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Energy Balance-Related Behaviors and Body Mass Index in Asian School-Aged Children with Congenital Heart Disease

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Abstract

Background: Overweight/obesity is a substantial global public health concern, which can be caused by genetic factors and energy balance-related behaviors (EBRBs). If it occurs in children with congenital heart disease (CCHD), it can yield an extra burden on their health. Most studies on CCHD have taken place in Western societies, leaving Asian populations understudied, especially children.

Objective: We sought (1) to determine body mass index (BMI) distribution among school-aged CCHD in Taiwan; (2) to ascertain whether the BMI of CCHD differs from that of the general population; (3) to describe EBRBs in CCHD; and (4) to identify the associated factors of underweight and overweight/obesity among CCHD.

Methods: In this cross-sectional study, 97 child-parent dyads (53.6% boys; mean age 9.73 years; 25.8% moderate-to-severe heart conditions) were enrolled. Self-administered questionnaires were used to collect demographics, medical factors, food frequency, physical activity, and sedentary behaviors. Anthropometric measurements were taken in the hospital. Independent variables of EBRBs and health conditions were calculated through logistic regression analysis.

Results: Among Taiwanese CCHD, 19.6% were underweight and 14.4% were overweight/obesity. Children with moderate-to-severe heart defects were more often underweight. BMI did not differ between CCHD and children in the general population. More complex heart defects and asthma were associated with being underweight, whereas sedentary behaviors, cardiomegaly, and the New York Heart Association Classification II-IV were associated with being overweight/obesity.

Conclusions: Sedentary lifestyle is seemingly the only EBRBs correlated with being overweight. Physical activity programs for children may help prevent and treat overweight or obesity in Asian CCHD, similar to Western countries.

KEYWORDS: congenital heart disease, energy balance-related behaviors, children, body mass index, obesity

The global prevalence of overweight/obesity in children and adolescents has increased from 4% in 1975 to over 18% in 2016.^{1,2} The main reason for developing overweight and obesity in childhood is an energy imbalance.² When energy intake exceeds energy expenditure, weight increases, which leads to overweight/obesity. Energy balance-related behaviors (EBRBs) are mainly related to diet habits, physical activity, sedentary behaviors, and sleep.^{3,4} Recent studies on EBRBs have focused on healthy children and have reported that the inability to maintain a healthy weight is caused by unhealthy diets and a lack of physical activity.^{3,5,6} A healthy lifestyle in childhood, however, is already essential because the lifestyle in the first decade of life affects adulthood pre-disease pathways and chronic health conditions.^{2,7,8}

Children with congenital heart disease (CCHD) form a particular group that requires attention from health care professionals. With advances in medical equipment, diagnosis, treatment, and interdisciplinary care over the past 40 years, the survival rate of CCHD has risen. To date, the overall survival rate into adulthood is 90%.^{9,10} In addition to providing disease treatment, health care professionals must focus on life challenges and long-term functioning to ensure adult health. Several studies on children with congenital and acquired heart disease have investigated body mass index (BMI) distribution. These studies have determined that over 20% of children with heart disease were overweight or obese.¹¹⁻¹⁹ In adults with congenital heart disease, the prevalence of overweight or obesity is higher (i.e., 50%).²⁰⁻²³ CCHD with overweight and obesity face cardiovascular risk factors that may lead to subsequent exacerbated cardiovascular burden into adulthood, such as hypertension, atherosclerosis, coronary artery disease, and diabetes.^{12,17,18} Therefore, overweight and obesity pose considerable health risks to all individuals with CHD who are already vulnerable because of structural aberrations of the heart.

Studies have explored the relationship between EBRBs and BMI.³⁻⁶ However, these

studies have investigated healthy children and adolescents. To the best of our knowledge, no studies have investigated CCHD regarding their EBRBs and BMI distribution. Furthermore, prior investigations have been mainly conducted in Western societies; limited research has addressed child and adult Asian populations. Thus, this study explored the following questions: (1) What is the distribution of BMI among school-aged children with CHD in Taiwan? (2) To what extent does the BMI of CCHD differ from the BMI of children in the general Taiwanese population? (3) What are the distributions of EBRBs among school-aged children with CHD? And (4) What factors are associated with being underweight and overweight/obese among school-aged CCHD?

