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Pediatric youth who have obesity have high rates of adult criminal behavior and low rates of homeownership

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Abstract

Objectives: The social outcomes in adulthood for pediatric patients with obesity are not well-described. This study investigated lifetime criminal behavior and homeownership in youth with obesity.

Methods: Retrospective data on all children enrolled in the weight management program from 1999 to 2009 and who completed exercise testing were collected. Demographic and public record collection included body habitus, death records, real estate transactions, and criminal conviction history with comparisons made to published normative data.

Results: In the children with obesity studied ($N = 716$; 12.0 ± 3.1 years old), the now-adult patients (28.5 ± 3.7 years) had a 1.5% mortality rate (11/716). Overall, 9.6% of these adults were convicted of a felony compared to ~7% lifetime prevalence in Ohio ($p = 0.03$). Also, 14.7% of study patients purchased a home compared to 38.3% of Midwest adults <30 years old ($p < 0.0001$). Mortality, history of a criminal conviction, or homeownership was associated with any exercise or study parameter.

Conclusion: Children with obesity appear to have greater social risk than their peers in adulthood with higher rates of criminal behavior and lower rates of homeownership. This appears to highlight the need for treatment in this vulnerable group of children and young adults.

Keywords

Obesity, criminal behavior, risk-taking behavior, homeownership, fitness

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Introduction

Obesity is a multifactorial disorder that often becomes apparent in childhood. There is growing evidence that obesity beginning in childhood increases the risk of adult medical morbidity, including early coronary vascular disease, hypertension, and dyslipidemia.[1,2] Long-standing obesity will often result in impaired musculoskeletal strength, decreased aerobic capacity, and overall impaired fitness measured by cardiopulmonary exercise testing (CPET), with all of these abnormalities beginning in childhood.[3] There are other complications of obesity outside of medical morbidity and mortality. The psychological toll of obesity has also been described, with known higher risks of depression, anxiety, and poor quality of life.[4,5]

The social complications related to obesity have been incompletely described.[6] Lower socioeconomic status is a known risk factor for the development of obesity.[7] In addition, adults who have obesity have been shown to have higher rates of risk-taking behavior, social isolation, and school difficulties.[8,9] There has been minimal research evaluating the relationship between pediatric obesity and future criminal behavior despite the fact that future criminality shares many of the same complex risk factors such as obesity, race, and gender.[10,11] In addition, there has been no research to date evaluating whether childhood obesity affects homeownership rates later in adulthood with

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homeownership being a potential tool to measure socioeconomic status and wealth.

The primary aim of this study was to evaluate the lifetime rates of criminal behavior and homeownership in youth with obesity with these serving as our primary outcomes. We hypothesize that youth with obesity will have higher rates of adult criminal behavior and lower home ownership rates. The secondary aim was to determine whether age, exercise tolerance based on CPET, gender, or race serve as predictors of future health-related outcomes, risk-taking behavior, homeownership, and mortality for youth with obesity. For this aim, we hypothesize that gender and race will be related to outcomes but that exercise tolerance and age will not be related to the primary outcomes. The final aim of the study was to further characterize the physical fitness profile of youth with obesity using CPET.

Methods

Participants

We performed a retrospective chart review on all patients aged 5–18 years who presented to the HealthWorks! pediatric weight management program from January 1999 to December 2009. HealthWorks! is a family-based weight management program in the Heart Institute at Cincinnati Children's Hospital for children and teenagers with overweight or obesity conditions in the greater Cincinnati area. The program seeks to promote healthier eating habits and increased physical activity, and during the study period, a formal CPET at the time of the visit was a requirement for clinic enrollment. Patients with incomplete records were excluded from the analysis.

Inclusion criteria included pediatric patients aged 5–18 years and enrollment in the HealthWorks! clinic. Exclusion criteria included incomplete records and orthopedic injury that would prevent exercise.

Procedure

Once the appropriate patients were identified, the most recent contact information was obtained through both the electronic medical record and LexisNexis (RELX Group, Horsham, PA, USA). LexisNexis is a search engine that pools a conglomerate of publicly available information and was used to assess death certificates, arrest and incarceration records, and home purchasing transactions. Once demographic data were obtained, these now-adult patients were contacted via mail for recruitment, with opt-out instructions included as well. If a patient opted out of the study, none of their data was used in the analysis. Once the previous steps were completed, a LexisNexus search was performed. Outcome measures recorded from the LexisNexis search included mortality data including cause of death, felony convictions, previous or current incarcerations, previous or current home purchases, and prior declaration of bankruptcy. The cause of death was recorded if it was noted on the public record.

