Severity of obesity is associated with comorbidities in obese youth, but does not identify those with abnormal glucose metabolism.

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Previous studies in groups of normal, overweight and obese children have shown that higher BMI (adjusted for age and sex) is associated with higher levels of obesity-related comorbidities (1). It is unclear, however, whether severity of obesity alone is associated with a greater risk of comorbidities in groups of obese children, such as those seen in specialist paediatric obesity clinics.

Aim

To identify the anthropometric, biochemical, physical activity and dietary factors associated with obesity-related comorbidities in obese youth.

Take Home Points

1. **Increased adiposity measures (BMI-Z, WHtR and %fat) were all associated with hypertension, NAFLD and OSA.** WHtR was also associated with orthopaedic problems and %fat was associated with mental health issues. No other correlation with other comorbidities, including pre-diabetes and T2DM, were seen. *(Main table below)*

2. **Lower vitamin C and beta-carotene intake were weakly associated with a higher number of comorbidities.** This remains significant after adjusting for BMI-Z. Dietary micronutrient deficiencies may influence obesity-related comorbidities due to their antioxidant properties. Both vitamin C and beta-carotene have been associated with obesity-related comorbidities in children and adults (2, 3). This could be due to differences in dietary fruit and vegetable intake between obese youth with and without obesity-related comorbidities. This could also reflect poorer diet choice in those with comorbidities.

Main table. Mean BMI-Z (CDC) scores, waist-height ratio and total body percentage fat in those with and without various comorbidities of obesity. Results presented as mean (SD).

		BMI-Z			Waist-height ratio			Total percentage body fat		
Comorbidity (n)	**No. with comorbidity (%)**	**Yes**	**No**	**p-value**	**Yes**	**No**	**p-value**	**Yes**	**No**	**p-value**
Prediabetes (170)	65 (38)	2.53 (0.51)	2.45 (0.3)	0.201	0.65 (0.2)	0.69 (0.1)	0.07	44.0 (8.9)	43.7 (8.0)	0.859
T2DM (221)	8 (3.6)	2.44 (0.2)	2.45 (0.4)	0.952	0.65 (0.04)	0.66 (0.1)	0.790	45.5 (5.4)	42.4 (8.7)	0.326
Hypertension (321)	160 (50)	2.48 (0.4)	2.39 (0.5)	**0.048**	0.68 (0.1)	0.64 (0.1)	**<0.001**	44.0 (8.0)	40.2 (8.9)	**<0.001**
Hyperlipidaemia (348)	83 (23.9)	2.46 (0.5)	2.47 (0.5)	0.848	0.66 (0.1)	0.66 (0.1)	0.737	42.2 (7.3)	42.3 (9.0)	0.893
NAFLD (347)	114 (32.9)	2.56 (0.4)	2.42 (0.5)	**0.001**	0.65 (0.1)	0.69 (0.1)	**0.003**	45.6 (8.1)	40.8 (8.5)	**<0.001**
PCOS (180)	26 (14.4)	2.53 (0.3)	2.57 (0.5)	0.742	0.7 (0.1)	0.65 (0.1)	0.072	45.4 (6.8)	42.4 (8.2)	0.133
OSA[+] (349)	78 (22.3)	2.56 (0.4)	2.44 (0.5)	**0.030**	0.69 (0.1)	0.65 (0.1)	**0.004**	46.1 (8.7)	41.1 (8.3)	**<0.001**
OSA-sleep study proven (75)	31 (41.3)	2.50 (0.4)	2.65 (0.4)	0.241	0.65 (0.1)	0.74 (0.1)	**0.017**	44.0 (7.2)	48.0 (9.4)	0.076
Mental health (349)	40 (11.4)	2.52 (0.3)	2.46 (0.5)	0.387	0.69 (0.1)	0.65 (0.1)	0.074	48.0 (8.5)	41.6 (8.4)	**<0.001**
Orthopaedic (349)	14 (4.0)	2.61 (0.3)	2.46 (0.5)	0.234	0.73 (0.1)	0.66 (0.1)	**0.004**	47.2 (8.5)	42.1 (8.6)	0.056
Eating disorder (349)	5 (1.4)	2.37 (0.2)	2.47 (0.5)	0.637	0.65 (0.1)	0.66 (0.1)	0.804	47.4 (11.7)	42.2 (8.6)	0.239
Neurological (349)	1 (0.3)	2.26	2.46 (0.5)	0.663	0.64 (0)	0.66 (0.1)	0.834	39.0 (0)	42.3 (8.7)	0.704

Methods

Anthropometric, routine clinical blood tests and comorbidity data were collected from overweight and obese paediatric patients who were recruited inthe COBRA study whilst attending the Weight Management Service at The Royal Children's Hospital (Melbourne) (4). Standard definition of comorbidities were used. Body composition was measured by bioimpedance (Tanita-BC418). Activity level (Actical© accelerometry) and dietary consumption (Australian Food Frequency Questionnaire) data were additionally collected. *Statistical analysis was performed using chi-squared, one-way ANOVA, Pearson's correlation tests and linear regression as appropriate.*

