Parental imprisonment, childhood behavioral problems, and adolescent and young adult cardiometabolic risk: Results from a prospective Australian birth cohort study

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Research Article

Keywords: parental imprisonment, behavioral problems, body mass index, systolic blood pressure, diastolic blood pressure, waist circumference, cardiometabolic risk

Posted Date: October 11th, 2023

DOI: https://doi.org/10.21203/rs.3.rs-3406640/v1

Additional Declarations: No competing interests reported.

Abstract

Objectives

Recent studies have demonstrated that parental imprisonment (PI) is associated with cardiometabolic risk later in life. However, underlying risk factors for these associations have not previously been explored. The present study examines how early childhood behaviors and parental imprisonment may be associated with cardiometabolic risk in adulthood.

Methods

The study follows a subset of 7,223 live, singleton births from 1981–1984 in Brisbane, Australia where data was collected on parental imprisonment at ages 5 & 14 and behaviors from the Child Behavioral Checklist (CBCL) at age 5. Our sample examines 1884 males and 1758 females whose mothers completed prenatal, age 5, and age 14 interviews and respondents completed one or more interviews at ages 14, 21, and 30. Multivariate regression was used to examine cross-sectional results, while individual growth models examined longitudinal patterns.

Results

Dividing analysis by sex, we examined how parental imprisonment was potentially mediated or moderated by CBCL subscale measures for aggression, social-attention-thought disorders and general internalizing. No associations were found among male respondents. Among female respondents, controlling for these behaviors, there was a significant association between parental imprisonment and higher systolic blood pressure at age 30, while all CBCL measures were found to moderate waist circumference at age 30 and BMI at ages 14, 21, and 30. Using individual growth curve modelling, we observed the increased CBCL aggression and SAT scores were more strongly associated with higher BMI in adulthood.

Conclusions

Using prospective cohort data, our results suggest that PI and high levels of behavioral problems are associated with significantly increased cardiometabolic risk in women, with potentially increasing risk in adulthood.

Introduction

Parental imprisonment (PI) is linked to a range of adverse behavioral and health outcomes in the life course. Studies have shown that PI is associated with childhood aggression and internalizing behaviors, along with increased risk for mental health and antisocial and delinquent behaviors in adolescence and adulthood [1–6]. Physical health outcomes, including asthma, childhood sleep problems, increased BMI and blood pressure, sexually transmitted infections, physical disability, and premature mortality, are also linked with having a parent imprisoned [7–14]. PI is also associated with a complex array of adversities and outcomes, such as poorer academic performance, social exclusion, and criminal justice involvement that compound over the life course, leading to cumulative disadvantages that may impact health and well-being [15–17]. Depending on the level of adversity, PI may either directly lead to poorer health outcomes, or act as an indicator for poorer health [18].

The prevalence of imprisonment in the U.S., the U.K. and Australia indicate that PI has the potential to significantly impact population health, particularly among minority populations. In Australia, an estimated 4% of all children and up to one-fifth of Indigenous children may experience PI by age 16 [19]. In the U.S., one-third of young adults ages 18–29 report a parent who has undergone detention, with 4% of white and one-fourth of African American children having experienced a parent spend one year or more in prison [20, 21]. In England and Wales., an estimated 310,000 children per year experience PI [22]. The large number of children impacted by parental imprisonment has increasingly led for calls to focus on PI as a cause of health disparities and a public health issue [23, 24].

When thinking about risks of PI on physical health outcomes, it is critical to consider the interrelationship of imprisonment with a range of overlapping adverse childhood experiences (ACEs), known by Giordano & Copp as “packages of risk,” which include parental absence, residential instability, parental mental health and substance abuse, and childhood poverty [16, 25–28]. These “packages of risk” may also include broader psycho-social factors, such as neighborhood and school effects like living in a food desert or lacking educational support services, which may contribute to broader inequalities in health [29]. A recent national study of American adolescents found that 51% of adolescents who experienced a PI reported having four or more ACEs in childhood, compared with 12% of adolescents in the general population [30]; a recent literature review found that adults reporting four or more ACEs were at twice the risk for experiencing cardiovascular disease and premature death [31]. Recent studies have found that depression and anxiety mediate the association between ACEs (including PI) and cardiovascular disease [32, 33]. The associations between increased adversity and mental health issues may help to explain a growing body of research linking parental or familial imprisonment and subsequent cardiovascular and metabolic disease risk in later life [9, 10, 34–36].