Methods

Design, Setting, and Participants

A cross-sectional study was conducted from July to October 2014. Participants were recruited in the pediatric cardiology outpatient clinic, echocardiogram room, and pediatric wards of a single children's hospital in Northern Taiwan, which is the major treatment and referral center for CCHD in the country. According to the prevalence of the common subtypes of congenital heart disease in Taiwan²⁴, we performed purposive sampling to select the following 6 subtypes of congenital heart disease. We included (i) children aged 7–12 years with mild congenital heart disease (ventricular septal defect, atrial septal defect, or patent ductus arteriosus) or moderate-to-severe congenital heart disease (tetralogy of Fallot, transposition of the great arteries, or endocardial cushion defect); (ii) children who had not undergone surgery or cardiac catheterization within the preceding 3 months; (iii) children who understood Mandarin Chinese and had at least one parent who also understood Mandarin; and (iv) both the child and parent agreed to participate in the study. We excluded (i) children who had a pacemaker device inserted, had undergone heart transplant surgery, or were on a transplant waiting list; (ii) children

who had undergone single ventricle surgery; or (iii) children who were visually impaired or had a muscular, neurological abnormality or intellectual disability that would limit their physical activities or affect cognition.

Overall, 280 child–parent dyads were eligible for inclusion. Of these, 146 dyads could not be approached during the clinic visit due to logistical reasons (e.g., they did not attend their clinical appointment). Thus, 134 dyads were recruited; 11 of which declined. Of the 123 consenting dyads, complete data were obtained for 97 dyads (Figure 1). This study was approved by the research ethics committee of the hospital (No. 201403052RIND).

Measurements

All the children and parents were asked to complete self-administered questionnaires. The questionnaires consisted of demographics, medical factors, food frequency, physical activity, and sedentary behaviors. The contents of the questionnaire were suitable for children with third-grade reading ability, divided into children and parental versions, and can be completed in 20–35 minutes. To help the children read the questionnaire, Mandarin phonetic symbols were included. If the children were unable to complete the questionnaire, their parent could assist them. In addition, anthropometric measurements (height and weight) were taken.

Demographics and Medical Factors. The children’s version of the survey included sex, age, dietary habits, total sleep time on weekdays and weekends, and a self-assessment of the New York Heart Association (NYHA) Heart Failure Functional Classification I–IV, which is modified by Cardiac Children’s Foundation Taiwan.^{25,26} Dietary habits included the pattern of eating breakfast, lunch, dinner, and late-night supper, respectively, with three-option responses (the meal skipped, home cooked or dined out) for each meal. The parental version included parents’ age, education level, occupation, average monthly

household income, and whether their children travel to school by foot or by car. Medical factors reported by the parents included the child's cardiac defect diagnosis, current cardiac medications, and the presence of other chronic health conditions.

Food-Frequency Questionnaire. This questionnaire was adopted from previous studies^{27,28} and included 30 items pertaining to the intake of high and low nutrient density foods, such as fruits, vegetables, meats, seafood, fries, added sugars and animal giblets, and the frequency of the food intake per week. The response to each question was rated on a 7-point Likert-type scale (0 = *did not eat*; 1 = *ate once*; ... and 7 = *ate every day*). The original questionnaire scale's content validity index was 0.77–0.95. The Cronbach's alpha coefficient of the original version was 0.74, and that of the present study was 0.77. In this study, item analyses were conducted and 4 items (breakfast, snack, nutrition supplement, and late-night supper) were deleted for inter-item correlation less than 0.30. Factor analysis revealed eight food-frequency components included high-fat and high-sucrose foods (6 items), ice cream and soda (3 items), meat (6 items), dairy and eggs (4 items), vegetables and fruit (2 items), seafood (2 items), yoghurt (2 items), and water (1 items). The eight components explained 56.6% of the total variance; construct validity was attained. For each component, an average score was computed, ranging from 0 to 7, with 0 representing no consumption of the component and 7 representing daily consumption of the component.

