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Psychosocial measures and weight change in a clinical paediatric population with obesity

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Abstract

Purpose Poor quality of life has been shown to occur in youth with obesity. This study aimed to assess associations between health-related quality of life, general mental health and general psychological distress measures, collectively termed psychosocial health questionnaires (PSH), with weight outcomes in a busy paediatric weight management service.

Methods A cross-sectional longitudinal clinical cohort, 'Childhood Overweight BioRepository of Australia (COBRA)', was used ($n = 250$, median age 11, range 2–18 year, mean BMI z-score 2.5 ± 0.2). Clinical data were collected and HRQOL questionnaires; Pediatric Quality of Life 4.0 (PedsQL), 'Sizing Me/Them Up' (SMU/STU), and psychological well-being questionnaires; strengths and difficulties questionnaire (SDQ) and Kessler 10 (K10) were completed by the child and primary caregiver. PSH results were compared to age- and sex-adjusted BMI z-score at baseline and follow-up. Direct logistic regression modelling was performed to assess the impact of PSH factors on the likelihood of successful weight reduction over a period of ≥ 12 months.

Results Mean self-report PSH scores were: 68.0 ± 15.28 (PedsQL, range 0-100), 64.8 ± 15.8, (SMU, range 0-100), 17.3 ± 4.4 (SDQ, range 0–40) and 20.0 ± 7.7 (K10, range 0–50). A significant negative correlation was observed between PSH scores and childhood obesity (baseline BMI z-scores ($p < 0.01$)). No correlations were observed between psychological well-being measures and BMI z-scores. Higher subscale scores of the PedsQL and SDQ, which measure impaired psychosocial health and more difficulties with hyperactivity and inattention, significantly predict weight loss in children with obesity after 12 months.

Conclusion PSH questionnaires may be useful in identifying individuals who require additional support to achieve weight loss goals in a tertiary weight management service.

Keywords Paediatric obesity · Health-related quality of life · Weight management

Introduction

Childhood and adolescent overweight and obesity are major public health concerns with prevalence reaching over 25% in many developed countries [1]. Overweight and obesity are significantly associated with poor psychosocial health (PSH) and health-related quality of life (HRQOL) in both the 'functioning and disability' and 'contextual behaviour' domains

Brooke E. Harcourt and Anke Pons have contributed equally to this work.

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(as summarised by the WHO ICF for Children and Youth, Fig. 1, [2]). Severe obesity in childhood has previously been reported as being similarly detrimental to HRQOL as childhood cancer in a clinical population [3, 4]. However, it is unknown whether specific domains or 'psychosocial health' as a whole might influence treatment outcomes for youth with obesity.

HRQOL can be measured via generic questionnaires [5–7] or by disease-specific questionnaires [8, 9], allowing comparison with lean participants and between disease states, or via the latter assessing disease-specific effects of obesity in clinical populations. Domains of HRQOL are further categorised into physical functioning, social functioning and emotional functioning. Studies consistently report that not only do youth with obesity have impaired physical functioning when compared with study participants of lean or average weight [3, 5, 9–15], but functional decline and quality of life is inversely proportional to degree of obesity [10, 14]. Negative relationships have also been shown to exist between degree of obesity and psychosocial functioning [14] particularly, social function [3, 5, 9, 16]. It is known that the degree of social and emotional support has a positive effect on PSH [10, 15, 17], and there is a consensus that obesity is a potential factor for diminished mental health in children and adolescents [18].

Consistent long-term predictors of weight loss success from previous studies include successful weight loss in the first 3 months and higher scores relating to hyperactivity-inattention status [19–22]. Furthermore, weight loss has been found as having a positive influence on PSH [23], however, the converse remains unknown, i.e., Do the domains of PSH have a positive or negative influence on the potential success of weight management interventions? Therefore, the aim of this study was to assess PSH measures in a treatment seeking paediatric population with overweight and obesity, and in retrospect address whether the questionnaires could be useful for baseline prediction of weight loss outcomes. A secondary aim was to identify specific PSH domains that may be useful in identifying those who may need psychological support through a weight management service (WMS). We utilised both general paediatric QOL questionnaires and disease-specific questionnaires through self- and proxy-administration.

