

# Quality of life improves in children and adolescents during a community-based overweight and obesity treatment

Pernille M. Møllerup<sup>1</sup> · Tenna R. H. Nielsen<sup>1,2</sup> · Christine Bøjsøe<sup>1,2</sup> · Julie T. Kloppenborg<sup>1,3</sup> · Jennifer L. Baker<sup>2,4</sup> · Jens-Christian Holm<sup>1,2,5</sup>

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## Abstract

**Purpose** The quality of life is compromised in children and adolescents with overweight or obesity. The aim of this study was to evaluate whether the quality of life improves during a community-based overweight and obesity treatment, and whether improvements depend on reductions in the degree of obesity.

**Methods** Quality of life was assessed using the Pediatric Quality of Life Inventory (PedsQL) 4.0 in children and adolescents aged 3–18 years with overweight or obesity [body mass index (BMI)  $\geq$ 85th percentile] upon entry into a community-based chronic care overweight and obesity treatment based upon The Children's Obesity Clinic's Treatment protocol, and upon follow-up after 10–30 months of treatment. Height and weight were measured at each consultation and converted into a BMI standard deviation score (SDS).

**Results** Upon entry, 477 children (212 boys) completed a PedsQL, and 317 (143 boys) completed another PedsQL after a median of 13 months of treatment. Quality of life improved ( $p < 0.001$ ), regardless of sex, age, and pubertal development stage upon entry ( $p \geq 0.108$ ). Greater reductions in BMI SDS and high socioeconomic status were associated with greater improvements in the quality of life ( $p \leq 0.047$ ). However, improvements also occurred in children and adolescents with low socioeconomic status or who increased their BMI SDS ( $p < 0.001$ ).

**Conclusions** Improvements in quality of life occurred in children and adolescents during a community-based overweight and obesity treatment, even in children and adolescents who increased their BMI SDS. Thus, improvements may be due to the treatment itself and not exclusively to reductions in BMI SDS.

**Trial registration** Clinicaltrials.gov, ID-no.: NCT02013843.

✉ Pernille M. Møllerup  
Pmm@regionsjaelland.dk

<sup>1</sup> Department of Paediatrics, The Children's Obesity Clinic, Copenhagen University Hospital Holbæk, Smedelundsgade 60, 4300 Holbæk, Denmark

<sup>2</sup> The Novo Nordisk Foundation Center for Basic Metabolic Research, Section for Metabolic Genetics, University of Copenhagen, Universitetsparken 1, 2100 Copenhagen, Denmark

<sup>3</sup> Department of Paediatrics, Copenhagen University Hospital Herlev, Herlev Ringvej 75, 2730 Herlev, Denmark

<sup>4</sup> Institute of Preventive Medicine, Bispebjerg and Frederiksberg Hospital, The Capital Region, Nordre Fasanvej 57, 2000 Frederiksberg, Denmark

<sup>5</sup> Faculty of Health and Medical Sciences, University of Copenhagen, Blegdamsvej 3B, 2200 Copenhagen, Denmark

**Keywords** Adolescent · Child · Community health services · Obesity · Overweight · Quality of life

## Abbreviations

BMI	Body mass index
PedsQL	Pediatric Quality of Life Inventory
Qol	Quality of life
SDS	Standard deviation score
TCOCT	The Children's Obesity Clinic's Treatment

## Introduction

The quality of life (Qol) may be compromised in children with overweight or obesity even at young ages [1]. In adolescents with severe obesity, the Qol may be as low as the Qol in adolescents treated for cancer [2]. Thus, a

compromised QoL constitutes a critical part of the overweight- and obesity-related psychosocial complications in children and adolescents, and improving the QoL is essential in the treatment of child and adolescent overweight and obesity [1, 2]. Due to the pandemic of child and adolescent overweight and obesity [3], treatment programs are faced with a need for improvements in availability and accessibility [4]. Community-based treatment options may help meet these needs [4], but whether the results of effective hospital-based treatment protocols can be transferred to the community healthcare setting is unknown [5], and few studies have investigated if community-based treatment programs result in an improved QoL [6, 7]. A study of 115 children aged 6–17 years found improvements in QoL after a 6-month program [7], and another study of 24 children aged 6–13 years found improvements in QoL after a 16-week program [6]. However, larger studies are needed to confirm these results.

Intuitively, improvements in QoL attained by overweight and obesity treatment are associated with the reductions in body mass index (BMI) standard deviation score (SDS) [8]. Nonetheless, a hospital-based obesity treatment of 267 children and adolescents aged 8–18 years resulted in improvements in QoL despite only slight reductions in BMI SDS [9]. Similarly, another hospital-based obesity treatment of 707 children and adolescents aged 7–20 years resulted in improvements in QoL, but these improvements were not associated with the reductions in BMI SDS [10]. Hence, improvements in QoL during overweight and obesity treatment may not exclusively be attributed to the weight loss.