Physical Activity and Sedentary Behaviors Questionnaire. This part was adopted in the original questionnaire developed by Gau et al. (2013),²⁹ which was designed after consulting physical therapists and the healthy lifestyle guidelines provided by the Health Promotion Administration.^{30,31} This questionnaire consisted of 7 items describing physical activity habits and sedentary behaviors of participants over the preceding week. Three questions for assessing physical activity habits included “types of

exercise,” “exercise frequency,” and “exercise intensity.” Further, physical activity relative time was determined using two questions: “How many days did you spend time for activities at least 30 minutes?” “How much time did you spend on activities causing difficulty breathing and tiredness?” The item options included “< 30 minutes,” “30-60 minutes,” “1-2 hours,” and “> 2 hours.” The statistical weights of the four choices were 0.25, 0.75, 1.5, and 3.0, which were multiplied by the number of days with more than 30 minutes of continuous activity to obtain the physical activity relative time. The scores ranged from 0 to 21, with higher scores indicating more time spent on the activity during a week. In addition, sedentary behaviors were assessed by 4 questions about time spent using a computer, mobile phone, watching TV, or studying/reading on an average weekday/weekend, respectively?” A similar scoring system was used as for physical activity. The Cronbach’s alpha was 0.74 in the original questionnaire ²⁹ and 0.67 in the present study.

Anthropometric and cardiac variables. Height and weight were obtained for all the participants (i.e., children and parents). Weight was measured using an electronic scale; participants were asked to remove their shoes and coat to obtain an accurate weight. Height was measured three times to the nearest 0.1 cm, and the average height was calculated. These data were then used to calculate BMI. In Taiwan, the BMI of children is classified into four categories, namely underweight (<5th percentile), normal (5th–85th percentile), overweight (85th–95th percentile), or obese ($\geq$ 95th percentile) according to age and sex.^{32,33} Furthermore, because the BMI distribution of our sample was skewed, when comparing the BMI of the children in our sample with that of children in the general population, we used the cut-off point of the 50th-percentile BMI for Taiwanese children as a standard by Chen and Chang³³ (Online Table 1). The BMI data for the Taiwanese general population were established by linking the 2006 World Health Organization

growth standards with the 2003 Taiwan health-related physical fitness measurements.³³ The combination of the two datasets have been used to model growth charts for Taiwanese children and adolescents aged 0 to 19. Next, the median BMI data on Taiwanese children for age and sex were subtracted from the BMIs of our sample to obtain the average adjusted median for BMI (i.e., $[\text{BMI of CHD}-50\text{th BMI}]/n = \text{the average adjusted median BMI}$). Medical data were retrieved from electronic medical records, including the left ventricular ejection fraction, assessed through echocardiography, and heart size, as assessed through chest X-ray.

Statistical Analysis

All analyses were conducted using SPSS Statistics 22.0 (SPSS Inc., Chicago, Illinois, USA). The level of significance was set at a two-sided $P \leq 0.05$. Descriptive statistics employed means, standard deviations, and percentages to describe participants' demographics and clinical characteristics. BMI was calculated; the average adjusted median of participant BMIs and the skewed data were computed. A one-sample t test was used to determine whether the adjusted median BMI score differed from zero. BMI categories for sex, heart defect complexity, and NYHA functional classification were determined using an extension of the Fisher's exact test; EBRBs in different BMI categories and lesion complexity were examined using the one-way analysis of variance and Bonferroni's post hoc test for testing significant results. When missing data occurred, we handled by the median substitution. Multivariable logistic regression with stepwise entry was performed to identify the associated factors for underweight and overweight/obesity in children with CHD. The outcome variable, underweight, was compared with normal BMI before entering it into the model, we selected 23 explanatory variables, such as age, sex, left ventricular ejection fraction, EBRBs, disease complexity, NYHA Class, cardiomegaly, cardiac medication use, chronic health conditions,

transportation mode to school by foot or by car, parental BMI and education level, and household income to identify factors associated with the outcome. Odds ratios (ORs) with 95% confidence intervals (CIs) were computed in the logistic model. Hosmer-Lemeshow test was non-significant result to support the goodness of fit of our two models both underweight and overweight/obesity ($P = 0.9$ and $P = 0.56$, respectively). The outcome variable, overweight or obesity, was used following the same process.

Results

Participant Characteristics

In this study, 97 child–parent dyads were included. Among the children, the mean age was 9.73 ± 1.49 years, and 53.6% were boys. Three-quarters of the children had a mild congenital heart disease. More than 60% of the children had undergone cardiac surgery. Nine percent of the children were prescribed cardiac medication (e.g., digoxin, furosemide, captopril, aspirin, or warfarin). Almost 71% of cases of mild congenital heart disease required surgical treatment in childhood. More than half of the children had concomitant chronic health conditions, of which 10 had 2 or more chronic diseases. The demographic and medical characteristics of the participating children and their parents are described in Table 1.

