Cardiology in the Young

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Sports participation, activity, and obesity in children who have undergone the Fontan procedure

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Original Article

Cite this article: Baleilevuka-Hart ME, Khader A, Gonzalez De Alba CE, Holmes KW, and Huang JH (2022) Sports participation, activity, and obesity in children who have undergone the Fontan procedure. *Cardiology in the Young* **32**: 1027–1031. doi: 10.1017/S1047951121003541

Received: 14 June 2021
Revised: 24 July 2021
Accepted: 4 August 2021
First published online: 3 September 2021

Keywords:
Fontan; sports participation; activity; obesity

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Abstract

Background: Children with CHD are at risk for obesity and low levels of activity. These factors are associated with an increased risk of poor outcome. Participation in organised sports is an important avenue for children to maintain physical activity, though the relationship between sports participation and obesity has not been examined in the Fontan population. *Methods:* We performed a cross-sectional study of children aged 8–18 who had been evaluated between January 1, 2015 and October 1, 2019 at the Doernbecher Children's Hospital outpatient paediatric cardiology clinic and had previously undergone a Fontan. Patients were excluded if they were unable to ambulate independently or if they had undergone a heart transplant. Patient characteristics were recorded from the electronic medical record. Parents were interviewed via a telephone survey and asked to describe their child's activity levels and sports participation. *Results:* Our final cohort included 40 individuals, 74% were male. The overall prevalence of obesity (CDC BMI >95% for sex/age) in the cohort (23%) was significantly higher in non-athletes (33%) than athletes (0) ($p = 0.02$). There was no difference in cardiac complications or comorbidities between athletes and non-athletes. Athletes were more likely to meet daily activity recommendations ($p = 0.05$). *Conclusion:* Fontan patients who do not participate in sports are significantly more likely to be obese and less likely to be active than those who do. This is the first study to demonstrate the association between competitive sports participation and decreased likelihood of obesity in the Fontan population.

There is a growing body of evidence that exercise is safe in Fontan populations[1-3] and is associated with numerous health benefits.[1,4-7] Exercise training in this population has been correlated with improved exercise capacity,[1,2,4,5,8-11] lung function,[7,12] muscle mass,[9] strength,[9] quality of life,[4,13,14] and sleep hygiene.[6] Exercise has even been shown to create pulsatile Fontan blood flow,[9] improve inferior caval vein venous blood return[9,15] and increase aortic flow.[9] While exercise is important in single-ventricle patients with Fontan circulation, they have been found to be less active than peers[16,17] and have reduced exercise capacity.[4,18-25] Compared to healthy peers, patients with Fontan physiology have decreased muscle mass,[19,26] increased adiposity,[26] and a high prevalence of obesity[27] that increases with age.[28]

Sports participation in childhood has been linked to increased physical activity in adulthood.[29-32] There is growing evidence that exercise programmes can improve exercise tolerance,[1,2,4,5,8-11] suggesting that inactivity is a modifiable factor mediating this process. Paediatric cardiac programmes have increased efforts to institute exercise programmes, including cardiac rehabilitation programmes and exercise prescriptions. These interventions have demonstrated success at improving exercise tolerance.[1,4,5,8,11,33] Traditionally, these programmes have been instituted in a hospital-based environment; however, given challenges associated with travel to care centres for cardiac rehabilitation, increasing attention has been paid to home-based programmes, which have demonstrated overall good results.[1,18,34] Ultimately, the goal of exercise programmes and prescriptions is not only to increase exercise capacity in the short term, but to also increase daily activity as a means of maintaining exercise capacity in the long term. Unfortunately, the Fontan population has continued to have decreased activity levels[16,17] when compared to healthy peers. The goal of our study was to examine the relationship between sports participation, obesity, and daily activity levels in children who have undergone the Fontan procedure.