Methods

Study design

Children and adolescents referred to the multidisciplinary WMS at The Royal Children's Hospital (Melbourne, Australia), were screened for inclusion suitability for the Childhood Overweight BioRepository of Australia (COBRA) study [24]. Participants were sent study materials for completion prior to their appointment, so that answers could not be influenced by advice given at the appointment. Participants and guardians were advised that an estimated 30–45 min were required for completion of questionnaires. At the initial WMS visit, the following aspects were assessed: medical history, auxological measurements (weight, height, waist circumference, bioimpedance and pubertal stage), medical examination, blood pressure and routine biochemical tests. COBRA participants (child and parent/primary caregiver) were then asked to complete four PSH questionnaires; two HRQOL questionnaires: the PedsQL 4.0 questionnaire which measures generic HRQOL and the "Sizing Me/Them

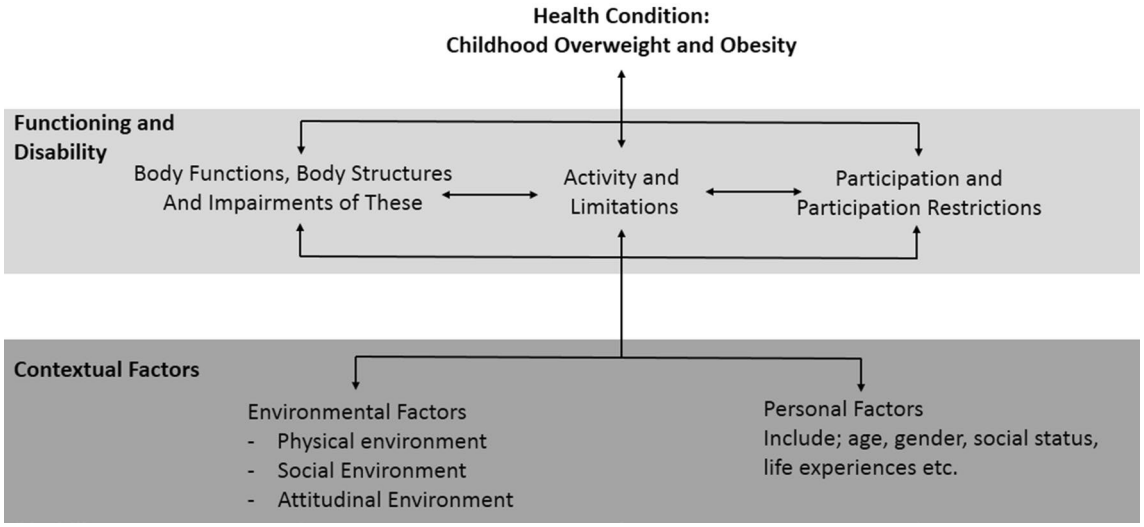

Fig. 1 International classification of functioning, disability and health for children and youth, modified from [2]

Up" questionnaire which measures obesity-specific HRQOL domains and; two generic mental health and psychological stress questionnaires: the 'strengths and difficulties questionnaire (SDG)' and the 'Kessler-10 (K10)'. Inclusion criteria for this study was enrolment between April 2009 and June 2018 and completion of at least one of the four psychosocial questionnaires. Informed consent to participate in this study was obtained from participants' guardians, and participants ≥ 16 years and their guardians, and assent was gained from all participants ≥ 11–16 years. This study was conducted in accordance with guidelines stipulated by, The Royal Children's Hospital Human Research Ethics Committee (RCH HREC Ref#28081, Melbourne, Australia).

Auxology

Patient's height was measured via stadiometer to the nearest 0.1 cm. Patient's weight (to the nearest 0.01 kg) and total body fat percentage were measured via four-point bioimpedence body composition analyser (Tanita BC-418, Tanita Corporation, Tokyo, Japan). Body mass index *z*-score (BMI-Z) is the most common measure of adiposity in paediatric clinical and research settings as it adjusts for sex- and age-specific growth patterns. BMI *z*-scores were calculated from date of birth, sex, height and weight data using the US Centre for Disease Control reference values [25] via the 'zanthro' function from the STATA Version 14 (Statacorp LP, College Station, TX, USA). Waist circumference was measured to the nearest 0.1 cm using the midpoint between the bottom of the ribs and top of the hip bone. Pubertal stages were determined clinically by a specialist paediatric endocrinologist and categorised into pre, peri or post-pubertal stages according to the Tanner method [26, 27].

