct problems	305	1.4 (1.3)	0-6	165	1.5 (1.3)	0-6	140	1.3 (1.3)	0-6
Hyperactivity difficulties	305	2.8 (2.1)	0-9	165	3.2 (2.3)	0-9	140	2.2 (1.6)	0-7
Peer problems	305	0.8 (1.2)	0-9	165	0.8 (1.2)	0-9	140	0.8 (1.1)	0-4
Pro-social behaviours	305	8.1 (1.7)	2-10	165	7.8 (1.8)	2-10	140	8.4 (1.4)	5-10

Abbreviations: BMI, body mass index; MVPA, moderate-to-vigorous physical activity.

BodPod was translated into values for fat mass and fat-free mass. Body mass index was calculated from the child's weight and height (body weight [kg]/height^2 [m]). Fat mass index was calculated as (fat mass [kg]/height^2 [m]), and fat-free mass index was calculated as (fat-free mass [kg]/height^2 [m]).

Cardiorespiratory fitness was assessed by using the 20-metre shuttle run test, from the PREFIT fitness measurement.[19] Physical activity was measured over seven consecutive days as participants were wearing an ActiGraph wGT3x-BT triaxial accelerometer on their non-dominant wrist. Details of the analyses of activity data have been provided elsewhere.[20] Data from the 7-day measurements were analysed to calculate a total of vector magnitudes in 10-second epochs. A cut-off for a valid day long measure was set to >600 minutes, at least three valid days, of awake wearing of the equipment.[21]

For each participant, the time spent in moderate-to-vigorous physical activity (MVPA) and sedentary time was calculated.

Intake of fruits and vegetables, as well as sugar-sweetened beverages, was assessed by using the TECH method.[22] This measurement technique is based on parents or caretakers photographing all foods and drinks consumed by the child with their mobile phone camera during four 24-hour periods. Participants received standardised plates and glasses to facilitate accurate portion size calculations.

2.2 | Data analysis

Descriptive statistics were calculated to obtain demographic and general characteristics of the included children and are shown as

mean values and standard deviation (Table 1). The associations between SDQ scores and the outcome variables were analysed with two-tailed linear regression analyses. SDQ scores were used as a continuous variable and entered into linear regression models as a score of total difficulties, and scores on the five subscales in separate models. We used two different regression models for all analysed variables; one unadjusted and one with adjustment for age, sex and maternal education. In additional regression models, we tested for interaction effects from participant's sex and found no significant results (all p-values > .35), (data not shown in tables). Therefore, separate regression analyses for boys and girls were not performed. All analyses were calculated using SPSS version 26 (IBM).

2.3 | Ethical considerations

The main study (MINISTOP) was designed and conducted following the Declaration of Helsinki. It was approved by the Ethical Committee in Stockholm, Sweden (2013/1607-31/5; 2013/2250-32). The trial was prospectively registered in the database Clinicaltrials.gov: NCT02021786. Informed consent was obtained from both parents.

3 | RESULTS

3.1 | Participant characteristics

The characteristics of children included in the study are shown in Table 1. The mean age of the children was 4.5 years (SD ± 0.1). The mean BMI was 18.8 (SD ± 1.3) for girls and 15.7 (SD ± 1.4) for boys. Among participants, 8.7% was overweight or obese, corresponding to 26 subjects (4 obese). The average result of the shuttle run test (ie a measure of cardiorespiratory fitness) was 5.8 laps (SD ± 2.6), and the average time spent in MVPA per day was 101 minutes (SD ± 25). Mean sedentary time was 479 minutes per day (SD ± 52). The average consumption of fruits and vegetables was 209 g per day (SD ± 112). The average intake of sugar-sweetened beverages was 0.6 dL per day (SD ± 0.7). The majority of mothers (72%) had a university degree. As shown in Table 1, the children covered a wide range in body composition, MVPA, food consumption and cardiorespiratory fitness.