Aim 1: Distribution of BMI

In our sample, 65.9% of the children had a normal BMI (Table 2). Underweight was observed in 19.6% of the CCHD, and overweight/obese was recorded in 14.4% of our CCHD sample. No statistically significant difference in BMI between boys and girls was noted. A significant association was observed between heart defect complexity and BMI ($P = 0.007$), such that the children with moderate-to-severe heart defects were more often underweight. More obesity was reported in children with mild heart defects. Bonferroni post hoc test results indicated differences in underweight and obesity ($P = .04$).

Regarding the functional status, 72.3% of the patients with NYHA Class I had a normal BMI, compared to 53.1% of the patients with NYHA Class II–IV. A higher proportion of the children in Class II–IV were overweight or obese. These differences, however, did not reach statistical significance (Table 2).

Aim 2: Comparison with General Population

The BMI-for-age median (Online Table 1; 50th percentile) was set as the standard. The average adjusted median BMI of our sample was -0.09 ± 3.61 . This result indicated that BMI did not significantly differ between the school-aged CCHD and children in the general population. In addition, the average adjusted median BMI with positive skew had skewness of 1.46 and kurtosis of 1.79 ($t = -0.24$, $P = 0.82$).

Aim 3: EBRBs among School-aged Children with CHD

The EBRBs of the children with CHD are described in Table 3. Vegetables and fruit and water were consumed most frequently. Consumption of ice cream, soda, and high-fat and high-sucrose foods were reported least frequently. No significant difference between the 3 BMI groups (underweight, normal, and overweight/obesity) for food content was observed. In terms of physical activities, children who were overweight/obese were sedentary for significantly longer each day ($F_{2, 19.09} = 3.60$, $P = 0.03$); post hoc testing revealed differences in overweight/obesity and normal BMI ($P = 0.03$). EBRBs did not differ between the children with mild or moderate-to-severe heart lesions (Table 3).

Aim 4: Associated factors of underweight and overweight/obese among children with CHD

Being underweight in the children was associated with moderate-to-severe CHD and by having asthma. Being overweight/obese was associated with cardiomegaly, NYHA Class II–IV (with heart failure symptoms during ordinary physical activity), and sedentary behaviors. Parental BMI appeared in the multivariable model, although it was not

statistically significant. Nagelkerke R^2 values were 17% and 38% of the explained variation of the 2 models, respectively (Table 4).

Discussion

Although EBRBs and BMI distribution in CCHD have been discussed previously, the relationship between both the factors has not been investigated to date. Furthermore, Asian populations have been understudied in this respect. Therefore, we investigated the distribution of BMI among school-aged children with CHD, compared it with the general population, described EBRBs, and explored medical factors and demographics associated factors for being underweight and overweight/obese.

We determined that 19.6% of the CCHD were underweight and almost 14.5% of them were overweight or obese. Our results are in line with those of a prior large-scale study in Taiwan, in which 21% of first-graders with congenital heart disease were underweight and 14.5% were overweight/obese.³⁴ However, the findings differ from those of studies that have reported a prevalence of 18.2%–35.7% for overweight/obesity in CCHD in Western countries.^{11–19,35} This suggests that findings from Western studies cannot be generalized for Asian populations and that studies such as the present one are necessary. Our study also indicated that BMI in the CCHD did not differ significantly from the age- and sex-adjusted BMI of the children in the general Taiwanese population. This finding supports the results of previous studies in Taiwan—as well as in Canada, the United States, and Brazil—that reported that the prevalence of underweight, overweight, and obesity in CCHD is similar to that of the general population.^{11,12,15,34} Consistent with the results of previous studies,^{19,34} we observed that the children with moderate-to-severe congenital heart disease presented more often as underweight and less often as overweight/obese than did the children with mild congenital heart disease.