All patients enrolled in the study had a formal CPET performed previously in childhood, which was a requirement for enrollment in the clinic during that time. All patients were tested using a modified Balke treadmill protocol.[12] Oxygen consumption and carbon dioxide production were measured at rest and during each workload using a metabolic cart (True Max 2400, ParvoMedics, St. Lake City, UT, USA). Heart rate on a 12-lead electrocardiogram strip and blood pressure were measured at rest, during each minute of exercise, immediately post-exercise, and 1, 3, 5, 10, and 15 min post-exercise. An exercise test was judged to be a maximal test if two of the following three criteria were met: respiratory exchange ratio >1.1, maximal heart rate $\geqslant 85\%$ of the age-predicted maximal heart rate (220-age in years), and maximal Rating of Perceived Exertion score $\geqslant 18$ (range, 6–20).[13] As there are no normal prediction equations for the peak oxygen consumption (VO_2peak) in pediatric patients with obesity, the percentage of predicted VO_2peak was calculated using ideal body weight factored into the prediction equations described by Cooper et al.[14] Normal values were defined as greater than 80% predicted.[14] Ideal body weight was calculated using the Devine formula.[15] Outcome measures recorded from the CPET included age, height, weight, body mass index (BMI), sex, race, respiratory exchange ratio, peak heart rate, VO_2peak, and peak systolic blood pressure.

Obesity was classified into three classes: class 1 obesity, BMI $\geqslant$95th percentile to $<$120% of 95th percentile for age and sex; class 2 obesity, BMI $\geqslant$120% to $<$140% of 95th percentile or BMI $\geqslant 35\,kg/m^2$; and class 3 obesity, BMI $\geqslant$140% of 95th percentile or BMI $\geqslant 40\,kg/m^2$. Overweight was defined as having a BMI between the 85th and the 95th percentile for age and sex.

Statistical analysis

The CPET data were compared to the LexusNexus search data to evaluate possible associations between pediatric exercise capabilities and adult health and social outcomes. Patient social, demographic, and CPET data were presented as mean $\pm$ standard deviation.

As our data were pooled data over the patient's lifetime and national law enforcement agencies only publish yearly incidence data, we used the study from Shannon et al.[16] to compare lifetime criminal prevalence by region. The lifetime criminal prevalence was calculated by using the Department of Justice yearly prison census and felony conviction data, prior research on recidivism, and state demographic life tables to give state and regional assessments of both prior felony convictions and incarcerations. This study found a lifetime felony prevalence of 6%–7% in Ohio, and 7% was chosen as the comparison group. Felony was defined by