3.2 | SDQ scores

The average total difficulties score was 6.4 (SD ± 3.9) (range 0-25), which is far below the approximated cut-off for the normal range (<13).[21] The average emotional problem score was 1.4 (SD ± 1.5), which is also below the cut-off for the normal range (<4). The average score of conduct problems was 1.4 (SD ± 1.3) (normal < 5). The average hyperactivity score was 2.8 (SD ± 2.1) (normal < 7), and in the study sample, 62 participants (20%) scored above the cut-off for slightly raised (5-6), and 22 participants (7%) scored above the

cut-off for a high likelihood of an ADHD diagnosis (>6). The average score for peer problems was 0.8 (SD ± 1.2) (normal < 4). Finally, the average score for pro-social behaviours was 8.1 (SD± 1.7), which was slightly above the cut-off for normal. As expected, boys had slightly higher SDQ scores based on descriptive calculations. Mean scores and standard deviations of SDQ are shown in Table 1, which show that the children covered a wide range in the SDQ scores.

3.3 | Associations of SDQ subscales with body composition and physical fitness

Results for SDQ scores, body composition and physical fitness are shown in Table 2. The score for total difficulties was positively related to fat-free mass index in the unadjusted model, but on the border of statistical significance in the adjusted model (adjusted; $\beta = 0.12$, $P = .052$). However, it showed no statistically significant association with fat mass index (adjusted; $\beta = -0.07$, $P = .257$). Total difficulties were also significantly negatively associated with fat mass per cent (adjusted; $\beta = -0.11$, $P = .049$, data not shown in Table 2). Emotional problems and conduct difficulties were not significantly associated with any outcome measures. Hyperactivity scores were positively related to fat-free mass index in both unadjusted and adjusted models (adjusted; $\beta = 0.20$, $P = .001$). However, hyperactivity showed no statistically significant association with fat mass index (adjusted; $\beta = -0.02$, $P = .701$). None of the SDQ subscales were associated with physical fitness.

3.4 | Associations of SDQ subscales with health behaviours

Only the subscale hyperactivity showed statistically significant associations with health behaviours. Hyperactivity scores were positively associated with MVPA (adjusted; $\beta = 0.16$, $P = .003$) and negatively associated with sedentary behaviours (adjusted; $\beta = -0.18$, $P = .001$). In the adjusted model, hyperactivity was positively associated with intake of fruit and vegetables (adjusted; $\beta = 0.15$, $P = .007$). Neither the total SDQ score nor the subscale was related to sugar-sweetened beverages. Results for SDQ scores and health behaviours are shown in Table 3.

3.5 | Contributions of individual facets of hyperactivity

Since the hyperactivity subscale showed significant associations with fat-free mass index, MVPA, sedentary behaviour and fruit and vegetable consumption, we performed additional analyses with the five items in the hyperactivity subscale. This analysis showed that, in models with adjustment for mothers' educational attainment, age and sex, all items contributed to at least some of the associations. No single item seemed to explain the observed relationship. Results from this additional analysis are shown in Table S1.

TABLE 2 Associations of Strengths and Difficulties Questionnaire Scores with body composition and physical fitness

SDQ scores and subscales	BMI (kg/m^2)		Fat mass index (kg/m^2)		Fat-free mass index (kg/m^2)		Shuttle run (20 m)	
	β	P	β	P	β	P	β	P
Total difficulties								
Unadjusted	0.03	.591	−0.10	.106	0.15	.010	−0.06	.293
Adjusted[a]	0.02	.697	−0.07	.257	0.12	.052	−0.04	.549
Emotional problems								
Unadjusted	−0.03	.565	−0.04	.472	−0.01	.981	−0.03	.581
Adjusted[a]	−0.04	.544	−0.04	.530	−0.01	.834	−0.01	.806
Conduct problems								
Unadjusted	0.25	.661	−0.04	.476	0.09	.124	−0.02	.777
Adjusted[a]	0.02	.705	−0.03	.605	0.07	.199	−0.01	.942
hyperactivity								
Unadjusted	0.11	.048	−0.07	.269	0.24	.001	−0.05	.434
Adjusted[a]	0.11	.067	−0.02	.701	0.20	.001	−0.01	.837
Peer problems								
Unadjusted	−0.08	.144	−0.10	.089	−0.02	.753	−0.06	.282
Adjusted[a]	−0.09	.141	−0.09	.100	−0.02	.666	−0.07	.239
Pro-social behaviour								
Unadjusted	0.01	.932	0.06	.295	−0.07	.249	0.04	.459
Adjusted[a]	0.02	.791	0.03	.578	−0.03	.655	0.02	.673

Abbreviations: BMI, body mass index; SDQ, Strengths and Difficulties Questionnaire.

[a]Adjusted for mother's education attainment (university degree or not), sex and age of the child.