If associations between improvements in QoL and weight reductions are not straightforward, the influence of other factors may be considered. For example, the QoL may be lower in girls than in boys [11–14] particularly in adolescents [15], though this difference may be less certain in children and adolescents with overweight or obesity [11, 14, 16]. Similarly, the QoL may be lower in older children and adolescents compared with younger children [12, 17, 18]. Early adolescence may be associated with a pronounced decline in the QoL, and [14, 15] this may be due to growth and pubertal development, which may have a greater impact in girls than in boys [17]. Moreover, low socioeconomic status may be associated with a compromised QoL in children and adolescents [15]. However, whether these factors impact the changes in QoL during overweight and obesity treatment is unknown.

In this study, we investigated, if improvements in QoL would occur in children and adolescents enrolled in a community-based chronic care overweight and obesity treatment for more than 10 months. We investigated if the QoL upon entry was associated with the BMI SDS, if the changes in QoL upon follow-up were associated with the changes in BMI SDS, and if improvements in QoL would

occur in children and adolescents who did not reduce their BMI SDS. To elucidate the influence of sex, age, pubertal development stage, and socioeconomic status, we investigated if the QoL upon entry or the changes in QoL upon follow-up were associated with these factors.

## Methods

### Patients

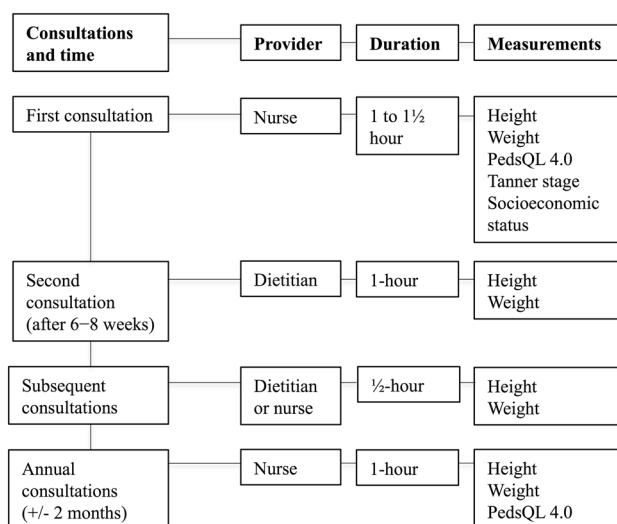
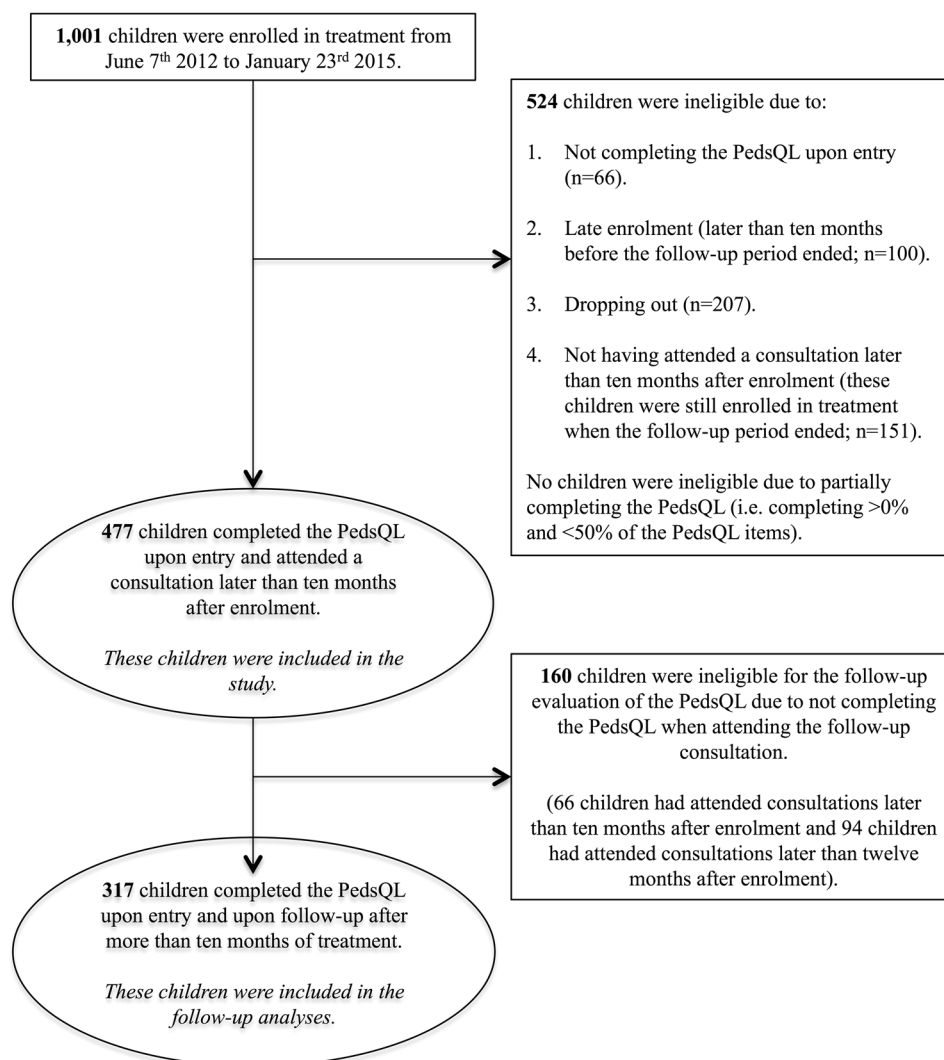
This observational study included children and adolescents, who entered into a community-based overweight and obesity treatment program from June 7th, 2012 to January 23rd, 2015 (Fig. 1). The follow-up period ended on March 14th, 2015. Criteria for entering into treatment were an age from 3 to 18 years and a BMI  $\geq$  85th percentiles according to age- and sex-specific Danish references [19, 20]. No other eligibility criteria for entering into treatment were applied.

