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The prevalence of obesity in children with CHD: what has changed over the past decade in Southwestern Ontario?

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Abstract

Objective: To assess the prevalence of obesity and investigate any changes in body mass index in children with CHD compared to age-matched healthy controls, in Southwestern Ontario. *Methods:* The body mass index z-scores of 1259 children (aged 2–18) with CHD were compared with 2037 healthy controls. The body mass index z-scores of children who presented to our paediatric cardiology outpatient clinic from 2018 to 2021 were compared with previously collected data from 2008 to 2010. A longitudinal analysis of patients with data in both cohorts was also completed. *Results:* In total, 21.4% of patients with CHD and 26.6% of healthy controls were found to be overweight or obese ($p < 0.001$). The 2018–2021 cohort of CHD patients and controls had significantly higher body mass index z-scores compared to the 2008–2010 cohort ($p < 0.001$). Longitudinal analysis showed that body mass index z-scores significantly increased over time for CHD patients with data in both cohorts (2018–2021: $M = 0.59$, $SD = 1.26$; 2008–2010: $M = -0.04$, $SD = 1.05$; $p < 0.001$). *Conclusion:* The prevalence of obesity in all children, irrespective of CHD, is rising. The coexistence of obesity and CHD may pose additional cardiovascular risks and complications.

Introduction

Childhood obesity is an escalating public health concern worldwide, significantly impacting the well-being and long-term health of affected individuals.[1–3] Over the past 30 years, the prevalence of obesity among children and youth in Canada has nearly tripled[1], meaning almost 1 in 3 children aged 5–17 are overweight or obese.[2] Childhood obesity increases the risk of developing various health problems; including asthma, type-2 diabetes, heart disease, high blood pressure, sleep apnoea, low self-esteem, and depression.[1,2] These negative comorbidities are exacerbated in conditions such as CHD, where an active lifestyle can be hindered.[4]

CHD, the most common birth defect in newborns, involves abnormalities in heart structure that occur before birth, affecting approximately 1.8% of live births globally.[5,6] Ventricular septal defects and atrial septal defects are the most prevalent CHDs, accounting for 30% of all cases.[5] Advances in diagnostic techniques and surgical treatments have drastically improved the life expectancy of children and adolescents with CHD.[6] Today, 9 out of 10 children with CHD survive to adulthood.[7] In Canada, over 80,000 Canadian children with CHDs have ongoing management in the form of follow up and medical treatment of late complications.[6,7]

Obesity is a modifiable risk factor for the cardiovascular health of children with CHD, potentially exacerbating cardiovascular risks and complications.[4,8] Moreover, children with CHD may be at a higher risk of developing obesity.[4,8] Many children with CHD are often restricted from participation in physical activity, either by the direction of a physician or due to personal or family beliefs about their heart condition.[8] Conversely, some CHD patients at risk for failure to thrive in infancy are encouraged or recommended to gain weight through excessive feeding, which can affect long-term eating patterns.[4,8]

A previous study done in our catchment area of Southwestern Ontario in 2013 examined overweight and obesity rates between children with CHD and healthy controls.[10] The study found no significant differences between groups; however, both groups had an overall high prevalence at 18.2% and 20.8%, respectively.[10] Considering the additional cardiovascular risk that obesity imposes on CHD patients, the present study aimed to assess changes in the prevalence of overweight/obesity over the past decade.

The aims of the current study were to (1) investigate the prevalence of overweight and obesity rates in children with CHD in Southwestern Ontario compared to regional age-matched controls, (2) compare BMI z-scores of the current CHD and control cohorts to those from 10 years ago, and (3) conduct a longitudinal analysis of CHD patients with follow up data to investigate changes in body mass index z-scores over the last decade.

Materials and methods

Data collection

This retrospective cross-sectional and longitudinal study was approved by the institutional review board at Western University, London, Canada (HSREB #123396). We reviewed the charts of all patients aged 2 to 18 years old who presented to our Paediatric Cardiology Outpatient Clinic from January 2018 to March 2021. A total of 6131 patient charts were reviewed and only those with complete data (weight, height, age, sex, and diagnosis) were used for the analysis. The anthropometric data at the most recent visit were used for patients with more than one visit during this period. Patients with confirmed CHD formed the CHD group and those who were referred to the cardiology clinic for evaluation but found to have no heart disease formed the healthy control group.