4 | DISCUSSION

This study of Swedish preschool children showed that the total score of psychological difficulties was positively associated with fat-free mass index, but not significantly associated with BMI. These findings highlight a potential fallacy of using BMI as the only measurement of overweight and obesity in studies including preschool children. Among the subscales in the SDQ questionnaire, hyperactivity was most strongly associated with body composition and health behaviours. Except for pro-social behaviours, which showed a positive association with sedentary behaviours and negative associations with sugar-sweetened beverages, none of the other subscales showed significant associations with neither body composition measures, nor to health behaviours.

Contrary to the general finding in studies of school-aged children and adolescents that hyperactivity and inattention are related to overweight and obesity,[10] in our study population, hyperactivity was negatively associated with fat mass and positively related to fat-free mass. In addition, hyperactivity scores were positively related to MVPA and negatively associated with sedentary behaviours. The positive association between hyperactivity and both fat-free mass and MVPA levels is similar but not entirely consistent with the findings of Ebenegger et al.[14] In a cross-sectional study of 2- to 6-year-old children, the authors found lower per cent body fat, measured with a bioelectrical impedance measurement device, and higher levels of physical activity among participants with high hyperactivity

scores. Our results extend the findings of Ebenegger et al. since we showed that hyperactivity was associated with fat-free mass rather than fat mass. Our results were also in line with Camfferman et al.,[23] who followed a cohort of children between 1 and 6 years of age. They reported that both BMI and behaviour problems were stable during these early years and that associations between behaviour problem and overweight during the preschool period were small.

The main findings thus highlight the critical question of *when* the dynamic interaction of psychological characteristics and body composition begins to fuel the development of overweight and obesity. Perhaps interaction effects from the environment begin to contribute exponentially in early school-age.[23] Indeed, symptoms of hyperactivity and inattention are often becoming more prominent between 5-10 years of age,[24] and this period coincides with crucial changes in the child's psychosocial environment. Some children might start life with a genetic predisposition for hyperactivity,[4] and some might also be subject to an early psychosocial and socioeconomic milieu that reinforces their innate temperament.[25] During the first years of life, and perhaps extending into the preschool period, these children are usually free to move more than an average child, and energy intake is, to a large extent, controlled by caretakers. Like the average participant in this study, many of these children might have a perfectly normal body composition or even healthier than average. When these children start school, they are forced to be more sedentary and begin to control portion sizes. They are also freer to find unhealthy snacks,

TABLE 3 Associations of Strengths and Difficulties Questionnaire Scores with health behaviours and diet

SDQ scores and subscales	MVPA (min/d)		Sedentary behaviour (min/d)		Fruit and vegetables (g/d)		Sugar-sweetened beverages (dL/d)	
	β	P	β	P	β	P	β	P
Total difficulties								
Unadjusted	0.05	.345	−0.10	.076	0.27	.643	0.02	.677
Adjusted[a]	0.06	.323	−0.11	.072	0.52	.364	−0.02	.790
Emotional problems								
Unadjusted	−0.07	.261	0.08	.169	−0.53	.360	0.01	.849
Adjusted[a]	−0.05	.370	0.08	.172	−0.52	.373	0.01	.922
Conduct problems								
Unadjusted	0.06	.291	−0.09	.136	−0.02	.746	0.01	.886
Adjusted[a]	0.06	.274	−0.09	.134	−0.01	.926	−0.01	.800
Hyperactivity								
Unadjusted	0.16	.004	−0.18	.002	0.11	.046	0.03	.563
Adjusted[a]	0.16	.003	−0.18	.001	0.15	.007	−0.02	.732
Peer problems								
Unadjusted	−0.10	.098	−0.02	.721	−0.03	.634	−0.01	.969
Adjusted[a]	−0.10	.083	−0.02	.726	−0.02	.681	−0.01	.905
Pro-social behaviour								
Unadjusted	−0.48	.405	0.13	.023	0.17	.765	−0.06	.258
Adjusted[a]	−0.05	.421	0.13	.024	0.008	.883	−0.06	.316

Abbreviations: MVPA, moderate-to-vigorous physical activity; SDQ, Strengths and Difficulties Questionnaire.