Children and adolescents were eligible for this study if they completed a Pediatric Quality of Life Inventory (PedsQL) 4.0 [21] within 2 months after their enrolment and attended a follow-up consultation placed more than 10 months after enrolment. Children and adolescents were included in the follow-up analyses of the PedsQL scores, if they completed another PedsQL at a follow-up consultation placed more than 10 months after enrolment. If more than two PedsQLs were completed by the same child or adolescent, the results of the first and the latest completed PedsQLs were included in the analyses. At least 50% of the items in each PedsQL had to be completed for the PedsQL scores to be calculated [21].

### The obesity treatment program

The treatment program was based upon The Children's Obesity Treatment (TCOCT) protocol which is described in detail elsewhere [22]. When delivered at hospitals, the TCOCT protocol results in reductions in BMI SDS [22, 23], degree of dyslipidaemia [24], degree of hypertension [25], and ectopic fat in the liver and muscles, and the drop-out rate is low [26]. In brief, the TCOCT protocol builds upon the understanding of obesity as a complex and chronic disease [27] influenced by a tight neuroendocrine regulation of fat mass [28], and accompanied by a multitude of medical and psychosocial complications [2, 29]. Thus, a comprehensive and chronic care treatment is required [27].

The treatment program was delivered by nurses and dietitians at community healthcare centers across Denmark (Fig. 2). The treatment was family-centered and began with a questionnaire-based interview, through which comprehensive knowledge about the families' intake at all

**Fig. 1** Inclusion and follow-up on children and adolescents in this study**Fig. 2** The community-based treatment program

meals, physical activities, psychosocial wellbeing, sedentary behaviours, sleep times, and school attendance, was acquired. Based upon this, an individualised treatment plan consisting of 10–20 items of advice regarding lifestyle changes was produced, and the families were instructed in how to implement them immediately. The recognition of overweight and obesity as a disease [27] and the presence of biological mechanisms counteracting weight loss [28] were carefully communicated to all families in layman's terms to provide an understanding of why an individual may struggle with weight loss and why introducing multiple lifestyle changes is important. Subsequent consultations were scheduled with a nurse and a dietitian in turn, and at all consultations, the treatment plan was evaluated and adjusted. If any lifestyle changes were not implemented initially, these were focused upon in subsequent consultations. Examples of lifestyle changes were changes in allowances, dietary intake at all meals, lunch bags, physical activities, screen time and other sedentary behaviours, sleep time,

social activities, and means of transportation. The frequency of consultations was individualised, but an average of four-to-six consultation hours were invested in the treatment of each child and family per year. The treatment program continued until normal weight was achieved (BMI SDS < 85th percentile [19, 20]), until the child turned 19 years, or until the families discontinued treatment at their own wish or repeatedly neglected appointments.

### Quality of life

The QoL was evaluated using the PedsQL 4.0, which is a 23-item questionnaire assessing physical, emotional, social, and school functioning [21, 30]. The PedsQL 4.0 was chosen due to the wide age-range from 2 to 18 years, the availability of a linguistically validated Danish version, and the thorough validation studies. Cross-sectional studies demonstrated internal consistency coefficients (Cronbach's  $\alpha$ ) above 0.70 across age groups, and the PedsQL scores discriminated healthy children and adolescents from children and adolescents with acute or chronic diseases [30, 31]. Furthermore, a longitudinal study demonstrated that changes in PedsQL scores after 1 year were likely to represent real changes rather than differences in the interpretation of the PedsQL items [32].