One research question which has not been addressed are whether early childhood emotional problems and PI may be linked with cardiometabolic risk in later life. Longitudinal studies suggest that delinquency and depression differentiate risk for increased BMI among females who experience PI in adulthood [9, 37]; however, potential interrelationships between PI and early childhood mental health and behavioral issues has, to our knowledge, not been explored. Research suggests a potential association between early childhood behaviors and psychiatric illness with adult obesity and BMI gain [38–40], while other research suggests that ACEs are associated with a range of childhood emotional and behavioral problems [41, 42]. A recent literature review examining the associations between parental separation and cardiometabolic disease, noted that childhood psychosocial problems may act as a mediating or moderating mechanism [43]. This body of research is suggestive, in the light of the association between ACEs and cardiometabolic disease discussed above, that behavioral problems associated with parental imprisonment may moderate cardiometabolic disease risk in later life.

The link between PI and cardiometabolic risk may also vary by sex or gender. Research on parental and familial incarceration also suggests that cardiometabolic risk markers and diseases are concentrated in females and women [9, 10, 34, 36, 37, 44], with only one study linking familial incarceration with ischemic heart disease in men at mid-life [35]. Using a stress paradigm may be helpful for understanding potential variations, given PI is recognized as a stressor which has been found to vary in magnitude by biological sex for a a range of adverse behaviors and outcomes, including internalizing behaviors and delinquency, substance use, poor social outcomes, and health [15, 45–48]. General research has linked incarceration of a parent with measures of biological stress and premature aging in adolescence and young adulthood, including early menarche, reduced telomere length, and higher allostatic load [45, 49, 50]. However, results from studies examining sex and gender variations for PI find that stress-related cardiometabolic risk factors, including BMI, waist circumference, blood pressure, and C-Reactive Protein are concentrated in adolescent and young adult females, potentially indicating that biological stress-markers associated with PI manifest as increased risk for early cardiovascular and metabolic diseases in females [6, 9, 10, 50].

Given research linking childhood internalizing and externalizing behaviors with the emergence of cardiometabolic risk in adolescent girls, PI and cardiometabolic risk for females in adolescence and adulthood may be mediated by high levels of emotional and behavioral problems childhood [51, 52]. Thus, while PI may lead to stress processes associated with increased risk, the association between PI and cardiovascular risk may manifest in adolescence and adulthood among women who experience mental health issues in childhood. The current will investigate if mediating/moderating effects between PI and cardiovascular risk vary by respondent's biological sex.

Another major limitation of previous research on PI is the lack of longitudinal and prospective cohort studies in general population studies, both generally and with measures of physical health [13, 53]. One recent prospective cohort study found that PI in early childhood (≥ 5 age) was associated with a range of cardiovascular risks, but did not find an association for a larger group of children reporting PI through age 14 [10]. The present study builds on these findings by examining if PI through age 14 and cardiometabolic risk is mediated by early childhood problems.

A final limitation in existing literature is potential bias arising from attrition. Using multiple imputation, we assess the bias of missing data present in longitudinal analysis, an issue with the prior MUSP study by Roettger et al [10]. Missing data may bias existing results and this paper will examine whether the overall consistency of findings remains after accounting for missing observations. Addressing missing data issues can help to ameliorate concerns about the validity of complete case analysis in the MUSP data.

DATA AND METHODS

We used data from the Mater Hospital-University of Queensland Study of Pregnancy (MUSP). The study contains 7223 children born in live, singleton births between 1981–1984 in Brisbane, Australia. The study contains several waves of data collection of both mothers and children, using both respondent-completed surveys and collection of obstetric and additional biometric data collected by trained health professionals. For this study, we incorporate maternal data collected during pregnancy, when the child was age 5, and when the child was age 14, while child biometric data for children were collected at ages 14, 21, and 30. At these waves of interview, biometric data was available for 3,794 respondents at age 14, 2,336 respondents at age 21, and 1,712 respondents at age 30. Further details of the MUSP data are available in the MUSP cohort profiles and research publications [54, 55].

With differing cardiometabolic risk previously observed by biological sex or gender, we separate analyses by biological sex at birth. To remove missing data from respondents who exit the study and have substantial missing data, our analytic sample consists of respondents whose mothers completed prenatal, age 5 and age 14 interviews, along with respondents having height and weight recorded for at least one interview at ages 14, 21, and 30. There are 1,884 males and 1,758 females who form a core of our analytic sample, with 1665 males and 1,532 females at age 14, 1087 males and 1,117 females at age 21, and 637 males and 844 females at age 30.