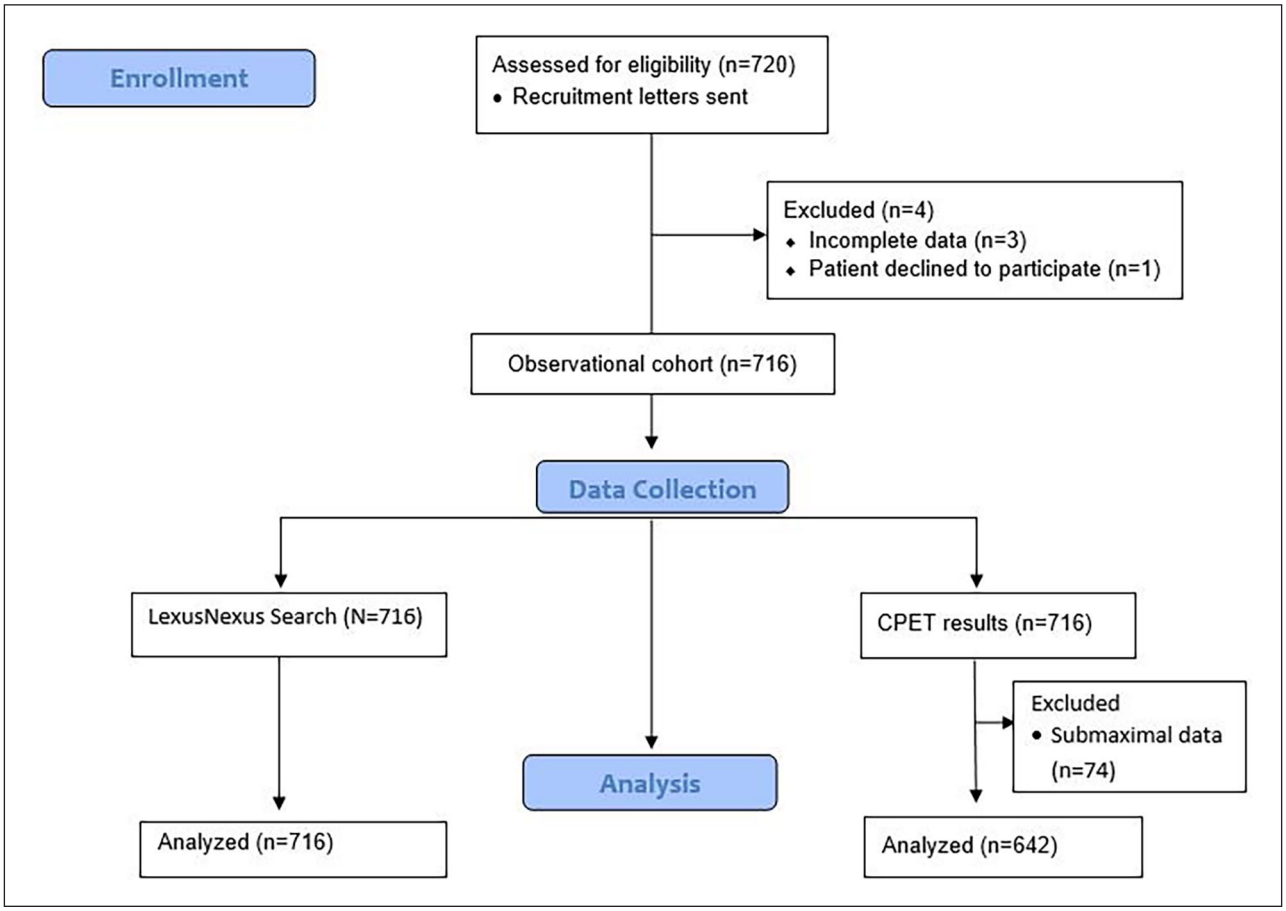

Figure 1. Flow diagram demonstrating the selection of patients for the study. Telephone interview refers to the completion of the Behavioral Risk Factor Survey over the telephone. LexusNexus search denotes the acquisition of social outcomes by a public record search. CPET: cardiopulmonary exercise test results.

Shannon et al. and included criminal convictions for violent crime, theft, breaking and entering, arson, and/or drug offenses. In addition, incarceration was defined as anyone having a felony that required time in prison, and the range for former incarceration was 2%–3%, and 3% was used for the incarceration comparison group. Lifetime homeownership rates were compared to published homeownership data.[17,18] Differences between groups were assessed with either a two-sided *t* test or a chi-square test when appropriate. Associations between normally distributed variables were calculated using the Pearson correlation coefficient. A logistic regression analysis was performed with the dependent variables being prior incarceration and home ownership. Variables analyzed included gender, race, BMI >95%, substance abuse, and peak VO_2. In addition, a Bonferroni correction was done for multiple tests to further test for significance. As there were six comparisons, a $p < 0.0083$ was used to refine the significance. A $p < 0.05$ was considered significant. Statistical analyses were performed using JMP®, version 14 from SAS Institute Inc. (Cary, NC). This study was approved by the Cincinnati Children's Hospital Medical Center Institutional Review Board (#2019-0737).

Results

From 1999 to 2009, 720 patients were seen in the HealthWorks! pediatric weight management program and were contacted for this study (Figure 1). One patient declined and three patients were excluded from the analysis secondary to incomplete records. The remaining 716 patients were included (12.2 ± 2.9 years at enrollment; 28.5 ± 3.7 years at study initiation). Demographic data are presented in Table 1. At the time of CPET, 51.4% (368 patients) had class 3 obesity, 31.2% (223 patients) had class 2 obesity, 16.4% (117 patients) had class 1 obesity, and 1% (7 patients) were overweight.