Methods

We performed a single-centre retrospective cross-sectional study of all paediatric cardiology patients at Oregon Health and Science University with a diagnosis of "Fontan procedure" in

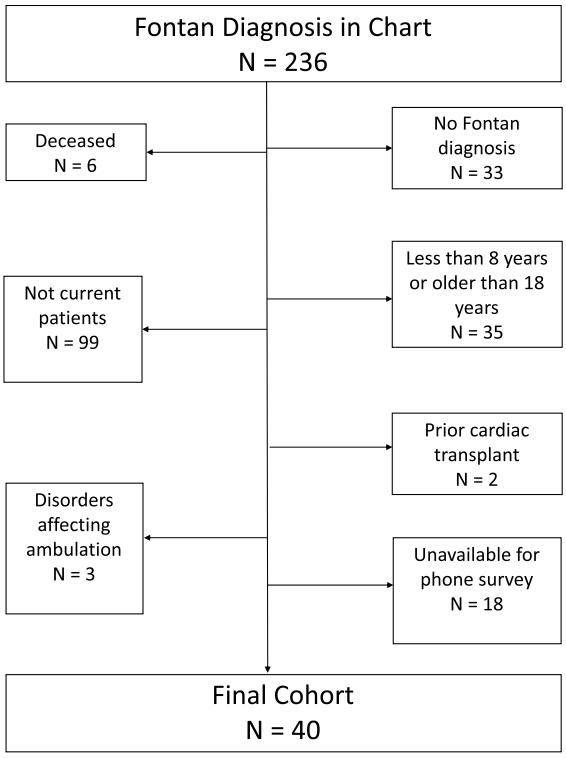

Figure 1. Cohort selection.

Table 1. Cohort characteristics

Characteristic	Cohort n = 40
Male gender	29 (74.4%)
Mean age	12.5 years ± 3.2
Grade	
Elementary school (grades K-5)	15 (37.5%)
Middle school (grades 6–8)	14 (35.0%)
Highschool/Postgraduate (grades 9+)	11 (27.5%)

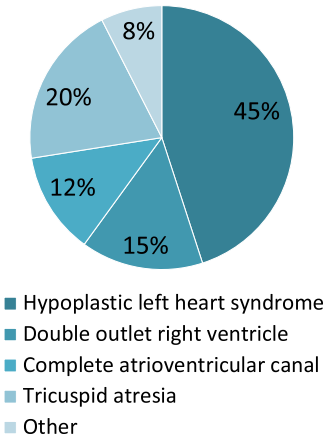

Figure 2. Single-ventricle morphologies.

their chart and who underwent an echocardiogram or were seen in paediatric cardiology ambulatory clinic between October, 2015 and January, 2020. Patients had to have undergone the Fontan procedure, be current patients in the paediatric ambulatory clinic, have no prior history of heart transplant, and be able to ambulate independently (Fig 1). Parents were then contacted for permission to participate in the study, and were subsequently given a phone survey detailing their child's level of daily activity and participation in competitive sports within the last 12 months. Parents were contacted through April, 2020. Native Spanish speakers were interviewed in Spanish by a native Spanish-speaking paediatric cardiologist. A maximum of three attempts was made in contacting the parent or guardian. In the phone survey, parents were questioned on their child's physical activity in comparison to recommended physical activity guidelines for children (60 minutes of moderate to vigorous physical activity daily[35]). In surveys, moderate to vigorous physical activity was defined as "walking briskly.[35] Parents were asked to identify if their child had participated in a competitive or organised sport within the last 12 months and athletes were defined as those who had.

Charts from the electronic medical record were subsequently reviewed. Each study patient's last height and weight were recorded and the BMI was calculated for age and sex-based Center for Disease Control and Prevention BMI curves. Study patients were classified as "overweight" with a BMI 84–94% and "obese" with a BMI >95% in accordance with CDC guidelines.[36] The patient's last clinic note, echocardiogram, cardiac catheterisation, MRI, CT, ambulatory cardiac monitor, and exercise test were reviewed from the EMR.

STATA software version 16.1 for Macintosh (StataCorp LLC, College Station, TX) was used for analysis. Patient characteristics and survey results were summarised using counts, percentages, medians, and interquartile ranges (expressed as 25th and 75th percentiles). Pearson's chi-squared testing was utilised to examine categorical variables (e.g., sex, BMI category) and t-tests were used to examine continuous variables (e.g., age, BMI percentile).