All families were asked to complete the PedsQL at the initial and annual consultations. However, completing the PedsQL or not had no consequences for the treatment offered. The PedsQL is age-specific with the age groups: 2–4, 5–7, 8–12, and 13–18 years. The parents completed the questionnaire for the 2–4-year-old children, whereas children aged 5–18 years completed the questionnaires themselves. For the children aged 5–7 years, the questionnaire was read aloud by the parents, but was not further explained [21]. The parents of the 2–4-year-old children and the children and adolescents aged 8–18 years were asked to answer how much of a problem each of the 23 items had been during the past month. The rating scale was: 0 = never a problem, 1 = almost never, 2 = sometimes, 3 = often, or 4 = almost always. For the 5–7-year-old children, the rating scale was: 0 = not at all a problem, 2 = sometimes, or 4 = a lot, and the ratings were supplemented with a smiling, a neutral, or a sad face [21]. The PedsQL ratings were transformed to a score on a 0–100 scale (0 = 100, 1 = 75, 2 = 50, 3 = 25, and 4 = 0) with a higher score indicating a better QoL. A physical score was calculated as the mean of eight scores. Similarly, emotional, social, and school scores were calculated as the mean of five scores each. A total score was calculated as the mean of all 23 scores, and a psychosocial score was calculated as the mean of the 15 scores comprising the emotional, social, and school scores. At least 50% of the items comprising each mean score had to be completed for the mean score to be calculated [21].

### Anthropometrics

At each consultation, height was measured to the nearest 0.1 cm using a Tanita® HR100 stadiometer (Tanita Corp. Tokyo, Japan) and weight was measured to the nearest 0.1 kg on a Tanita® BC418 scale (Tanita Corp. Tokyo, Japan). The children and adolescents wore light indoor clothes and no shoes during the measurements. BMI was calculated as weight in kilograms divided by height in metres squared and converted into a standard deviation score (SDS) using the LMS method [33] based upon Danish references [19].

### The pubertal development stage

Stage of pubertal development was self-reported according to the Tanner stages [34, 35] guided by a depiction of the stages of pubertal development and written instructions [36]. Questions regarding menarche were asked, and if it had occurred, the girl was considered pubertal [34]. If the questionnaire was not completed, girls < 8 years and boys < 9 years were considered pre-pubertal [37].

### Socioeconomic status

At the initial consultation, information on current occupations was reported by the parents, and socioeconomic status was categorized in accordance with Statistics Denmark's national classification scheme, defining five groups with one being the highest and five being the lowest. The classification scheme uses the Danish version of the International Standard Classification of Occupation (ISCO-88) [38].

### Ethical considerations

Children and adolescents gave informed consent and their parents signed a written consent before enrolment. The study was approved by the regional Danish Ethics Committee (Protocol ID SJ-104) and the Danish Data Protection Agency. Clinicaltrials.gov, ID-no.: NCT02013843.

### Statistics

Statistics were performed using *R* (Version 3.2.2) [39]. Using the Wilcoxon signed rank test and the Chi-squared test, sex, baseline age, BMI SDS, socioeconomic status, and Tanner stage were compared in eligible and ineligible children and adolescents, and in children and adolescents who completed or did not complete the PedsQL upon follow-up. Using the Wilcoxon signed rank test, baseline PedsQL scores and reductions in BMI SDS were compared in the children and adolescents who completed or did not complete the PedsQL at follow-up.

Within-subject changes in BMI SDS and PedsQL scores upon follow-up were analysed using the paired T test. A 4.4-point change has been suggested as clinically relevant [30]. Hence, the percentage of children and adolescents achieving an improvement in total score  $\geq 4.4$  points was calculated.

Associations of the total score upon entry with the BMI SDS, sex, age, Tanner stage, and socioeconomic status were analysed using bivariate regression analyses (basic models) and using multiple regression analyses, including all factors (adjusted model). Associations of the total score upon entry with sex were analysed in young children (age below median age) or older children and adolescents. To examine if the association between QoL upon entry and Tanner stage differed in boys and girls, an interaction term between Tanner stage and sex was included in the adjusted model. Associations of changes in total score with changes in BMI SDS, sex, age, Tanner stage, and socioeconomic status were analysed separately using multiple regression analyses adjusted for the total score upon entry and the time to follow-up (basic models). The same associations were analysed using multiple regression analyses, including all factors, and adjusted for total score upon entry and time to follow-up (adjusted model). Basic and adjusted models of associations with changes in BMI SDS were adjusted for the BMI SDS upon entry. In all analyses, socioeconomic status and Tanner stages were dichotomised: moderate-to-high socioeconomic status (1–3) or low socioeconomic status (4–5), and pre-pubertal (Tanner stage 1) or pubertal and post-pubertal (Tanner stages 2–5).

Sensitivity analyses were performed, in which children and adolescents who changed PedsQL age group upon follow-up were excluded.

## Results

During the study period, 1,001 children and adolescents consecutively entered treatment, of whom 524 children and adolescents were ineligible for inclusion in this study (Fig. 1). Ineligible children and adolescents had lower socioeconomic status than eligible children and adolescents ( $n=477$ ,  $p=0.037$ ), but no differences were found with regards to sex ( $p=0.645$ ), age ( $p=0.143$ ), BMI SDS ( $p=0.093$ ), or Tanner stage ( $p=0.451$ ). Children and adolescents who completed the PedsQL upon follow-up ( $n=317$ ) reported higher total, physical, and emotional scores upon entry, than those who did not complete the PedsQL upon follow-up ( $n=160$ , all  $p \leq 0.023$ ; Table 1), but no differences were found for psychosocial, social, or school scores (all  $p \geq 0.120$ ). Likewise, no differences were found with regards to sex, age, BMI SDS, socioeconomic status, Tanner stage, or the mean reductions in BMI SDS

upon follow-up (all  $p \geq 0.140$ ). All children and adolescents included in this study completed enough PedsQL items for each of the PedsQL scores to be calculated.