Results of CPET

There were 716 patients with complete maximal effort CPET data (Figure 1). The results of CPET are described in Table 1. Of note, 90% (642/716) of patients were able to complete a maximal effort CPET. In addition, 75% (481/642) of the patients who completed a maximal effort CPET had a normal percentage of predicted VO_2peak defined as being greater

Table 1. Baseline demographics and results of cardiopulmonary exercise testing during childhood in now-adult youth with obesity.

Total patients	716
Age at CPET (years)	12.0 ± 3.1
Age at public data search (years)	28.5 ± 3.7
Gender	Male 39%
	Female 61%
Race	W 52%
	AA 44%
	Hispanic 1%
	Asian 0.5%
	Other 2.5%
Weight at CPET (kg)	88.6 ± 30.9
Height at CPET (cm)	154.9 ± 15.0
BMI at CPET	35.8 ± 7.9
Results of maximal effort CPET ($N = 642$)	
Respiratory exchange ratio	1.06 ± 0.08
VO_2peak (mL/kg/min)	26.0 ± 5.1
Percent predicted VO_2peak (%)	99.0 ± 24.1
Maximal systolic blood pressure (mmHg)	177.9 ± 22.4
Maximal heart rate (bpm)	193.5 ± 10.3
Percent predicted maximal heart rate (%)	87.3 ± 29.1

CPET: cardiopulmonary exercise test; BMI: body mass index; VO_2peak: oxygen consumption at peak exercise; W: White; AA: African American. Data presented as means ± standard deviation.

than 80% predicted when adjusted for ideal body weight. In addition, 98% (701/716) had a normal heart rate response to exercise (i.e. ⩾85% predicted peak heart rate), and all patients had a normal systolic blood pressure response to exercise (i.e. ⩾20 mmHg increase during exercise).

Inability to complete a maximal effort CPET was associated with younger age ($r = 0.25$, $p < 0.0001$), higher weight ($r = 0.11$, $p = 0.003$), and higher obesity class ($r = 0.11$, $p = 0.003$). Boys tended to have higher percentages of predicted VO_2peak than girls ($r = 0.59$, $p < 0.0001$). Percent predicted VO_2peak was associated with age ($r = 0.62$, $p < 0.0001$) and weight ($r = 0.49$, $p < 0.0001$). Percent predicted peak heart rate was also associated with age ($r = 0.53$, $p < 0.0001$) and weight ($r = 0.34$, $p < 0.0001$).

Results of public record search

All 716 patients were able to be located in the LexusNexus database and have a public record review performed (Figure 1). There was a 1.5% mortality rate (11/716), and the cause of death was reported as cardiomegaly for one patient. There were no specific causes of death or age of death for the remaining 10 patients who died. Of these 11 patients who died, 55% (6/11) were male compared to 38% (270/705) male in those that did not die ($p = 0.3$). Patients who died had a significantly lower percent predicted heart rate compared to those who did not die (91.9 ± 3.1 vs 96.8 ± 5.1 bpm; $p = 0.02$). In addition, the patients that died had a higher BMI during childhood compared to those who survived during the study period (41.4 ± 10.3 kg/m^2 vs 35.7 ± 7.9 kg/m^2; $p = 0.02$).

On review of the criminal records, 9.6% (69/716) of these young adult patients were convicted of a felony compared to ~7% published lifetime prevalence in Ohio during this time period ($p = 0.03$) (Figure 2). Of these 69 patients, the reason for conviction included 14 patients for violent crime, 27 patients for drug-related offenses, 22 patients for theft/burglary, 2 patients for arson, 2 patients for driving under the influence, and 2 patients for illegal possession of a firearm (Figure 3). There was no difference between the incarceration rates of these now-adults who were seen for pediatric weight management and the reported lifetime prevalence in Ohio (26/716; 3.6% vs 3%, $p = 0.45$) (Figure 2). There was no difference in conviction history when comparing African-American to Caucasian patients (10.4%; 33/318 vs 9.7%; 36/370; $p = 0.78$). Youth with obesity who committed a felony in adulthood tended to have lower percent predicted peak heart rates on exercise testing than those that didn't commit felonies (95.1 ± 6.6 vs 97 ± 4.9 bpm; $p = 0.006$). Patients with criminal convictions were more likely to be male than patients not convicted of a crime (51% vs 37%, $p = 0.03$).