Results

The total cohort of eligible patients included 58 individuals. Of these, 40 parents participated in the telephone survey (Fig 1). The final cohort was 74% male (Table 1). The median age of study patient was 12.5 ± 3.2 years with no difference between athletes (12.2 ± 3.1 years) and non-athletes (12.7 ± 3.0 years) (p = 0.56). There was an overall equal distribution of individuals between school age groups, with 37.5% in elementary school (defined as kindergarten through 5th grade), 35% in middle school (defined at 6th grade through 8th grade), and 27.5% either in higher school (defined as 9th grade through 12th grade) or recently postgraduate. Only two individuals identified as "post graduate." Both participated in sports in the prior year. The most common single ventricle morphology was hypoplastic left heart syndrome (Fig 2). The overall cohort had minimal significant comorbid disease (Table 2). There was no statistically significant difference between the prevalence of comorbid conditions between athletes and non-athletes or between obese and non-obese individuals (Table 2).

Parents reported they worry about their child due to their heart in approximately half of the cohort, with no difference between athletes (54%) and non-athletes (52%) (p = 0.91). Parents reported they sometimes limit their child's activity equally between the athlete (23%) and non-athletes (22%) (p = 0.95). Providers recommended some form of competitive sports restriction in 12.5% of cases (n = 5). At this time, the AHA guidelines[37] recommend

https://doi.org/10.1017/S1047951121003541 Published online by Cambridge University Press

Table 2. Comorbid conditions and complications for athletes and non-athletes and obese and non-obese patients

Echo or cardiac catheterisation finding	Athletes n = 13% (n)	Non-athletes n = 27% (n)	p-value	Non-obese n = 31% (n)	Obese n = 9% (n)	p-value
More than mild atrioventricular valve regurgitation	46.2% (6)	37.0% (10)	0.58	45.2% (14)	22.2% (2)	$P = 0.22$
More than mildly reduced systemic ventricular function	0	0	–	0	0	–
Re-coarctation of the aorta	7.7% (1)	0	0.14	3.2% (1)	0	0.59
Glenn or pulmonary artery narrowing	30.8% (4)	55.6% (15)	0.14	48.4% (15)	44.4% (4)	0.84
Pulmonary vein stenosis	7.7% (1)	3.7% (1)	0.55	6.5% (2)	0	0.43
Pulmonary hypertension	7.7% (1)	3.7% (1)	0.55	3.2% (1)	11.1% (1)	0.35
Systolic hypertension	7.7% (1)	3.7% (1)	0.59	3.2% (1)	11.1% (1)	0.339
Pacemaker	7.7% (1)	11.1% (3)	0.71	6.5% (2)	22.2% (2)	0.18
Plastic bronchitis	0	3.7% (1)	0.48	3.2% (1)	0	0.59
Liver disease	0	3.7% (1)	0.48	0	11.1% (1)	0.06
Arrhythmia	23.1% (3)	25.9% (7)	0.74	22.6% (7)	33.3% (3)	0.58
Protein-losing enteropathy	7.7% (1)	3.7% (1)	0.59	3.2% (1)	11.1% (1)	0.33
Previous stroke	0	14.8% (4)	0.16	9.7% (3)	11.1% (1)	0.92

Table 3. Characteristics of athletes versus non-athletes.

	Total cohort n = 40	Athlete n = 13	Non-athlete n = 27	p-value
Age (years)	12.5 ± 3.2	12.1 ± 3.5	12.7 ± 3.0	0.56
BMI %, mean, SD	57.8 ± 35.3	45.6 ± 35.8	63.7 ± 34.2	0.13
Overweight	7.5% (3)	7.7% (1)	7.4% (2)	0.97
Obese	22.5% (9)	0	33.3% (9)	0.02
Overweight/Obese	30.0% (12)	7.7% (1)	40.7% (11)	0.03
Meet daily activity recommendations	55.0% (22)	76.9% (10)	44.4% (12)	0.05

exercise tests performed prior to sports recommendations; however, providers at our institution typically do not follow this (only two performed in cohort, one for pre-sports participation and the other due to fatigue with exercise).