## Changes in QoL

After a median of 13 months of treatment (range 10–30 months), the mean values of all PedsQL scores had improved (all  $p < 0.001$ ; Fig. 3). The total score had improved by a mean of 4.1 points (95% CI 2.9–5.4,  $p < 0.001$ ). The total score improved in 204 (64.3%) children and adolescents, and in these children and adolescents, the mean improvement was 10.3 points (95% CI 9.2–11.2,  $p < 0.001$ ). 152 (49%) children and adolescents improved their total score by  $\geq 4.4$  points.

## QoL and BMI SDS

Upon entry, the total score was inversely associated with the BMI SDS ( $p < 0.001$ ; Table 2), and upon follow-up, changes in the total score were inversely associated with changes in BMI SDS, regardless of sex, age, and Tanner stage ( $p < 0.001$ ; Fig. 4). Children and adolescents who reduced their BMI SDS ( $n=249$ , 79%) improved their total score by 4.7 (95% CI 3.4–6.1,  $p < 0.001$ ) and children and adolescents who increased their BMI SDS ( $n=68$ , 21%), improved their total score by 2.8 (95% CI 2.2–5.4,  $p < 0.001$ ).

## QoL and sex

Neither the total score upon entry nor the change in total score upon follow-up was associated with sex ( $p=0.413$  and  $p=0.366$ , respectively; Table 2). This did not change when addressing the total score in younger or older children and adolescents separately ( $p \geq 0.191$ ).

## QoL and age

Upon entry, the total score was inversely associated with age ( $p=0.046$ ; Table 2). Upon follow-up, the total score was improved regardless of the age upon entry into treatment ( $p=0.108$ ).

## QoL and Tanner stage

Upon entry, the total score was not associated with Tanner stage ( $p=0.841$ ; Table 2). Upon follow-up, the total score was improved independently of the Tanner stage upon entry into treatment ( $p=0.901$ ). A statistically significant interaction was not found between Tanner stage and sex ( $p=0.854$ ).

**Table 1** Characteristics of the study population

	Patients included in follow-up analyses of PedsQL	Patients not included in follow-up analyses of PedsQL	<i>p</i> value
<i>N</i> (boys)	317 (143)	160 (69)	0.866
Age (years)	10.6 (3.5–17.5)	11.0 (3.3–18.4)	0.252
BMI SDS	2.54 (1.10–5.40)	2.65 (1.30–6.64)	0.140
Tanner stage			
Boys	2 (1–5) ( <i>n</i> = 116)	2 (1–5) ( <i>n</i> = 58)	
Pre-pubertal	54 (47%)	26 (45%)	0.932
Pubertal/post-pubertal	62 (53%)	32 (55%)	
Girls	2 (1–5) ( <i>n</i> = 171)	2 (1–5) ( <i>n</i> = 85)	
Pre-pubertal	49 (29%)	28 (33%)	0.588
Pubertal/post-pubertal	122 (71%)	57 (67%)	
Socioeconomic status	3 (1–5) ( <i>n</i> = 306)	3 (1–5) ( <i>n</i> = 150)	
Moderate to high	217 (71%)	97 (65%)	0.213
Low	89 (29%)	53 (35%)	
Change in BMI SDS	−0.34 (−1.20 to −2.00)	−0.21 (−0.93 to −2.50)	0.117
PedsQL scores upon entry			
Total score	78.3 (39.1–100)	75.0 (35.9–100)	<b>0.014</b>
Psychosocial score	75.0 (33.3–100)	73.3 (28.3–100)	0.120
Physical score	84.4 (21.9–100)	81.3 (28.1–100)	<b>&lt;0.001</b>
Emotional score	75.0 (15.0–100)	70.0 (25.0–100)	<b>0.023</b>
Social score	85.0 (10.0–100)	85.0 (10.0–100)	0.591
School score	65.0 (12.5–100)	66.7 (0.0–100)	0.647

Bold values indicate ( $p < 0.05$ )

The characteristics are presented as medians with ranges and as numbers with percentages

Age, BMI SDS, change in BMI SDS, and PedsQL scores were compared using the Wilcoxon signed rank test. Sex, Tanner stage, and socioeconomic status were compared using the Chi-squared test