The CHD cohort was further divided into two groups: operated and non-operated. Congruent with our previous study,[10] and based on a study by Perloff et al.,[11] the operated group was further divided into three subgroups: curative, reparative, and palliative. The non-operated group was also divided into three subgroups: valvar disease, shunt lesions, and miscellaneous (Table 1).

A registered nurse measured standing height using a Harpenden stadiometer and body weight on a calibrated digital scale. Body mass index was calculated from height and weight data and plotted on the Centers for Disease Control and Prevention body mass index curves to determine age- and sex-appropriate percentiles and z-scores. Based on a study by Hedley et al.,[12] and in line with our previous study,[10] body mass index was categorised as underweight (< 5th percentile [z-score < -1.2]), normal weight (5th–85th percentiles [z-score -1.2 – 1.2]), overweight (85th–95th percentiles [z-score 1.2 – 1.7]), and obese (> 95th percentile [z-score > 1.7]).

Exclusion criteria included patients with genetic diseases and other comorbidities; for example, Down's syndrome, Duchenne's muscular dystrophy, Marfan syndrome, and any malignancy or tumour that could affect body habitus (as the sequelae of treatment), and those who required a tracheostomy for ventilation or a gastrostomy tube for feeding.

Analysis and statistics

Continuous variables were summarised with means and standard deviations and comparisons between groups were examined using independent or dependent t-tests, as appropriate. Categorical variables were summarised with frequencies and percentages, and comparisons between groups were examined using chi-square tests or Fisher's exact tests, when appropriate. Logistic regression models were used to examine predictors of overweight/obese status. All analyses were conducted using SPSS v29 (IBM Corporation, Armonk, NY, USA), and p-values<0.05 were considered statistically significant.

Results

The CHD group consisted of 1259 children and the control group included 2037. There was no significant difference in sex between groups (p = 0.66). The control group was slightly older than the CHD patients on average (9.6 versus 9.1 years, Table 2), but this was combatted through the use of age-independent z-scores.

Table 1. Categories of patients with CHD; operated patients are classified according to Perloff et al.[11]

Category of CHD patients
Operated
Curative: Repair of VSD, ASD, PDA without no residual lesion
Reparative: Repair of Fallot, TGA, TAC, AVSD, valve disease, coarctation
Palliative: Fontan, Mustard, Senning
Non-operated
Shunt lesions
Valvar disease
Miscellaneous: Cardiomyopathy, coronary malformation, coarctation of aorta, peripheral pulmonary artery stenosis, arch anomaly, cardiac tumour

ASD = atrial septal defect; AVSD = atrioventricular septal defect; CHD = congenital heart defect; PDA = patent ductus arteriosus; TAC = truncus arteriosus communis; TGA = transposition of the great arteries; VSD = ventricular septal defect.

Significantly fewer CHD patients were obese compared to controls (14.2% vs. 19.5%, $p < 0.001$, Table 2), and significantly more CHD patients were normal body mass index compared to controls (72.1% vs. 68.3%, $p = 0.02$). However, there were no significant differences between the groups in terms of overweight or underweight status. Figure 1 illustrates the prevalence of overweight and obesity in the control group and the subgroups of CHD patients.

Table 3 shows the distribution of the weight categories within each CHD subgroup. More patients were in the non-operated group than in the operated group (865 and 394, respectively). The prevalence of overweight or obesity in each subgroup was similar (data not shown).

The body mass index z-scores of overweight or obese patients were plotted against age in controls and CHD patients separately (Figs 2 and 3). The overall distribution of the body mass index z-scores within the different age groups was comparable, except for the age at which body mass index peaked. In the control group, this occurred between ages of 15 to 17 years, and in the CHD group between ages 5 to 7 years.

Age significantly predicted overweight/obese status both for control patients (OR = 1.03, 95% CI = 1.01-1.06, $p = 0.002$) and for CHD patients (OR = 1.04, 95% CI = 1.01-1.07, $p = 0.007$), with older age increasing the risk of overweight/obesity. Male sex significantly predicted overweight/obese status for control patients (OR = 1.28, 95% CI = 1.04-1.56, $p = 0.02$) but was not significant for CHD patients (p = 0.28).