In addition, 14.7% (105/716) of study patients purchased a home in adulthood compared to 38.3% of Midwest adults <30 years of age ($p = 0.0001$) (Figure 2). There was a significant difference between African American and Caucasian patients in homeownership rates (6.7%; 21/318 vs 22.7%; 84/370; $p < 0.0001$). Also, there was a significant difference in homeownership between the African American study patients and published data on African Americans homeowners less than 34 years of age (6.7% vs 35%; $p < 0.0001$). There was no difference in home ownership rates between patients who were convicted for a crime and those who were not. In addition, 5% (36/716) of study patients declared bankruptcy during this study period. There was no significant difference between BMI and any exercise test parameter in homeownership or bankruptcy rates. Now-adult youth with obesity who declared bankruptcy were more likely to be convicted of a crime compared to those who did not declare bankruptcy (12% vs 4%, $p = 0.02$).

On the logistic regression analysis, when analyzing incarceration as the dependent variable, the only significant variable using the Bonferroni correction was prior substance abuse conviction (odds ratio, 12.75 (3.9–42.1), $p < 0.0001$). When home ownership was the dependent variable, the only significant variable with the Bonferroni correction was race (odds ratio, 3.23 (1.9–5.4), $p < 0.0001$).

Discussion

This study demonstrates that children with obesity appear to have a similar or higher rate of lifetime criminal behavior compared to the general population. In our cohort, this was independent of race as there was no difference in convictions

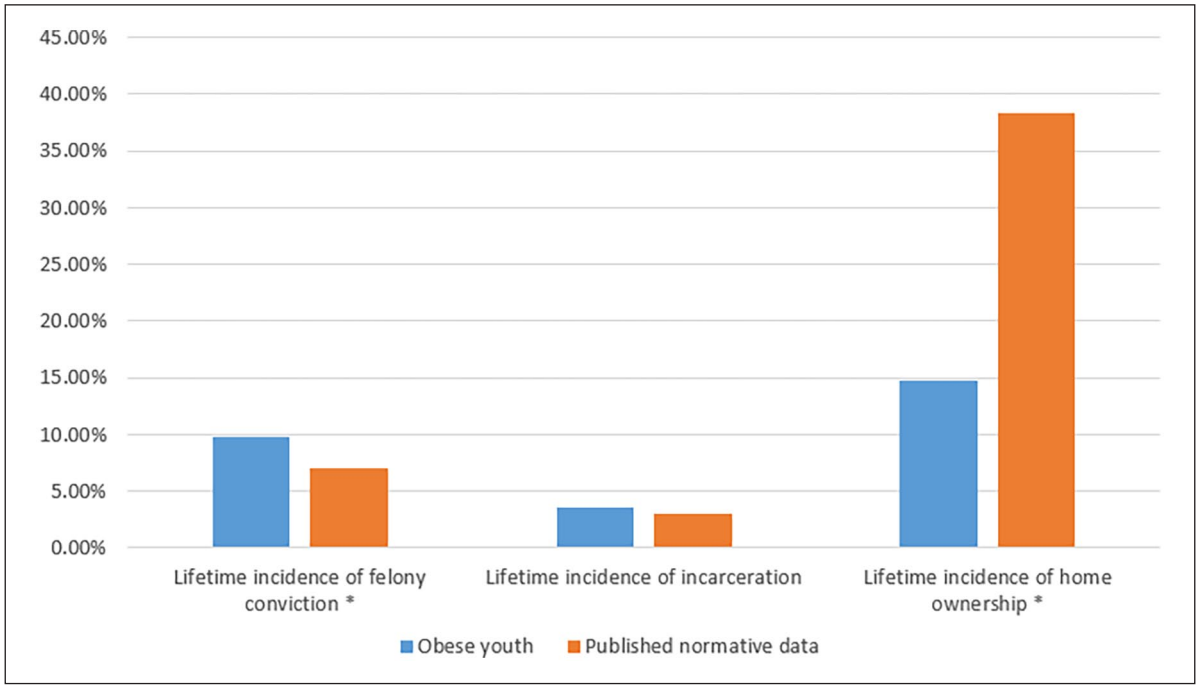

Figure 2. Comparison between future adult behaviors of youth with obesity versus published normative data.
* denotes a p value <0.05.