*BMI SDS* body mass index standard deviation score

## Qol and socioeconomic status

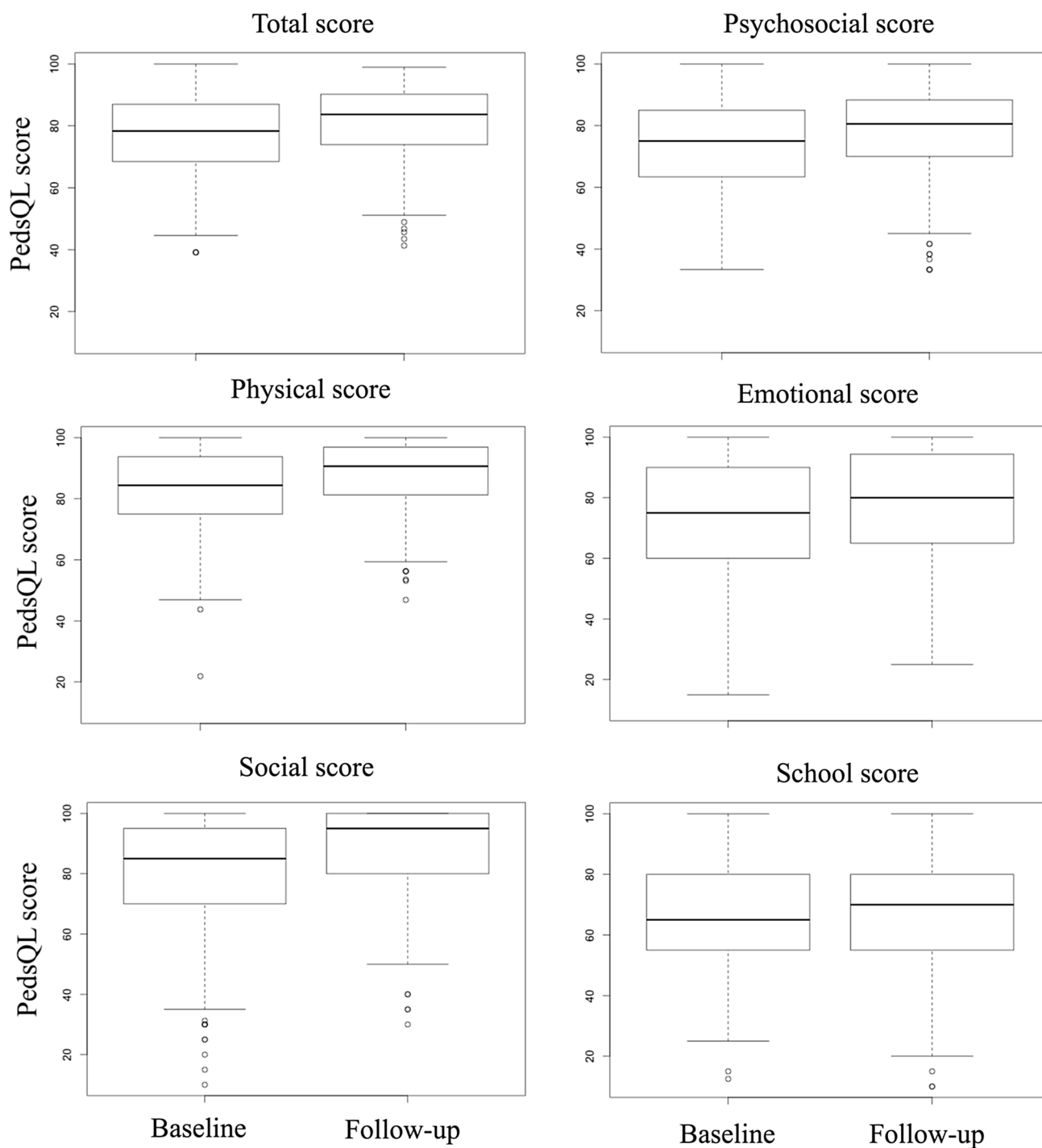
Upon entry, the total score did not depend on socioeconomic status ( $p = 0.281$ ; Table 2). Upon follow-up, moderate-to-high socioeconomic status was associated with a 2.3 points greater improvement in the total score compared with low socioeconomic status. Children and adolescents with low socioeconomic status ( $n = 89$ , 29%) improved their total score by 3.8 points (95% CI 1.2–6.8,  $p < 0.001$ ), and children and adolescents with moderate-to-high socioeconomic status ( $n = 217$ , 71%) improved their total score by 4.1 (95% CI 2.7–5.5,  $p < 0.001$ ).

## Sensitivity analyses

Excluding the 82 children and adolescent who changed PedsQL age group upon follow-up did not change the results (data not shown).

## Discussion

We found that improvements in Qol occurred in children and adolescents treated in this community-based chronic care overweight and obesity treatment program. Upon entry, Qol was inversely associated with BMI SDS and age but was not associated with sex, socioeconomic status, or Tanner stage. Upon follow-up after more than 10 months of treatment, greater improvements in Qol were associated with greater reductions in BMI SDS and with higher socioeconomic status, independently of sex, age, and Tanner stage. However, notably, improvements in Qol also occurred in the children and adolescents who increased their BMI SDS and the children and adolescents with low socioeconomic status.