The 2018–2021 cohort of CHD patients had significantly higher body mass index z-scores (M = 0.36, SD = 1.46) than the 2008–2010 cohort of CHD patients (M = 0.10, SD = 1.18; $p < 0.001$). The 2018–2021 cohort of controls also had significantly higher body mass index z-scores (M = 0.67, SD = 1.76) compared to the 2008–2010 cohort of controls (M = 0.29, SD = 1.15; $p < 0.001$). For CHD patients with follow up data in both cohorts (n = 133), body mass index z-scores significantly increased over time (2018–2021: $M = 0.59$, SD = 1.26; 2008-2010: M = -0.04, SD = 1.05; $p < 0.001$).

Table 2. Study cohort characteristics

Characteristics	All (n = 3296)	Control group (n = 2037)	CHD group (n = 1259)	p
Male	56.8% (1871)	57.1% (1163)	56.2% (708)	0.66
Female	43.2% (1425)	42.9% (874)	43.8% (551)	0.66
Age (years)	9.4 (SD = 4.6)	9.6 (SD = 4.6)	9.1 (SD = 4.6)	<0.001
Underweight	186 (5.6%)	104 (5.1%)	82 (6.5%)	0.09
Normal weight	2299 (69.8%)	1391 (68.3%)	908 (72.1%)	0.02
Overweight	235 (7.1%)	145 (7.1%)	90 (7.1%)	0.97
Obese	576 (17.5%)	397 (19.5%)	179 (14.2%)	<0.001

CHD = congenital heart defect; SD = standard deviation.

Table 3. CHD subgroups and their distribution into weight categories

CHD patients	All (n = 1259)	Underweight [82 (6.5%)]	Normal [908 (72.1%)]	Overweight [90 (7.1%)]	Obese [179 (14.2%)]
Operated	394	30 (7.6%)	285 (72.3%%)	28 (7.1%)	51 (12.9%)
Curative	98	9 (9.2%)	74 (75.5%)	6 (6.1%)	9 (9.2%)
Reparative	240	16 (6.7%)	170 (70.8%)	17 (7.1%)	37 (15.4%)
Palliative	56	5 (8.9%)	41 (73.2%)	5 (8.9%)	5 (8.9%)
Not operated	865	52 (6%)	623 (72%)	62 (7.2%)	128 (14.8%)
Shunt	301	19 (6.3%)	226 (75.1%)	20 (6.6%)	36 (12%)
Valvar Disease	472	25 (5.3%)	336 (71.2%)	36 (7.6%)	75 (15.9%)
Miscellaneous	92	8 (8.7%)	61 (66.3%)	6 (6.5%)	17 (18.5%)

CHD = congenital heart disease.