Weight management service

Weight management interventions at the Royal Children's Hospital WMS are not standardised but individually prescribed to meet patients' needs by a specialist multidisciplinary team that includes specialist paediatric endocrinologists, general paediatricians, paediatric dietitian, paediatric psychologist, social workers and clinical nurse. Interventions include individualised medical treatment for any complications; healthy eating education and individual caloric restrictive advice or meal plans; lifestyle advice including exercise, sleep and screen time goals; psychological and behavioural supports; parental support and assisted access to community supports and programs.

Follow-up appointments

Follow-up appointments are scheduled at intervals determined to be medically necessary, however, generally these are 3–4 monthly. As is the nature of outpatient clinics, patients re-schedule/cancel/ or fail to attend which extends the follow-up interval for some patients as this study's subcohort reflects. A sub-cohort of COBRA patients ($n = 108$) were followed longitudinally for ≥ 12 months and each attended between three and seven outpatient clinic appointments. At each follow-up appointment; auxology measurements were recorded and age- and sex-adjusted BMI *z*-scores were calculated according to the CDC reference scale as was performed at the initial appointment [28]. Each of these BMI *z*-score values were used to calculate change in BMI *z*-scores (ΔBMI-z) by subtracting the initial BMI *z*-score from the BMI *z*-score at each follow-up appointment. A curve was then generated for each individual ΔBMI-Z/Time in Months and an AUC was generated using Graph Pad Prism 6 (GraphPad Software, San Diego, CA). As weight-loss in participants varied between appointments and at times measured as weight maintenance or gain, AUC values gave the advantage of measuring the overall magnitude of change from the initial appointment.

PSH questionnaires

Study materials sent to families; 'Survey 1' which garnered information on general health, perinatal medical history, relevant family medical history, general eating habits, attitude towards physical activity, sleep patterns, neighbourhood and household factors. Both the parent/primary caregiver and child rated their concern about the 'child's weight status' as well as the perceived child's or primary care givers concern about the child's weight status (3. *'Very concerned'*, 2. *'Moderately concerned'*, 1. *'A little concerned'*, 0. *'Not at all concerned'*). 'Survey 2' contained previously validated questionnaire tools to assess the HRQOL of the child. The PedsQL 4.0, comprising parallel parent proxy-reports (2–18 years old children) and child self-reports (5–18 years old children) [5]. It consists of 23 items in four subscales: Physical, Emotional, Social and School Functioning, in which a higher score (range 0–100) indicates a better QOL, scores. The 'Sizing Me Up' child self-report, was given to participants aged 5–18 years [8] and the 'Sizing Them Up' was provided to parents as a proxy-report for participants ages 2–18 years [29]. 'Sizing Me Up' is a 22-item measure with five subscales (Emotional Functioning, Physical Functioning, Teasing/marginalization, Positive Social Attributes and Social Avoidance). 'Sizing Them Up' is a validated 22 items measure, encompassing six subscales (Emotional Functioning, Physical Functioning, Teasing and Marginalization, Positive Social Attributes, Mealtime Challenges and School Functioning). For both questionnaires scores range from 0 to 100 and higher scores indicate better HRQOL. The generic SDQ [6] and K10 [7] questionnaire were used to assess psychological distress and

mental health problems. The SDQ is a 25-items screening questionnaire for assessing mental health problems, proxy-reports by parents (3–18 years-old children) and self-report by children (aged ≥ 11 years). Four subscales (Emotional Symptoms, Conduct Problems, Hyperactivity-Inattention and Peer Problems) measure social difficulties (higher scores indicate more difficulties), whereas the fifth subscale (Prosocial Behaviour) measures social strengths (higher scores indicate more prosocial behaviour). The five SDQ subscale scores range from 0 to 10, and the 'Total Difficulties Score' ranges from 0 to 40, with higher scores representing lower HRQOL. The exception is 'Prosocial Behaviour', where higher scores indicate more prosocial behaviour. The K10 is a ten-item screening questionnaire which measures symptoms of depression and anxiety in the previous 4 weeks period. Scores range from 10 to 50 and a higher score indicates a higher level of psychological distress. The K10 was used to indicate the individual levels of psychological stress in the child and the primary caregiver. Children aged 13 and older completed their own questionnaire. All questionnaire answers were analysed and scored according to the methods previously described [5–8, 29].