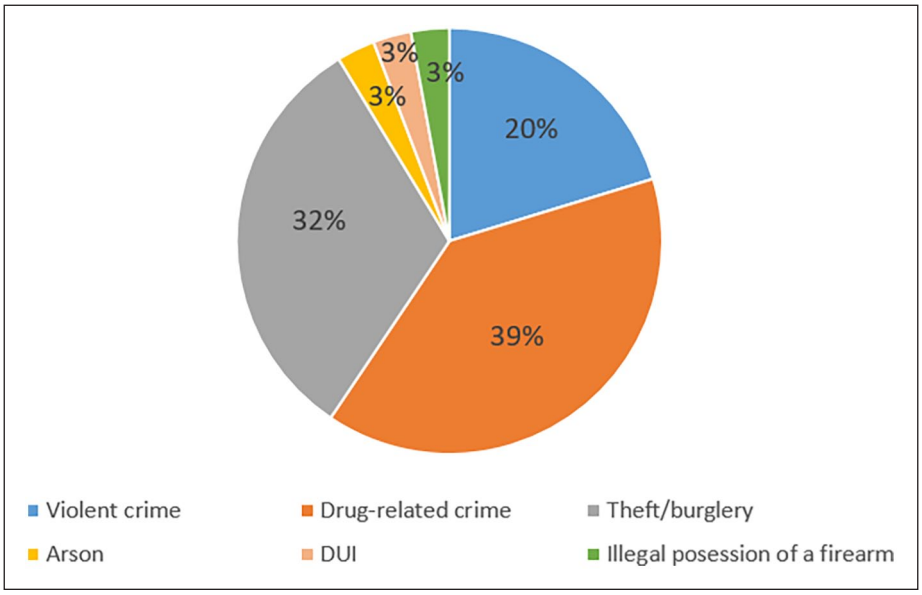

Figure 3. Reasons for a felony conviction in now-adult youth with obesity based on public record review.
DUI: driving under the influence.

between Caucasians and African Americans nor was there a significant association between African American race and felony history. While novel and to our knowledge not previously reported, this finding is plausible as many of the known risk factors for obesity are also risk factors for criminal behavior. Establishing this link between childhood obesity and the potential for future criminal behavior can impact how youth with obesity are screened and managed in the clinical setting. Increased surveillance for risk-taking behaviors and enhanced mental health screening can help identify comorbidities that can hinder both treatment and psychosocial well-being. Of note, as this was an observational study, this study did not answer whether treatment for obesity reduces the risk of these negative social outcomes.

This study contradicts previous mathematical models that postulated lower criminal behavior in young adults with obesity, which the authors hypothesized that their body weights and lower levels of fitness may prevent them from participating in certain criminal behaviors.[19] These data were based on population-averaged and conditional fixed effects logit models derived from a constructed panel dataset from the National Longitudinal Survey of Youth. The fact that our study utilized longitudinal patient data as opposed to mathematically derived data may explain the differences in results with the article by Kalist et al. The regional versus national crime differences may also explain the contradictory findings between studies. In addition, many of the felonies were drug-related in our study, which would not necessarily require a certain level of physical fitness and may explain the differences between studies. The fact that those who committed a crime had a lower peak heart rate during exercise testing during childhood may also argue against the hypothesis that a certain level of fitness is needed to commit a crime. This could also be an unrelated and incidental finding.

As the link between obesity in childhood and future social risk is starting to become clearer, mechanisms to understand this more fully need to be developed. Previous research has focused on the link between crime in childhood and the development of future obesity. A possible biochemical mechanism for the increased risk of obesity in pediatric victims of violent crime has been proposed by Gartstein et al. They demonstrated a moderation of diurnal cortisol pattern in youths exposed to community crime, which may, in turn, increase the risk of obesity later in life.[20] Mechanistic research examining criminal behavior in these at-risk youth with obesity later into adulthood is lacking. Childhood obesity has also been linked to future substance abuse, particularly binge drinking, which is noteworthy as binge drinking is a risk factor for future abuse of illicit substances and criminal behavior.[21–24]