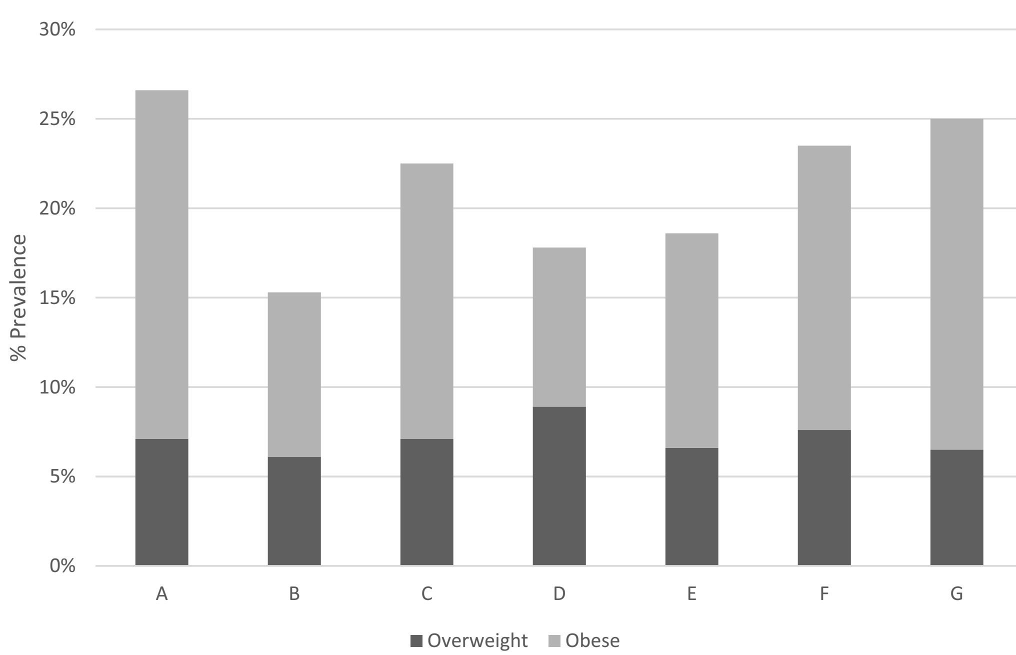

Figure 1. Prevalence of overweight/obesity. A: healthy control group; B: CHD patients after curative surgery; C: CHD patients after reparative surgery; D: CHD patients after palliative surgery; E: CHD non-operated patients with shunt lesions; F: CHD non-operated patients with valvar disease G: CHD non-operated patients with miscellaneous lesion.

Discussion

Childhood obesity is a growing public health concern worldwide, with one-third of North American children being overweight or obese.[13,14,15] Once established, childhood obesity is difficult to treat, and most strategies of lifestyle change lead to a rapid re-accumulation of weight once these efforts are stopped.[13]

While the Canadian average prevalence of excess weight in children and youth is 28.9%, regional differences are observed. In

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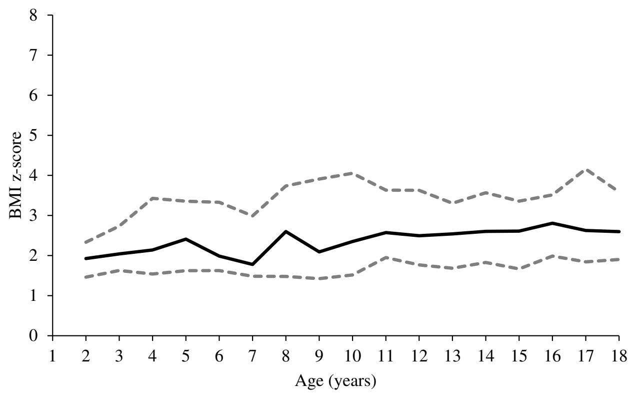

Figure 2. Body mass index z-score of overweight/obese control group children plotted against age. Median with 25th and 75th percentile.

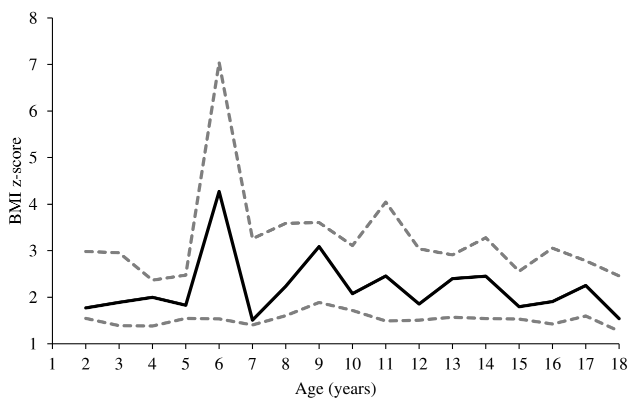

Figure 3. Body mass index z-score of overweight/obese children with CHDs plotted against age. Median with 25th and 75th percentile.