Statistical analysis

Participant data for COBRA are recorded in Research Electronic Data Capture program, 'RedCap', administered by the Murdoch Childrens Research Institute [30]. Data were analysed using IBM SPSS Statistics version 22 (Released 2013, IBM SPSS Statistics for Windows, Armonk, NY), AUC was generated using GraphPad Prism 6 (GraphPad Software, San Diego, CA). Descriptive statistics were calculated for demographic characteristics and questionnaire scores. Independent *t* tests were used to compare characteristics between different groups (male vs. female, different SDQ groups) and paired t tests were used to examine the discrepancies between parent/primary caregiver 'proxy' reports and child self-reports. Pearson's correlation coefficients were used to examine the relationship between questionnaire scores and BMI *z*-scores, and also to test concordance between the different questionnaires. Correlation effect size was designated as small (0.10), medium (0.30) and large (0.50). Partial correlations were used to control for sex, age and initial BMI *z*-score. The AUC was calculated based on ΔBMI-z and corrected for number of visits. A logistic regression model was used to determine factors contributing to the outcome of the WMS. Age, sex and initial visit BMI *z*-score were included in this model. A value of $p < 0.05$ (two-sided) was considered statistically significant.

Results

Clinical characteristics

Up to June 2017, 380 children/adolescents and their primary caregiver had participated in the COBRA study. A total of 250 participants completed at least one of the four questionnaires and were included for analysis. The characteristics of the included participants are shown in Table 1. Excluded participants ($n = 130$) had a mean age of 9.4 (± 3.7) years and a mean BMI *z*-score of 2.4 (± 0.5), indicating that participants who had not completed questionnaires were younger than participants who were included in the final analysis. In our study, the mean BMI *z*-score was higher in female than male participants. More female participants were post pubertal ($p < 0.05$, Table 1).

Table 1 Study participant characteristics

	All ($n = 250$)	Female ($n = 131$)	Male ($n = 119$)
Age (years)	11.5 (± 3.3)	11.4 (± 3.5)	11.5 (± 3.1)
Height (cm)	155.3 (± 17.2)*	153.0 (± 16.3)	158.0 (± 17.8)
Weight (kg)	84.8 (± 29.8)	82.2 (± 29.4)	87.7 (± 30.1)
BMI *z*-score	2.5 (± 0.4)*	2.6 (± 0.4)	2.4 (± 0.4)
Waist circumference (cm)	105.6 (± 18.1)	103.7 (± 19.2)	107.8 (± 16.6)
Body fat (%)	43.8 (± 7.9)	43.7 (± 6.9)	43.9 (± 8.9)
Blood pressure systolic (mmHg)	116.0 (± 15.7)	114.9 (± 15.7)	117.3 (± 15.7)
Blood pressure diastolic (mmHg)	67.2 (± 9.6)	66.9 (± 9.6)	67.7 (± 9.6)
Pubertal stage			
Prepubertal	94 (38%)*	43 (33%)	51 (43%)
Peripubertal	68 (26%)	31 (23%)	37 (31%)
Postpubertal	88 (36%)*	57 (44%)	31 (26%)

*Significant difference between females and males, $p < 0.05$ via two-tailed *t* test. Mean (± SD)

Self-administered and proxy-administered PSH questionnaires

Total scores reported for the PedsQL questionnaire completed by the children ranged from 8.0 to 97.0 and primary caregiver proxy report scores ranged from 17.8 to 100.0, with higher scores indicating a better quality of life (Suppl Table 1). The PedsQL questionnaire primary caregiver proxy-report scores were significantly lower both for the total QOL Score and all subscale scores when compared to the child's self-reported scores, the largest difference being observed in Physical Health (Self-reported mean 73.5 ± 17.7 v Proxy-reported mean 63.6 ± 21.9, $p < 0.01$, Suppl Table 1). This observation was especially true for questions relating to 'Physical Activity', such as *'How much of a problem has participating in sports or exercise been for your child?'* Correlations between proxy-report scores and self-report scores were all large, except for positive social attributes and prosocial behaviour ($r > 0.50$) (Suppl Table 2). Negative correlations were observed between all PedsQL self-report scores and baseline BMI z-scores (Table 2). A weaker relationship was observed between parent and guardian reported Total PedsQL scores and BMI z-score (Table 2).