Results

More female patients were pubertal than males. Females also had higher BMI-Z and lower serum ALT. There were no sex differences in physical activity levels and dietary intake *(table 1 below)*. Higher BMI-Z, WHtR and %fat were seen in those with more obesity-related comorbidities. *(table 2 below)* Lower vitamin C [OR 0.99 (CI: 0.988-0.998), p=0.001 adjusted for BMI-Z} and beta-carotene [OR 0.9998 (0.9996-0.9999), p=0.017 adjusted for BMI-Z] consumption were weakly associated with higher number of comorbidities, whilst other micronutrients or macronutrients were not associated with number of comorbidities. Physical activity levels and total energy intake showed no association with number of comorbidities.

Table 1. Characteristics of the participant population.

A. Anthropometry

	N	Mean (SD)	Male	Female	p
Sex	349		169	180	
Age	349	10.6 (3.6)	10.48 (3.5)	10.69 (3.6)	0.586
Peripubertal	348		79	110	**0.001**
BMI-Z	349	2.46 (0.46)	2.36 (0.43)	2.56 (0.47)	**<0.001**
WHTR	291	0.659 (0.109)	0.658 (0.097)	0.660 (0.119)	0.878
BP-Systolic	321	111.66 (16.4)	112.32 (17.1)	111.03 (15.7)	0.482
BP-Diastolic	320	65.77 (10.0)	65.83 (10.1)	65.71 (9.9)	0915
%fat	257	42.29 (8.7)	41.70 (9.3)	42.84 (8.0)	0.292
%truncal	240	36.61 (9.4)	36.25 (10.0)	37.0 (8.8)	0.566

B. Biochemistry

	N	Mean (SD)	Male	Female	p
GGT[†]	301	22.93 (13.4)	25.07 (16.4)	20.51 (9.6)	0.003
ALT[†]	307	39.21 (27.2)	46.53 (35.4)	32.74 (14.2)	**<0.001**
Fasting glucose[‡]	301	4.63 (0.68)	4.71 (0.86)	4.58 (0.47)	0093
Fasting insulin[‡]	285	24.17 (19.1)	24.24 (19.8)	24.11 (18.5)	0.953
2 hour glucose[‡]	127	6.44 (2.2)	6.29 (2.4)	6.61 (1.9)	0.414
HbA1c (%)	189	5.43 (0.65)	5.50 (0.61)	5.39 (0.66)	0.274
Cholesterol[‡]	296	4.48 (0.76)	4.43 (0.74)	4.56 (0.78)	0.140
Triglyceride[‡]	291	1.34 (0.81)	1.28 (0.76)	1.39 (0.87)	0.254
HDL-C[‡]	187	1.28 (0.68)	1.34 (0.92)	1.21 (0.24)	0.222
LDL-C[‡]	187	2.75 (1.6)	2.62 (0.70)	2.91 (2.12)	0.201

[†]IU/L
[‡]mmol/L

Table 2. Anthropometry markers by number of comorbidities[†], adjusted for age.

	Number of comorbidities								
	n	**0**	**1**	**2**	**3**	**4**	**5**	**OR**	**p**
n	349	74	105	92	48	23	7		
Male	169	34	51	43	24	13	4	0.87	0.475
Age (years)	349	8.27 (3.3)	10.58 (3.5)	11.5 (3.2)	11.6 (3.3)	12.0 (3.9)	11.9 (3.8)	**1.20**	**<0.001**
BMI-Z	349	2.30 (0.50)	2.50 (0.41)	2.49 (0.42)	2.54 (0.38)	2.53 (0.32)	2.53 (0.32)	**1.83**	**0.005***
WHtR	290	0.61 (0.10)	0.66 (0.85)	0.68 (0.90)	0.66 (0.17)	0.72 (0.83)	0.70 (0.11)	**24.0**	**0.017**
Total Body fat (%)	257	37.1 (8.1)	41.3 (8.0)	43.5 (8.5)	45.3 (7.9)	47.8 (6.4)	50.3 (8.6)	**1.07**	**<0.001**
Truncal body fat (%)	240	31.3 (8.8)	35.5 (8.3)	37.3 (8.6)	39.5 (8.6)	45.5 (10.6)	45.4 (9.2)	**1.06**	**<0.001**

† PCOS excluded
* BMI-Z not adjusted for age as BMI-z is already age adjusted

Abbrevations

WHtR	Waist-height ratio	**OSA**	Obstructive sleep apnoea
BMI-Z	Age and sex adjusted body mass index z-score	**T2DM**	Type 2 diabetes mellitus
%fat	Total percentage body fat	**CDC**	Centre for disease control and prevention
NAFLD	Non-alcoholic fatty liver disease	**PCOS**	Polycystic ovarian syndrome

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