In the present study, we identified no relationship between the food type

consumed and BMI category of the CCHD. Thus, we corroborated the findings of a large-scale study on children from the general population in New Zealand that observed that sugar or sucrose intake was unassociated with body weight status.³⁶ The time spent in physical activity in our sample of CCHD was 3.59 hours per week, which is lower than 5.9 hours in subjects with Tetralogy of Fallot, transposition of the great arteries, and a Fontan circulation, as reported by O’Byrne et al. (2018).³⁵ In our study, there was no significant association between physical activity and BMI categories, which was found in the O’Byrne et al. study³⁵. However, we identified an association between a sedentary lifestyle among children and being overweight/obese. Overall, children in our sample spent an average of 3.44 hours per day using computers, watching TV, or using mobile phones. This exceeded the Centers for Disease Control recommendation to limit screen time to ≤ 2 hours per day.³⁷ In overweight/obese CCHD, screen time per day approached 5 hours. Although we cannot draw conclusions in terms of the direction of effect, a US study used cross-lagged analyses and determined that each additional hour of daily TV watching was associated with 0.04 higher BMI z-scores in a nationally representative cohort of children, suggesting a causal relationship.³⁸ In our study, the association between sedentary time and overweight/obesity was confirmed through multivariable regression analysis. Our research findings are similar to a previous study on Brazilian CCHD¹²; parental BMI was among the factors associated with children’s BMI even if it was not significant in our study. The reason for inference may be related to genetics or family lifestyle. In addition, children with a higher NYHA classification may have limited physical activity, leading to an increased risk of being overweight/obese. Overweight/obese in our sample was associated with cardiomegaly, NYHA Class II–IV, and sedentary behaviors.

Underweight in our sample occurred more often in children with moderate-to-

severe congenital heart disease and in those having asthma. A population-based study in Denmark revealed that lesion severity predicted underweight in CCHD. Hazard ratios for underweight were higher in children with severe heart defects or with a single ventricle compared with children with mild congenital heart disease.³⁹ This relationship persisted in adults with congenital heart disease.²² One possible reason is that these patients undergo cardiac surgery during infancy; thus, they may encounter postoperative complications or have residual defects (e.g., valve regurgitation, ventricular outflow tract obstruction, and arrhythmias).⁴⁰ As a result, they may require more energy to maintain normal function in day-to-day life. Asthma is among the most common chronic conditions, and its prevalence is approximately 10% in children aged 5–7 years.⁴¹ Many studies have found that asthma and symptoms of allergy are positively associated with BMI in a general population.^{42,43} This is in contrast to our findings that indicated that CCHD who also had asthma were more likely to be underweight. The co-occurrence of congenital heart disease and asthma may play a role in this and may render CCHD more vulnerable to being underweight. Further research to confirm this finding and to understand the mechanism is required.

Methodological limitations

In interpreting our findings, we must consider some methodological limitations of this study. First, the findings may not be generalized to the entire Asian population of CCHD because the sample size was small and patients were recruited at a single center in Taiwan. Furthermore, a selection of common heart defects was included. However, they do not represent the full spectrum of structural heart diseases. Moreover, the Ross classification⁴⁴ for heart failure in children has provided more objective measurements than the NYHA classification. Since N-terminal pro-brain natriuretic peptide and maximal oxygen uptake values were unavailable for our sample, we used the NYHA

classification to assess children with heart failure older than 6 years, in accordance with Das.⁴⁵

The study had a cross-sectional design; therefore, we cannot draw conclusions in terms of the direction of effect or causality. People with a sedentary lifestyle may become overweight. However, overweight may cause people to be more sedentary. Longitudinal research designs are required to investigate the direction of effect.

In addition, this study used a self-report questionnaire completed by early school age children. Thus, children with developmental challenges were not included. This may have introduced a certain level of selection bias. For example, individuals with trisomy 21, which is often associated with congenital heart disease, are frequently overweight or obese. Also, the self-report questionnaire may lead to recall bias.^{46,47} To address this problem, we selected questionnaires with a 1-week recall. To improve this shortcoming, e-health monitoring and surveys are recommended in future studies. The food-frequency questionnaire in this study was used mainly to explore unhealthy food consumption patterns. However, it did not include staple food such as rice, pasta, and bread.

In this study, we surveyed the child–parent dyads. Comparing EBRBs between children and their parent would have been valuable; however, this study focused on CCHD, and we investigated factors that directly affected children’s BMI.

Conclusion

Overweight or obesity in childhood can lead to early comorbidity, which is a key health problem in adult populations. We investigated EBRBs and their relationship with BMI in Taiwanese school-aged CCHD. Sedentary lifestyle appears to be the only EBRB that was related to overweight. Physical activity programs for CCHD can play a vital role in preventing the development of overweight and obesity in children who are already vulnerable because of their structural heart defects. Nurses and other health care

professionals are essential in the development, implementation and testing of such health promotion programs.