Total scores for the 'Sizing Me Up' questionnaire ranged from 3.0 to 92.0 and scores for the 'Sizing Them Up' questionnaire ranged from 67.0 to 100.0, where higher scores indicate a better quality of life (Suppl Table 1). Proxy-report scores for 'Emotional functioning' on the 'Sizing Them Up' questionnaire were significantly lower than the mean child self-report 'Sizing Me Up' scores (Proxy-reported means 62.9 ± 16.7 v Self-reported mean 66.0 ± 27.9, $p < 0.01$, Suppl Table 1). However, by far the largest difference was reported for 'Positive Attributes' (22.5, $p < 0.01$), for which the proxy-report scores were significantly higher, demonstrating that primary caregivers believe their child possesses more positive qualities and strengths than the child believes. In agreement with the PedsQL, the correlations between 'Sizing Me Up' questionnaire scores and baseline BMI z-scores were

Table 2 Correlations between questionnaire scores and BMI z-score

Self-report	Correlation with BMI-z	Proxy-report	Correlation with BMI-z
PedsQL		**PedsQL**	
Total score	−0.23**	Total score	−0.16*
Physical health	−0.20**	Physical health	−0.12
Psychosocial health	−0.22**	Psychosocial health	−0.16*
Emotional functioning	−0.12	Emotional functioning	−0.10
Social functioning	−0.25**	Social functioning	−0.15*
School functioning	−0.19**	School functioning	−0.12
Size Me Up		**Size Them Up**	
Total QOL	−0.22**	Total QOL	−0.28**
Emotional functioning	−0.19**	Emotional functioning	−0.17*
Physical functioning	−0.26**	Physical functioning	−0.29**
Teasing/marginalization	−0.22**	Teasing/marginalization	−0.21**
Positive social attributes	0.09	Positive social attributes	−0.02
Social avoidance	−0.21**	Mealtime challenges	−0.31**
		School functioning	−0.20**
		Adolescent developmental adaption	−0.35**
SDQ		**SDQ**	
Total difficulties	0.07	Total difficulties	0.07
Emotional symptoms	0.07	Emotional symptoms	0.09
Conduct problems	−0.02	Conduct problems	0.00
Hyperactivity-inattention	0.00	Hyperactivity-inattention	−0.02
Peer problems	0.13	Peer problems	0.11
Prosocial behaviour	0.08	Prosocial behaviour	−0.01
K10	0.14	**Primary caregiver K10**	0.15*

Controlled for age and sex

PedsQL pediatric quality of life, *QOL* quality of life, *SDQ* strengths and difficulties questionnaire, *K10* kessler 10, *BMI-z* BMI z-score

*Correlation is significant at the $p < 0.05$ level (two-tailed)

**Correlation is significant at the $p < 0.01$ level (two-tailed)

negative for all subscales (Table 2). Correlations between 'Sizing Them Up' scores and baseline BMI z-scores were similar to the self-report correlations (Table 2), however the strongest positive correlation observed was for 'Mealtime Challenges', a subscale measuring parents' perceptions of their child's difficulties around mealtimes, example question; '*How often has your child argued about when, what and how much to eat?'*.

Questionnaire scores on the SDQ were transformed into four categories: 80% *'Close to average'*, 10% '*Slightly raised*', 5% *'High'* and 5% *'Very high'*. 'Pro-social Behaviour' scores were also transformed into four categories: 80% *'close to average'*, 10% *'Slightly lowered'*, 5% *'Low'* and 5% *'Very low'*. Our results indicate that 61% of the study population score *'Very high'* on 'Peer Problems' on self-report and 71% on proxy-report (Suppl Table 3). No significant correlations were observed between any of the SDQ subscale scores and baseline BMI z-scores.