**Fig. 3** Tukey boxplots illustrating the PedsQL scores at enrolment (baseline) and upon follow-up. *Boxes* display medians and interquartile ranges, *whiskers* display 1.5 interquartile ranges, and outliers are

marked with *circles*. Mean values of all PedsQL scores were significantly higher at follow-up ( $p < 0.001$ )

### Changes in QoL

The improvements in QoL demonstrated in this observational study suggest that community-based overweight and obesity treatment can improve QoL in children and

adolescents. A 4.4-point change has been suggested as clinically relevant [30] and 49% of the participants in this study fulfilled this criterion. Nonetheless, we suggest that any improvement in QoL represents a positive change and thus is clinically relevant.

**Table 2** Associations of PedsQL total scores with BMI SDS, sex, age, Tanner stage, and socioeconomic status

Total score upon entry ( <i>n</i> = 477)	Basic models <sup>a</sup>			<i>R</i> <sup>2</sup>	Adjusted models <sup>b</sup>			<i>R</i> <sup>2</sup>
	$\beta$	95% CI	<i>p</i> value		$\beta$	95% CI	<i>p</i> value	
BMI SDS	−3.0	−4.5 to −1.4	<b>&lt;0.001</b>	0.03	−3.5	−5.3 to −1.7	<b>&lt;0.001</b>	0.04
Sex	0.7	−1.7 to 3.0	0.572	0.00	−1.1	−3.9 to 1.5	0.413	
Age	−0.5	−0.9 to 0.13	<b>0.010</b>	0.01	−0.6	−1.1 to 0.0	<b>0.046</b>	
Tanner stage	−1.4	−3.9 to 1.03	0.249	0.00	−0.4	−3.8 to 3.1	0.841	
Socioeconomic status	−2.3	−4.8 to 0.23	0.075	0.00	−1.4	−4.1 to 1.2	0.281	
Changes in total score upon follow-up ( <i>n</i> = 317)	Basic models <sup>c</sup>			Adjusted models <sup>d</sup>				
BMI SDS change	4.0	1.9 to 6.1	<b>&lt;0.001</b>	0.36	3.7	1.6 to 5.9	<b>&lt;0.001</b>	0.40
Sex	−0.2	−2.2 to 1.8	0.848	0.32	−1.0	−3.2 to 1.2	0.366	
Age	0.3	0.0 to 0.7	0.079	0.33	0.4	−0.1 to 0.1	0.108	
Tanner stage	1.9	−0.3 to 4.0	0.085	0.36	−0.2	−3.2 to 2.8	0.901	
Socioeconomic status	−2.2	−4.4 to 0.12	0.064	0.32	−2.3	−4.5 to 0.0	<b>0.047</b>	

Bold values indicate ( $p < 0.05$ )

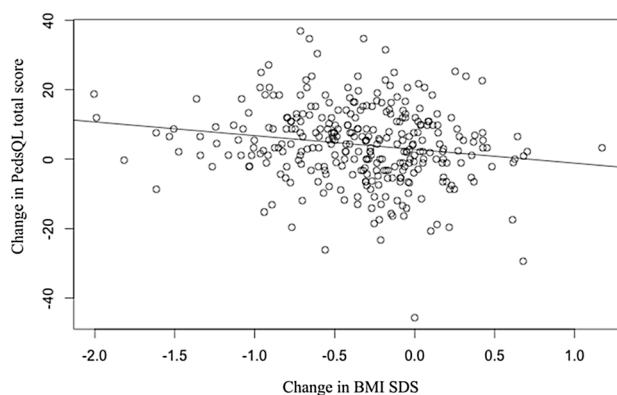
*R*<sup>2</sup>: Adjusted R-squared. BMI SDS: body mass index standard deviation score. Definition of variables (reference variable\*): BMI SDS\*. Sex: boys\* or girls. Age: years\*. Tanner stage: pre-pubertal\* or pubertal/post-pubertal. Socioeconomic stage: low or moderate to high\*

<sup>a</sup>Bivariate regression analyses

<sup>b</sup>Multiple regression analyses with all factors

<sup>c</sup>Multiple regression analyses adjusted for total score upon entry and the time to follow-up. Analyses of BMI SDS changes were adjusted for BMI SDS upon entry

<sup>d</sup>Multiple regression analyses with all factors and adjusted for total score and BMI SDS upon entry and the time to follow-up



**Fig. 4** Associations of changes in PedsQL total score with changes in BMI SDS upon follow-up

## Qol and BMI SDS

The inverse association between the Qol and the BMI SDS is consistent with the literature [40–44]. This study did not include children and adolescents with normal weight. Nonetheless, our results are similar to a study of 1099 children aged 9–12 years in Australia, where means of 79.7 and 75.6 points were found in children with overweight and obesity, respectively, compared with a mean of 80.8 points in children with normal weight [41]. Importantly, the Qol may be lower in treatment seeking than in non-treatment

seeking children and adolescents with overweight or obesity [45, 46], and thus, our results may not be generalizable to all children and adolescents with overweight or obesity.