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Table 1. Characteristics of the 97 child–parent dyads

Variable	Mean $\pm$ SD or n (%)	
	Child	Parent
<u>Age (y)</u>	9.73 $\pm$ 1.49	41.18 $\pm$ 4.34 (30.8-52.8)
<u>Sex</u>		
Male, n (%)	52 (53.6%)	22 (22.7%)
Female, n (%)	45 (46.4%)	75 (77.3%)
<u>LVEF (%)</u>	71.0 $\pm$ 6.9 (48.2-89.6)	
<u>Years of Education (child)</u>		
Lower Grades	19 (19.6%)	
Intermediate Grades	42 (43.3%)	
Higher Grades	36 (37.1%)	
<u>Diagnosis</u>		
Atrial Septal Defect	33 (34.0%)	
Ventricular Septal Defect	30 (30.9%)	
Patent Ductus Arteriosus	9 (9.3%)	
Transposition of the Great Arteries	9 (9.3%)	
Tetralogy of Fallot	12 (12.4%)	
Endocardial Cushion Defect	4 (4.1%)	
<u>Disease complexity</u>		
Mild CHD	72 (74.2%)	
Moderate-to-severe CHD	25 (25.8%)	
<u>NYHA Functional Classification</u>		
Class I	65 (67.0%)	
Class II	20 (20.6%)	
Class III	11 (11.3%)	
Class IV	1 (1.0%)	
<u>Cardiomegaly</u>	15 (15.5%)	
<u>Interventions, yes (overall)</u>	78 (80.4%)	
Cardiac surgery	61 (62.9%)	
Cardiac catheterization	61 (62.9%)	
<u>Interventions (mild CHD)</u>		
Observation	16 (22.2%)	
Surgery/(infancy vs. childhood)	38 (52.8%) / (28.9% vs. 71.1%)	
Cardiac catheterization	47 (65.3%)	
<u>Take cardiac medications, yes</u>	9 (9.3%)	
<u>Concomitant Chronic Conditions, yes</u>	52 (53.6%)	
= 1 disease	42 (80.8%)	
$\geq$ 2 disease	10 (19.2%)	
<u>Diagnosis of Chronic diseases</u>		
Asthma	9 (17.3%)	
Other allergic symptoms	45 (86.5%)	
Others	10 (19.2%)	
<u>Parent' Education</u>		

Father, < senior high school	4 (4.1%)
= senior high school	21 (21.6%)
> senior high school	72 (74.2%)
Mother, < senior high school	6 (6.2%)
= senior high school	19 (19.6%)
> senior high school	72 (74.2%)
<u>Household income (monthly)</u>	
Below TWD 100,000	58 (59.8%)
Above TWD 100,000	39 (40.2%)
<u>Travel to school by foot</u>	20 (20.6%)
<u>Parental BMI categories</u>	
Underweight	5 (5.2%)
Normal	57 (58.8%)
Overweight	22 (22.7%)
Obesity	13 (13.4%)
<u>Father' BMI (kg/m²)</u>	26.44 ± 5.71
<u>Mother' BMI (kg/m²)</u>	22.41 ± 3.19

LVEF: left ventricular ejection fraction; other allergic symptoms include allergic conjunctivitis, allergic rhinitis, atopic dermatitis, and allergic gastroenteritis; TWD: Taiwan dollar.

Table 2. Comparison of different BMI categories for sex, lesion complexity, and NYHA classification among children with congenital heart disease (n = 97)

n (%)	<u>Sex</u>			<i>p</i> [#]	<u>Lesion complexity</u>			<i>p</i> [#]	<u>NYHA</u>		<i>p</i> [#]
	Overall n = 97	Boys n = 52	Girls n = 45		Mild n = 72	Moderate-to- Severe n = 25	Class I n = 65		Class II-IV n = 32		
Underweight ₍₁₎	19 (19.6%)	8 (15.4%)	11 (24.4%)	0.41	10 (13.9%)	9 (36%)	0.007* (1>4) [‡]	12 (18.5%)	7 (21.9%)	0.08	
Normal ₍₂₎	64 (65.9%)	34 (65.4%)	30 (66.7%)		51 (70.8%)	13 (52%)		47 (72.3%)	17 (53.1%)		
Overweight ₍₃₎	5 (5.2%)	4 (7.7%)	1 (2.2%)		2 (2.8%)	3 (12%)		1 (1.5%)	4 (12.5%)		
Obesity ₍₄₎	9 (9.3%)	6 (11.5%)	3 (6.7%)		9 (12.5%)	0 (0%)		5 (7.7%)	4 (12.5%)		

[#] Fisher's exact test; NYHA: New York Heart Association functional classification; **P* < .05; [‡] Bonferroni post hoc test was significant (*P* < .05).