Nearly one-third (30%) of the cohort reported participation in competitive sports within the last year. The most common sport played was baseball (n = 7), which was also the most common sport parents reported their child had stopped due to recommendation by their child's cardiologist. The most common sport parents reported their child had asked to play but were not allowed due to concern for their heart was football.

The overall prevalence of obesity in the cohort was 23% with non-athletes significantly higher (33%) than athletes (0) (p = 0.02) (Table 3). There was no significant difference between overweight individuals between athletes (8%) and non-athletes (8%) (p = 0.97) (Table 3). Per parent reporting, 55% of the cohort met daily activity requirements of 60 minutes of moderate to vigorous physical activity daily, however, this was heavily skewed by athletes (77%) who were significantly more active than non-athletes (44%) (p = 0.05).

Discussion

Our study found that patients with Fontan physiology who participated in competitive sports within the last year were less obese and more active than those who did not participate in sports. We also found a high overall prevalence of obesity (22.5%), higher than previously reported findings in Fontan populations of 17%[27] and considerably higher than peers in the state of Oregon (12.9%).[38] The high prevalence of obesity in our study was entirely skewed by non-athletes, who had a staggeringly high prevalence of obesity (33%) compared to no cases of obesity in the athletes in this Fontan cohort (p = 0.02). This prevalence of obesity is particularly deleterious in this population as increased BMI is associated with congestive heart failure and increased mortality in adults with Fontan physiology.[39] Our study also found that there was no difference in the prevalence of significant comorbid cardiac conditions or complications between athletes and non-athletes (Table 2). This is consistent with prior literature demonstrating that decreased activity levels in Fontan patients are independent of exercise capacity.[17]

At present, there are no post-surgical interventions that have demonstrated mortality benefit to patients who have undergone a Fontan Procedure. Exercise interventions, however, have demonstrated promise in improving exercise capacity in patients with Fontan physiology.[1] Despite this, Fontan patients are less active than healthy peers.[17] Multiple comorbid factors have been associated with reduced exercise capacity including pulmonary abnormalities,[7,40-42] decreased muscle mass,[26] and older age at Fontan[43]; however, previous studies have also demonstrated that physical activity after the Fontan procedure did not

https://doi.org/10.1017/S1047951121003541 Published online by Cambridge University Press

correlate with cardiac status,[44] or even exercise capacity.[17] Studies suggest that lack of interest in exercise and health fears form major barriers to exercise.[45] Efforts to increase interest in exercise are therefore of chief importance in this population.

Youth participation in organised sport is an important avenue to promote lifelong activity.[29-32,46] In paediatric populations, participation in competitive and organised sports in childhood has been associated with decreased social anxiety[47] and improved social skills,[48] improved mental health,[49] decreased suicidality,[50] improved physical health,[49] improved health-related quality of life,[51] decreased BMI,[46] and even decreased cardiovascular risk.[52] In young adult Fontan populations, sports participation is associated with improved exercise performance.[10] Our study suggests that sports participation may have a role in combating obesity and maintaining daily activity. This low-cost intervention carries significant potential, but little downside.

Our study was limited by the retrospective nature of our study design. We were also limited by being a single-centre study with a small to moderate paediatric cardiac surgical programme, which inevitably led to a small single-ventricle sample size. Our study was also limited by parental report and recall bias, which may have led to inaccurate representation of their child's level of daily activity. Future work is needed to determine the role daily activity may play in decreasing functional decline and progressive Fontan circuit inefficiency in the long term.

In conclusion, we found sports participation in paediatric Fontan patients was associated with decreased obesity and the likelihood of meeting daily activity levels. Encouraging safe sports participation may, therefore, be an important means of combating obesity and encouraging activity in this vulnerable and more sedentary population.

Acknowledgements. The authors would like to thank Dr Ben Orwell for his help with data mining.

Financial support. This research received no specific grant from any funding agency, commercial, or not-for-profit sectors.

Conflicts of interest. None.

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