Analysis of the K10 questionnaire was performed by grouping scores into four different categories; Low (scores of 10–15, indicating little or no psychological distress), Mild (scores or 16–21), Moderate (scores of 22–29) and Very high (scores of 30–50), which allowed for monitoring of distress rather than utilisation of scores as diagnostic tools. Grouping by this method for the self-report, indicated that 57% of children scored low and had not suffered from significant psychological distress in the 4 weeks prior to completion of the questionnaire, 16% indicated mild psychological distress, 11% indicated that they had endured moderate psychological distressing conditions and 16% indicated suffering from very high psychological distress in the 4 weeks previous. Primary caregiver distress scores were; 57%, 19%, 13% and 11%, respectively. We did not observe any correlations between the child's K10 scores and baseline BMI z-score. A small positive correlation was observed between the level of distress in primary caregivers and their child's BMI z-score (Table 2). As parental psychological status was previously associated with perception of quality of life this association was assessed in our study [31, 32]. Our results showed no overall correlation between the level of parental psychological distress and the difference in perception of PSH between the children and their primary caregivers. However, we demonstrated a higher concordance between child and proxy reported PedsQL scores when parents when parents had a lower K10 score ($r = -0.19$, $p < 0.01$, PedsQL proxy v child scores, sub-group analysis selected for parental K10 score groups Low (10–15) and Mild (16–21)).

Fifty-three percent of the parents completed the question to indicate concern about their child's overweight/obesity status, of which 73% were *'very concerned*', 16% were '*moderately concerned'*, 10% were *'a little concerned'* and 1% were *'not concerned'*. The baseline BMI z-score was significantly higher in the group *'very concerned*' compared to the group *'a little concerned'* (2.6(±0.4) versus 2.2(±0.4), $p < 0.01$). Of the children who completed the question regarding concern about their weight ($n = 131$, 52%) these numbers were 47%, 35%, 14% and 4% respectively. We did not observe any baseline BMI z-score trends between 'level of concern' groups indicated by the children.

Do baseline QOL and K10 scores influence successful weight management?

A total of 108 children and adolescents attended follow-up appointments at The Royal Children's Hospital weight management clinic for ≥ 12 months (50% male, mean age 10.96 (±3.43) years, mean initial appointment BMI z-score: 2.5 (±0.5) kg/m^2) following completion of the PSH questionnaires (baseline PSH questionnaire answers for follow-up sub cohort in Supplemental Table 1). Using BMI z-scores recorded at each follow-up appointment the child's individual AUC was calculated. This sub-cohort attended the outpatient services for 12–61 mean 27.9 (±12.4) months. During this time, children attended a mean number of 6.6 (±2.4) visits. The AUC generated for the sub-cohort has a mean total area of 0.95 (±1.6; range 0.01–13.0), range 1–5 peaks (mean peaks 1.1 ± 0.7), with total negative peak area representing on average 87% of total peak area. In a logistic regression model, five subscales contributed significantly in determining success (weight loss or a reduction in BMI z-score, Table 3). Answers to 'Emotional Functioning' questions on the PedsQL positively contributed to subsequent significant improvements in weight status, whereas self-reported 'Hyperactivity-inattention' questions and proxy-reported 'Positive Social Attributes' and 'Conduct Problems' questions negatively contributed. Furthermore, increased parental/guardian distress (K10) resulted in weight gain or no change in BMI z-score (Table 3).

Discussion

This is the first report which has explored the potential of psychosocial health questionnaires as tools for highlighting domains of concern for individuals and subsequent weight change in a paediatric obesity service. We demonstrate significant differences between PSH scores reported by the child and their primary care giver, highlighting the importance of assessing both. We found that PSH as perceived by the child is worse with higher levels of obesity, while perceived QOL reported by the primary carer was less related to the child's BMI z-score. Further, we demonstrated that several aspects of the PSH questionnaires may be utilised to identify patients more or less likely to achieve subsequent improvements in weight status, so that multidisciplinary care teams can manage these health domains to better treat