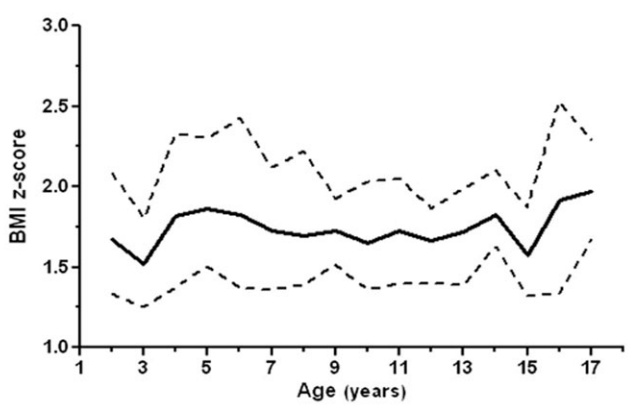

Figure 4. (2008-2010 cohort). Body mass index z-score of overweight/obese control group children plotted against age. Median with 25th and 75th percentile.

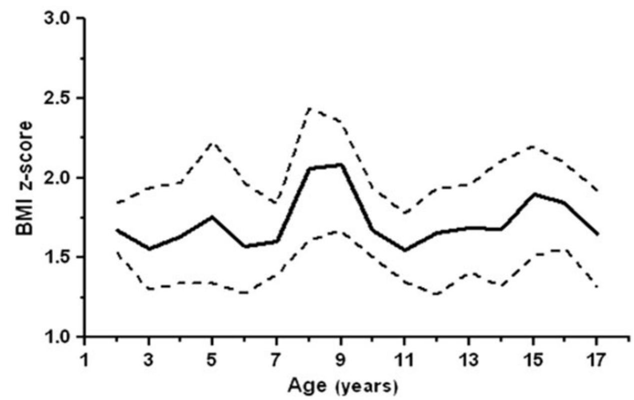

Figure 5. (2008-2010 cohort). Body mass index z-score of overweight/obese patients with CHDs plotted against age. Median with 25th and 75th percentile.

Ontario, 25.6% of children are overweight or obese.[16] Our findings confirm the high rates of overweight and obesity in healthy children as well as in those with CHD (Fig 1). The CHD group consisted of 21.4% of children who were overweight/obese, and this number was 26.6% in the healthy control group; part of this difference was due to an increased number of children with obesity in the control group (19.5% vs. 14.2%, $p < 0.001$), with a comparable number of overweight children between groups (7.1% for both groups). According to data collected from 2017 to 2020 by the U.S. Centers for Disease Control and Prevention, childhood obesity rates were 19.7% for children and adolescents aged 2 to 19 years.[17] These data are similar to our control group (19.5%) and slightly higher than that of our CHD group (14.2%).

Age and male sex predicted overweight/obese status in the control group, but only age significantly predicted overweight/obese status in the CHD group. These findings are different from Chen et al.[18] and Shustak et al.[8] who found that male sex significantly predicted overweight/obese status in CHD children, but in accordance with other publications.[4,19]

Our study observed a shifting of body mass index z-scores over the last decade, such that both CHD children and healthy controls increased their body mass index z-scores overall. This remains true for CHD children with follow up data between both cohorts (Figs 2–5). Our data are similar to the findings of Tamayo et al.[20] who found that CHD patients had a trend of becoming more overweight/obese over time, similar to that of the general population. They also found that children with transposition of the great arteries had significantly higher average weights compared to other CHD groups. However, our results did not show any significant differences between the subgroups of CHD patients in terms of overweight/obesity status.[8] Many patients lead sedentary lifestyles after cardiac repair and demonstrate poor activity levels, which may increase the risk of obesity and other comorbidities.[4,8]

Steele et al.[21] identified a critical period of 6–10 years of age where CHD patients had an increased risk of becoming overweight or obese. Our study showed a similar peak, between the ages of 5 and 7 years (Fig 3), where body mass index z-scores seemed to trend upwards. A similar spike was observed in our previous study,[10] but later in childhood, between the ages of 7 and 11 years (Fig 5). This may suggest that CHD children are getting overweight/obese at an earlier age than previously found. There is also a difference in body mass index peaks between CHD and control group children, whereas the control group had a peak between the ages of 15 and 17 years. We cannot offer an explanation for this finding and do not know whether there is any clinical relevance to it.