Table 3. Comparison of EBRBs in different BMI categories and lesion complexity among children with congenital heart disease (n = 97)

EBRBs (days per week for foods)	BMI categories				$p^{\S}$	Lesion complexity		$p^{\S}$
	Overall	Underweight ₍₁₎	Normal ₍₂₎	Overweight/Obesity ₍₃₎		Mild	Moderate-to-severe	
High-fat and high-sucrose	1.69 ± 0.98	1.63 ± 0.85	1.69 ± 1.04	1.75 ± 0.91	0.94	1.79 ± 1.00	1.39 ± 0.86	0.08
Ice cream and soda	1.29 ± 1.03	1.18 ± 1.10	1.22 ± 0.96	1.79 ± 1.14	0.15	1.31 ± 1.00	1.23 ± 1.10	0.71
Meat	2.67 ± 1.25	2.67 ± 1.14	2.65 ± 1.24	2.74 ± 1.53	0.97	2.68 ± 1.33	2.64 ± 1.00	0.89
Dairy and eggs	2.29 ± 1.45	2.63 ± 1.56	2.20 ± 1.47	2.24 ± 1.21	0.53	2.29 ± 1.48	2.29 ± 1.38	0.99
Vegetables and fruit	5.62 ± 1.30	5.32 ± 1.25	5.81 ± 1.27	5.14 ± 1.38	0.12	5.78 ± 1.28	5.46 ± 1.37	0.48
Seafood	2.27 ± 1.53	2.37 ± 1.85	2.26 ± 1.53	2.18 ± 1.14	0.94	2.35 ± 1.61	2.02 ± 1.27	0.35
Yoghurt	2.06 ± 1.38	2.04 ± 1.26	2.09 ± 1.42	1.95 ± 1.46	0.94	2.20 ± 1.44	1.65 ± 1.16	0.09
Water	6.65 ± 1.06	6.26 ± 1.63	6.73 ± 0.88	6.79 ± 0.80	0.94	6.64 ± 1.10	6.68 ± 0.95	0.87
Physical activity relative time (hours per week)	3.59 ± 4.29	4.03 ± 4.89	3.47 ± 4.45	3.54 ± 2.55	0.89	3.58 ± 4.27	3.60 ± 4.42	0.98
Sedentary time (hours per day)	3.44 ± 2.36	3.15 ± 2.81	3.19 ± 1.95	4.97 ± 3.01	0.03 * (3>2) ‡	3.36 ± 2.39	3.68 ± 2.33	0.56
Hours of sleep (hours per day)	9.18 ± 0.91	9.11 ± 0.83	9.19 ± 0.77	9.20 ± 0.98	0.94	9.26 ± 0.84	8.95 ± 0.67	0.11

§ One-way analysis of variance (ANOVA); * $P < .05$; ‡ Bonferroni post hoc test was significant ($P < .05$).

Table 4. Multivariable logistic regression analysis of the predictors of underweight and overweight/obesity

Variable/OR (95% CI)	Underweight vs. Normal BMI	Overweight/Obese vs. Normal BMI
Moderate-to-severe CHD (Ref = Mild CHD)	4.5* (1.4-14.2)	
Asthma, yes (Ref = No)	5.9* (1.2-29.1)	
Sedentary behaviors		1.3* (1.0-1.8)
Cardiomegaly (Ref = Normal heart size)		9.2** (1.7-48.7)
NYHA Classification II-IV (Ref = Class I)		4.6* (1.1-19.2)
Parental BMI overweight/obesity(Ref = underweight/normal BMI)		4.3 ^a (0.9-19.4)
<i>Nagelkerke R²</i>	<i>17%</i>	<i>38%</i>

OR: Odds ratio; 95% CI: 95% confidence interval; Ref: reference group; ^a $P = 0.056$; * $P \leq .05$; ** $P \leq .01$.

Figure 1. Flow chart of participant recruitment

Online Table 1: Fiftieth-percentile BMI (kg/m²) among Taiwan's general population children

Age (y)	Boys	Girls
7	15.9	15.6
7.5	16.1	15.8
8	16.3	16
(kg/m ²)	16.5	16.1
	16.7	16.3
9.5	16.8	16.5
10	17	16.8
10.5	17.1	17.1
11	17.4	17.5
11.5	17.7	17.9
12	18	18.3