This study demonstrated a marked difference between the homeownership rates of adults with a history of obese in youth and the general population. The implication of this finding is that youth with obesity may be less financially successful and experience greater financial difficulties than the general population in adulthood as homeownership generally requires a combination of current and future earnings. This is supported by the fact adults with obesity report greater financial hardship and have greater difficulties obtaining the same quality jobs as their counterparts with a normal BMI.[25–27] On the other hand, this study may have underestimated the number of people who have the financial means to purchase a home but chose not for various nonfinancial reasons. In addition, the low homeownership rates of African-Americans in our cohort compared to published normative data may also be a factor for the poor homeownership rates seen in our study, and this finding should be confirmed by future studies with a larger cohort.[18]

Our study was unable to determine a definitive link between fitness as measured by CPET obtained in childhood and future obesity-related health and social outcomes, including mortality, criminal history, and homeownership. Overall levels of fitness in youth do not appear to be correlated with future criminal behavior or homeownership. As demonstrated in Table 1, this cohort tended to have normal fitness and was able to complete maximal effort testing by the criteria used (i.e. 2 out of 3 from the following criteria including respiratory exchange ratio >1.1, percent predicted heart rate $\geqslant 85\%$, and subjective exhaustion). This cohort also had normal systolic blood pressure and heart rate response to exercise. Patients that died tended to have a lower peak heart rate in childhood during exercise testing. While interesting, these patients still had a normal heart rate response, and this finding should be confirmed in a larger cohort to determine if this is truly a marker of prognostic significance. Older patients were able to have higher fitness levels, which is an expected finding and reflects the normal maturation of exercise responses during childhood. In addition, the fact that heavier patients had a higher percentage of predicted VO_2peak is not a novel finding and likely reflects limitations in the prediction equation as there is no universally accepted prediction equation available for youth with obesity. While using the ideal body weight for the normal weight pediatric prediction equation likely overestimates the level of fitness, using the actual body weight for the prediction equation tends to underestimate fitness as fat is a metabolically inactive tissue.[28]

There are several additional limitations to this study. Perhaps most noteworthy is that lifetime criminal conviction and incarceration are not statistics that are readily recorded and available in the United States. For example, the US Justice Department and most local law enforcement agencies track yearly incidence (but not lifetime prevalence) of crime and people currently under criminal justice supervision but do not track former perpetrators. This led Shannon et al.[16] to write their paper describing the national and regional lifetime estimates for criminal behavior using the available US Department of Justice data and demographic life tables. The fact that this results in an estimation of lifetime criminal prevalence may represent a major limitation in not just this study but how lifetime criminal behavior is reported nationally. On the other hand, our cohort was still young (average age ~28 years old) at the time of comparison with the lifetime data and thus possibly underestimated final criminal behavior. This is a similar situation with homeownership statistics with our data possibly underestimating the reported incidence of homeownership for Midwest residents <30 years old.[17] In addition, this was a sample of convenience, and a sample size calculation was not performed. The missing cause of death data in the 10 patients who died also reflects an additional limitation. Finally, the pediatric patients recruited from the HealthWorks! Clinic may not be representative of the comparison group of Midwest adults. There

may be confounding factors not evaluated which could, in turn, explain these differences, such as income disparities, educational level, and living in underfunded areas. Further study in other patient groups should be performed to validate these findings.

Conclusion

Children with obesity appear to have higher social risk than their peers in adulthood as evidenced by somewhat higher rates of criminal behavior and lower rates of homeownership. Pediatric patients with obesity tend to have normal weight-adjusted levels of fitness and pediatric exercise capacity is not associated with mortality or social outcomes. This appears to highlight the need for improved screening for social risk factors in this vulnerable group of children and young adults and intervention with social support if indicated.

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Author contributions

The following were contributed by the study authors: Development of protocol and methodology—A.P., Z.S., C.K. W.M. and R.S.; Conceptualization—A.P., Z.S., C.K. W.M. and R.S.; Validation—A.P., R.K. and R.S.; Formal analysis—A.P.; Investigation—A.P., Z.S., C.K. W.M. and R.S; Resources—A.P. and R.S.; Data curation—Z.S., Writing- A.P., Z.S., C.K., W.M., R.K., and R.S; Supervision—A.P.; Writing review and editing—A.P., Z.S., C.K., W.M., R.K., and R.S.

Declaration of conflicting interests

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Ethical approval

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Informed consent

Informed consent was waived by the Institutional Review Board.

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