[a]Adjusted for mother's education attainment (university degree or not), sex and age of the child.

and some might have levels of impulsivity that result in overeating behaviours.[26] A resultant development of significant overweight could spark social difficulties, including exclusion and bullying,[27] struggles to participate successfully in sports, eroded self-esteem, anxiety and depression.[28] If the resulting emotional problems lead to overeating[26] as a way to soothe distress or loneliness, this vicious cycle could snowball into severe obesity and psychiatric diseases later during childhood or adolescence.[28]

Our results raise a second vital question of whether there are significant differences among subgroups of children with inattention and hyperactivity difficulties in the preschool phase of development. Perhaps a subset of children with isolated challenges in these domains continues to have a healthy body composition during the rest of childhood and into adult life. If this were indeed the case, it would be highly relevant to study how exactly they differ from peers who develop obesity. Thus, future research, with a longitudinal design, should study subgroups of these children with increased risk for obesity development and investigate whether there are differences in, for example appetite regulation, emotional stability, self-regulation and factors in their psychosocial environment. Indeed, there is preliminary evidence that overweight and obese children's impulsivity, propensity for overeating,[26] peer relations[28] and adverse social circumstances could explain why hyperactivity becomes a more significant risk factor during the second half of childhood.

The results of this study must be interpreted with several limitations in mind. Firstly, a direct comparison with studies of children with the clinical diagnosis of attention deficit hyperactivity disorder (ADHD) is not recommended. Although items in the hyperactivity subscale have a considerable overlap with clinical symptoms of ADHD, SDQ was designed as a screening tool, and the average study participant was in the normal range in all subscales.[17] Furthermore, while the SDQ scale has proposed cut-offs for probable clinical levels of difficulties, an ADHD diagnosis is most often given a child after careful evaluation from a multidisciplinary team of professionals.[13] With these caveats, we should note that the study population covered a wide variation in all investigated variables, including SDQ scores, and the proportion that scored above the cut-off for high likelihood of clinical diagnosis (7%) is in the same range as the observed prevalence of ADHD in the general population. Secondly, the self-report assessment of dietary intake, in the form of photos of meals taken by the parents, is also a limitation. Even though the method is validated in earlier studies, a bias from parent's awareness that their feeding was under observation could occur in this setting.

Thirdly, generalisations of results to the general population should be made with caution, since the participants in this study had well-educated mothers in a higher degree than the general population. Seventy-two per cent of the mothers in this population had a university degree, compared to the average Swedish

population, which was 49% (Statistical Agency Sweden). However, it is crucial to notice that our results remained after adjustments for the mother's education. These findings could be viewed as counter-arguments against the view that socioeconomic differences account for the whole association between hyperactivity and obesity development, although socioeconomic status certainly could be an important effect modulator.[11] It is also worthy of note that the prevalence of overweight and obesity in the study population was lower than the general population for 4-year-olds, although the difference was rather small (9% vs. 11%)[29]. The difference was actually smaller than the one between girls and boys (9% vs. 13%), and the study population contained children with both underweight and obesity.

The present study had several favourable characteristics. Overall the present study was conducted with validated and relevant outcome measures, and the size of the study population was adequately powered for the research question addressed. Our measurement of fat mass and fat-free mass, using an air-displacement plethysmograph,[18] provides additional information compared to the use of only BMI. Our findings of a statistically significant negative association between hyperactivity and fat-free mass thus represent an essential contribution to this area of knowledge.

The topic of time frames for obesity development has implications for future research. If there are critical thresholds in time, when a downward spiral gains momentum, they could also help researchers define specific periods as windows of opportunity for interventions to be introduced.[24] Furthermore, if there are certain psychosocial or environmental factors that help a subgroup of hyperactive children maintain healthy body composition into adolescence and adulthood, future studies should determine which of them matter the most. Such knowledge could also prevent the spending of limited healthcare resources on ill-timed interventions that, at best, are ineffective, but at worst, are harmful through reigniting a sense of hopelessness and frustration among children and their families. Finally, a complete understanding of the relationship between psychological factors and obesity could lead to interventions that ignite a reversed upward spiral of wholesome behaviours and psychological resilience.[30] Such progress is crucial if we are to find a way out of the global obesity crisis and its harmful health consequences.[1]

5 | CONCLUSIONS

This study of Swedish preschoolers showed that hyperactivity was associated with a higher fat-free mass index and high levels of moderate-to-vigorous physical activity, as well as lower levels of sedentary behaviours. These findings suggest that adverse health consequences of the tandem morbidities of hyperactivity and overweight might be established after the preschool period, which raises important questions about the time frame of contributing and modulating factors in obesity development, prevention, and treatment.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.