A study by Nadar et al.[22] indicated that pre-school-age children who were overweight or obese (body mass index > 85th percentile) were five times as likely to be overweight/obese later in childhood, compared to those children whose body mass index was below the 85th percentile in pre-school.[22]

A study by Pinto et al.[4] found that over 25% of children with congenital and acquired heart disease in Philadelphia and Boston

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were overweight or obese. This study also highlighted that paediatric cardiologists failed to document obesity in the majority of clinic letters, which could indicate an underestimation of its severity.[4] Similarly, a review by Shustak et al.[8] found rising overweight and obesity rates among children with CHD in New York, estimated at 27% overweight and 12% obese.

Obesity has been associated with adverse outcomes for children and adolescents undergoing surgery for CHD.[23,24] Garcia et al.[23] evaluated the effects of obesity on short-term outcomes of cardiac surgery in adolescents. They found that obesity was associated with adverse outcomes and increased health resource utilisation, independent of other risk factors.[23] O'Byrne et al.[24] looked at the effects of obesity and underweight status on the perioperative outcomes of CHD children, adolescents, and young adults undergoing cardiac operations. They found that obese and underweight body mass indexes were associated with an increased risk of adverse perioperative outcomes.[24] In our study, cohort the prevalence of underweight in CHD children was higher than the control group; although without statistical significance (possibly due to the low numbers). We believe this difference could be based on the combination of increased energy needs due to the heart defect and challenges in food intake that contribute to underweight status in CHD children.

Promoting a healthy body weight, good nutritional habits, and regular physical activity can help prevent and manage serious and chronic cardiovascular diseases.[25] In our Smart Heart Pilot Study, we were able to document positive changes in anthropometry, with significant improvements to some cardiovascular and metabolic risk factors, after 12 months of remote lifestyle counselling in overweight youth with CHDs.[26]

Reducing excess energy intake, especially low nutrient-dense items like sugar-sweetened beverages, and limiting daily screen time have been shown to help improve and prevent obesity in young children.[25] Implementing preventative measures, especially in early childhood, seems to be key for reducing overweight/obesity prevalence in children, adolescents, and young adults.[21,22] These preventative measures should also be targeted to adults and implemented in institutions like schools and daycares. Obesity trends in the paediatric population have followed those in adults, which is likely due to the increased consumption of processed and commercial foods. As such, healthy nutrition for children and adolescents will also rely on targeting nutritional campaigns and programmes to adult caregivers as they are often the gatekeepers of what food is accessible to children during their developmental years.[15] The Canadian government has recognised that curbing childhood obesity will require a multifaceted approach, including developing frameworks for nutrition at school.[27] A recent survey of 25 school representatives showed that many schools are making actionable changes with the physical environment being most supported, but the social environment could be further developed to build a community that is motivated in making healthy choices.[27] Finally, access to these interventions and resources is another barrier as children in lower socio-economic classes are disadvantaged. There are programmes available to help mitigate food insecurity and improve access to sports. For example, Nutrition North Canada works to subsidise food for isolated northern communities, and the Ontario Student Nutrition Program administers provincial grant funds to support healthy foods for schools in lower-income neighbourhoods.[28] However, more work needs to be done to ensure these and other vulnerable groups have equitable access to nutritious food and healthy activities.

There were some limitations of the present study. Our data were collected retrospectively and did not take into consideration participants' racial/ethnicity subgroups or socio-economic background. Comorbidities such as high blood pressure and medications were not assessed, which could have an impact on body composition. It is unclear whether the area investigated is representative of the Canadian population as a whole.

In conclusion, children with CHD are not exempt from the growing obesity epidemic that is affecting children and youth across the continent. Average body mass index percentages and z-scores have been increasing over the past decade, in both healthy controls and children with CHD, leading to further cardiovascular diseases and other comorbidities. In CHD patients, obesity is associated with adverse peri- and post-operative cardiac outcomes. There seems to be a "critical period," between the ages of 5 and 11 years, where CHD patients have an increased risk of becoming overweight and/or obese. Preventative measures like a healthy diet, regular physical activity, reducing sugar-sweetened beverage consumption, and reducing daily screen time are key for lowering the prevalence of overweight/obesity in children and adolescents. Paediatric cardiologists should reinforce the benefits of these lifestyle modifications to individual patients. Future studies should elucidate strategies for preventing the development of obesity in children with CHD; for example, establishing an exercise programme pre- and post-surgery.

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