We have no information about why improvements in the Qol occurred in the children and adolescents who increased their BMI SDS. Introducing physical activity may improve the Qol in children and adolescents [10] and may result in a stabilised BMI SDS despite reductions in fat mass [47]. Hence, the improvements in Qol may be due to improvements in body composition that are not reflected by reductions in the BMI SDS. The treatment itself may also have a positive impact beyond reductions in BMI SDS [48]. The recognition of the biological mechanisms counteracting weight loss [28] implies that failure to attain weight loss may result from biological regulations and not from the commonly assumed reason of personal failure. This non-judgemental understanding may be important as to why children and adolescents who do not reduce their BMI SDS may still improve their Qol.

## Qol and sex

Several studies found a lower Qol in girls than in boys [11–13, 15, 49]. However, in Australia, a study of 2353 children aged 12 years found a compromised Qol in boys with obesity, but not in girls [16]. Similarly and also in Australia, a study of 4743 children and adolescents aged

12–20 years found greater impairments in the QoL in boys than in girls with overweight and obesity [14]. Hence, the difference between the QoL in boys and girls may be less pronounced in children and adolescents with overweight and obesity, which may explain why we did not find a difference in QoL between boys and girls in this study. Importantly, upon follow-up, the QoL was improved regardless of the sex.

### QoL and age

The inverse association between QoL and age has been found by others as well [12, 13, 17, 49] and may be due to an increased awareness of physical appearance and thus of obesity-related stigmatisation [50]. Notably, the improvements in QoL during treatment were not associated with age, suggesting that younger and older children and adolescents may benefit from overweight and obesity treatment.

### QoL and Tanner stage

Similarly, we found that improvements occurred regardless of the stage of pubertal development. We did not assess the QoL upon follow-up and thus we cannot know if the transition into puberty during overweight and obesity treatment may influence the improvements in QoL. However, even though the adolescence may be associated with a decline in QoL [16], the results of this study suggest that the stage of pubertal development did not impact on the QoL.

### Socioeconomic status

We did not find an association between QoL upon entry and socioeconomic status. However, the smaller improvements in children and adolescents with low socioeconomic status suggest that these children and adolescents may constitute a vulnerable group who may face barriers in their responses to overweight and obesity treatment for this outcome [51]. Nonetheless, our results suggest that improvements are feasible despite these barriers.

### Strengths and limitations

The strengths of this study are the relatively large number of children and adolescents included in the study and the long follow-up period. A limitation is that some children and adolescents were ineligible for inclusion in the study. However, only the socioeconomic status and the PedsQL scores in the domains of total, physical and emotional function upon entry differed. Some children and adolescents did not complete the PedsQL upon follow-up, and reasons for this were not recorded. Not completing the PedsQL may be due to failure in improving QoL. However, the reductions

in BMI SDS did not differ in those who completed the PedsQL and those who did not complete the PedsQL upon follow-up. The follow-up period was not standardized, but ranged from 10 to 30 months. Hence, this was adjusted for in the statistical analyses. Typically, obesity treatment results in an initial rapid weight loss followed by a stabilised weight or a weight regain [28, 52]. Thus, to capture the long-term treatment effects, and not the effect of an initial rapid weight loss, we evaluated the changes after more than 10 months of treatment. The ability of the PedsQL to assess changes in QoL after 1 year has been documented [32]. This study evaluated changes after up to 30 months, and hence, a high percentage of children may have changed PedsQL age group thus completed a different PedsQL upon follow-up. However, the exclusion of these children and adolescents in the statistical analyses did not change the results. Information about enrolment of siblings or the occurrence of “life events” was not recorded, and thus, we were unable to adjust for this. However, while such circumstances may impact the results of treatment, they are also inevitable in a clinical reality. The stage of pubertal development was self-reported, and this method may be less accurate than assessment by an experienced paediatrician [53, 54]. However, this community-based treatment program did not employ paediatricians.

The study was observational, and thus, we cannot conclude that the improvements are a result of the treatment *per se*. However, without treatment, the children and adolescents are likely to remain overweight or obese [55], and thus without treatment, their QoL may likely remain compromised as well [56]. The choice of this non-controlled design was motivated by a lack of community-based child and adolescent overweight and obesity standard care treatment program in Denmark, and furthermore, we found it unethical to randomise to no treatment or to a waiting list [57]. Often, overweight and obesity treatment programs are evaluated in highly controlled academic settings with several exclusion criteria to ensure uniform study populations, and the advantages of this are obvious. Nonetheless, it may also limit the applicability in the daily clinical practise. In this study, we evaluated a community-based treatment modality designed to continue past this study period without prior exclusion of children and adolescents. Thus, the results represent an actual daily practise of a community-based child and adolescent overweight and obesity treatment.

### Conclusion

Our results suggest that improvements in the QoL can occur during community-based child and adolescent overweight and obesity treatment regardless of sex, age, and Tanner

stage, and even in children and adolescents who increase their BMI SDS. Thus, improvements may be due to the treatment itself and exclusively to reductions in BMI SDS.

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#### Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. (The regional Danish Ethics Committee Protocol ID: SJ-104).

**Informed consent** Informed consent was obtained from all individual participants included in the study.

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