Table 3 Logistic regression model for factors contributing to weight reduction

	Model self-report: age, sex, BMI-z	F (df)	Model proxy-report: age, sex, BMI-z	F (df)
PedsQL[a]				
Total score	0.13	11.63 (4, 81)	−0.05	11.18 (4, 82)
Physical health	0.02	10.93 (4, 81)	−0.10	11.53 (4, 82)
Psychosocial health	0.18	12.37 (4, 81)	−0.02	11.07 (4, 82)
Emotional functioning	**0.28****	15.11 (4, 81)	0.06	11.20 (4, 82)
Social functioning	0.12	11.57 (4, 81)	−0.03	11.08 (4, 82)
School functioning	0.03	10.95 (4, 81)	−0.09	11.42 (4, 82)
Sizing Me/Them Up[a]				
Total QOL	0.08	11.05 (4, 80)	−0.13	11.45 (4, 80)
Emotional functioning	0.11	11.26 (4, 80)	−0.06	10.93 (4, 80)
Physical functioning	0.00	10.78 (4, 80)	−0.18	12.15 (4, 80)
Teasing/marginalization	0.15	11.79 (4, 80)	−0.06	10.96 (4, 80)
Positive social attributes	−0.02	10.79 (4, 80)	**−0.21***	12.86 (4, 80)
Social avoidance	0.11	11.29 (4, 80)	–	–
Mealtime challenges	–	–	0.13	11.46 (4, 80)
School functioning	–	–	0.03	10.82 (4, 80)
Adolescent dev. adapt.	–	–	−0.26	2.92 (4, 18)
SDQ[a]				
Total difficulties	−0.17	6.81 (4, 45)	−0.02	11.60 (4, 86)
Emotional symptoms	−0.21	7.29 (4, 45)	0.06	11.74 (4, 86)
Conduct problems	−0.10	6.35 (4, 45)	**−0.18***	13.27 (4, 86)
Hyperactivity-inattention	**−0.25***	7.83 (4, 45)	−0.07	11.86 (4, 86)
Peer problems	0.19	6.99 (4, 45)	0.10	12.13 (4, 86)
Prosocial behaviour	−0.16	6.77 (4, 45)	0.06	11.76 (4, 86)
K10[a]	0.01	4.05 (4, 30)	**0.23****	12.96 (4, 78)

F degrees of freedom, *BMI-z* BMI *z*-score, *PedsQL* pediatric quality of life, *QOL* quality of life, *Adolescent dev. adapt.* adolescent developmental adaptation, *SDQ* strengths and difficulties questionnaire, *K10* kessler 10, *BMI-z* initial BMI *z*-score

Weight reduction determined as area under the curve (AUC), based on ΔBMI *z*-score. Bold: significance level $p < 0.05$, *= $p < 0.05$, **= $p < 0.01$

[a]PedsQL and Sizing Me/Them Up: higher scores indicate better QOL. SDQ and K10: higher scores indicate more difficulties/distress

children at risk of failing to achieve weight management goals.

Self-described behavioural difficulties and parent-described social and behavioural conduct problems are predictive of weight gain or an absence of weight change, whilst self-described positive emotional functioning attributes predict improvements in weight status at follow-up. Studies have previously utilised the mental health component of questionnaires to predict (long and short term) successful reduction in a child's weight [15, 18]. In unison with our observation that hyperactivity-inattention negatively contributes to weight management goals in a WMS, Van Egmond-Froehlich et al. [21], reported that weight loss success was negatively predicted by indication of inattention and hyperactivity-inattention conditions. Furthermore, we showed that less distressed primary caregivers were more likely to perceive a better HRQOL for their child. Additionally, children under the care of parents or primary caregivers with lower stress levels have an increased chance of achieving weight loss success. Our study expands on previous findings which demonstrated the negative impact of maternal depression on weight management [19] and highlights that 'caregiver stress levels' should also be considered and supported in multidisciplinary team management plans, regardless of whether the caregiver is female, male or related to the child.

Increased body mass is associated with a lower psychosocial health. The benefit of including a generic health-related quality of life tool such as the PedsQL, is the ability to compare total scores across health and disease domains [33]. Our PedsQL results agree with others who reported lower HRQOL in children with overweight/obesity compared to children of a healthy weight [3, 11, 15, 34–37]. In clinically obese populations, reported total PedsQL scores are comparable to our population [3, 11, 34, 35]. However, overweight

and obese youth from general population studies reported slightly higher HRQOL scores compared to our clinical population [36, 37]. Potentially, our treatment-seeking population have associated comorbidities which additionally effect their psychosocial health and we were unable to delineate the independent effect of obesity due to these in this study [3].

Our results from the obesity-specific 'Sizing Me Up' and 'Sizing Them Up' questionnaires are mostly consistent with previous studies in demonstrating a decreased obesity-specific HRQOL with increased body weight [8, 29, 38, 39]. In our population, participant's scores indicated significant impairment in the 'Positive Social Attributes' domains, which was also shown by Black et al. [38]. Interestingly, 'Social Attributes' measured via this tool did not associate with severity of obesity in our study, though the primary caregiver's answers for this domain were predictive of weight gain at follow-up. Our observations may be due to the statistical effects of not having a comparable lean population. There is general agreement that children with overweight and obesity are at risk for mental health problems [18], thus assessing psychosocial attributes and monitoring those at risk is important [18]. Positive self-esteem and self-confidence have been identified as factors which lead to not only successful weight reduction, but also successful weight maintenance. We are in agreement with others that these qualities should be continually instilled in children participating in weight management programs [40], as social and emotional support have a positive influence on mental health and HRQOL [15, 17, 41].

Difficulties in peer relationships among children and adolescents with obesity are frequently described and include difficulty forming friendships [42], being less accepted by peers [43], and being more socially withdrawn from peer situations [44]. Indeed, providing additional supports in school environments for adolescents with obesity may be an avenue for modulating the negative relationship between quality of life and BMI [45]. Similarly to 'Social Attributes', even though both children and caregivers indicated increased levels of 'Peer Problems' on the SDG, our study did not find any relationships between difficulties indicated on the SDQ and BMI z-score, nor were these attributes useful in predicting successful weight loss at follow-up. Previous studies in general populations that investigated the relationship between mental health problems and severity of obesity are inconsistent [18]. Given that we have used a clinical population of obesity without a comparable lean/normal weight population the resultant standard deviations are small, signifying that our population despite varying degrees of obesity have a consistently increased peer and social-related problems. These results indicate a possible avenue for intervention and improving health-related quality of life and psychosocial health for adolescents with obesity, through increasing social supports and decreasing societal/peer stigma of overweight and obesity [46].

This study also investigated the concordance between self-reports and primary carer or parental proxy-report for the HRQOL and psychosocial surveys, which resulted in positive moderately strong correlations for all surveys and domains, bar two. Concordance was not seen between self and proxy reports for the Sizing Me/Them Up 'Positive Social Attributes' and the SDG 'Prosocial Behaviour' questions, whereby proxy scores for these reports were significantly higher than those scored by children. Interestingly, neither of these domains were associated with degree of obesity in our study, though proxy scores for 'Positive Social Attributes' were predictive of weight loss at follow-up. These results give further validity to the notion that proxy-reports cannot substitute self-reports and vice versa, but the two sources of information should be considered with equal merit when considering treatment plans.

Strengths of this study include a relatively large sample size from a clinical paediatric population and their primary caregivers and the use of two validated HRQOL questionnaires [one generic (PedsQL) and one obesity-specific (Sizing Me/Them Up)], which enabled the assessment of HRQOL in a broad perspective. Several limitations of this study should however be noted. First, this study included a clinical sample of treatment-seeking children and adolescents with overweight and obesity but not a lean age-matched population for comparison. Results may not be applicable to a general community. Second, at the initial study inclusion stage, 130 of recruited participants had not completed at least one of the PSH questionnaires. It is possible that this caused a selection bias, as this group was slightly younger and the mean BMI z-score was slightly lower than the sample included in the study. A possible reason for non-completion of the questionnaires might be that primary caregivers felt the questions were irrelevant for younger children, as many of the questions focused on peer-relationships and school. Alternatively, participants reported that they did not fill in the questionnaires because they found the questions too confronting and elected not to answer all or certain questions as they forced them to reveal or question their obesity condition in relation to their mental health, physical functioning and social functioning. This could mean we had not included a population with lower psychosocial quality of life, and that going forward in clinical practice questionnaires should be completed with the option of support from a child psychologist or social worker.

In summary, this study demonstrates that children and adolescents with obesity are at risk of reduced health-related quality of life, with the detrimental effects of obesity evident across both physical and psychosocial domains. Parents/caregivers had a tendency to report greater difficulties, whilst also reporting less positive

opportunities compared to child reports. Furthermore, aspects of self-administered psychosocial health questionnaires may be effective in clinical practice for highlighting domains of concern for individual children and their caregivers. Predicting those children at risk of not meeting their weight management goals during treatment, through psychosocial health assessments, may assist in the management of this vulnerable group of patients.

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Compliance with ethical standards

Conflict of interest The authors have no conflicts of interest to declare in relation to this study.

Ethics approval This study was approved by and conducted in accordance with guidelines stipulated by, The Royal Children's Hospital Human Research Ethics Committee and with the 1964 Helsinki declaration and its later amendments (RCH HREC Ref#28081, Melbourne, Australia).

Informed consent Informed consent was obtained from all participants included in this study.

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