Measures of Cardiometabolic Risk

Body Mass Index (BMI, kg/m ^{2}). At ages 14, 21, and 30, biometric data for measured height (in centimeters) and weight (in kilograms) for respondents in the birth cohort was collected by a health professional. BMI is a well-established risk factor for cardiovascular and metabolic diseases in later life, particularly when combined with other cardiovascular disease measures [56].

Systolic Blood Pressure (SBP, mmHG). SBP at age 30 was measured during physical assessments of respondents. Two readings were taken 5 min apart when the respondents were sitting and at rest. The respondent's SBP was the average of these two readings [57]. For SBP, hypertension is measured in three categories, with normal from 90–129 mmHG, high-normal is 130–139 mmHG, and hypertension is ≥ 140 mmHG [58].

Diastolic Blood Pressure (DBP, mmHG). DBP at age 30 was measured during physical assessments of respondents. Two readings were taken 5 min apart when the respondents were sitting and at rest. The respondent's DBP was the average of these two readings [57]. For DBP, three categories of hypertension are recorded, with normal blood pressure at ≥ 84 mmHG, high-normal is 85–89 mmHG, and hypertension is ≥ 90 mmHG [58].

Waist size (cm). Self-reported waist size (centimeters) at age 30. To measure waist size, respondents were provided with a paper measuring tape and detailed instructions. A waist circumference above 80 cm in females and 90 cm in males is associated with an increased risk of type II diabetes and cardiovascular disease [59].

Predictor Variables

Parental Imprisonment. At age 5 and age 14 interviews, mothers were asked if they or their current partner had ever been imprisoned. We construct a variable used by Roettger and colleagues [10] to indicate if the mother indicated she or her partner had been held in detention at either wave.

Child Behavioral Problems. At age 5 interviews, mothers completed items from the Child Behavioral Checklist (CBCL), Ages 4–18. We use four subscales modelled from the original CBCL scales that include aggression (10-items, α = 0.83), internalizing (10- items, α = 0.76), social-thought-attention (SAT) problems (10-items, α = 0.74), and Attention Deficit Hyperactive Disorder (ADHD) scales (6-items, α = 0.66). These scales have been previously validated in prior research and are fully described elsewhere [60, 61].

Controls

Child ethnicity. Mother-reported child ethnicity, with indicators for if the child was of Indigenous Australian or Asian descent.

Child sex at birth. An indicator for if the child was classified as male or female at birth.

Pregnancy status. Whether female respondents reported being pregnant at ages 14, 21, or 30. An indicator for pregnancy is used to control for varying cardiometabolic measures which may occur in pregnancy, such as pre-eclampsia or increased BMI. Controlling for pregnancy has been done in prior research on PI and health outcomes [9, 10, 37].

Mother’s education. During initial interviews, mothers reported their highest level of education. We categorize education as not completing secondary education, completing secondary education, or completing some form of post-secondary education.

Mother's age at birth. Mother's age at the birth of the respondent.

Child birth weight (kg). Child's reported weight at birth obtained from obstetric records.

Mother's pre-pregnancy BMI (kg/m ^{2}) Mother's pre-pregnancy BMI, based on mother-reported height and weight in initial interviews.

Analytic Strategy

We use multivariate OLS regression to examine outcomes for 1) BMI at ages 14, 21, & 30, 2) SBP at age 30, 3) DBP at age 30, and 4) waist circumference at age 30. We test for interactions between PI and CBCL measures in a regression model, while controlling for maternal education, maternal age, maternal pre-pregnancy, respondent ethnicity, respondent pregnancy at the appropriate wave, and respondent birth weight. Due to prior studies finding PI being associated with cardiometabolic risk factors in females only, we estimate separate models for male and female respondents.

To make better use of partial data across waves and examine if observed patterns hold over time, we also use a 2-level random effects (multi-level) model to examine potential interactions between PI and CBCL measures for BMI at ages 14, 21, and 30. The 2-level random effects model controls for repeated measures at the individual level. We also test for potential 3-way interactions for PI, age, and CBCL measures to examine if the moderating effect of CBCL behaviors becomes more prevalent in adulthood, as found in one recent paper examining, BMI, PI, and delinquency [37].

All analyses are conducted using STATA version 17.1.

Missing Data

The number of respondents completing interviews at ages 14, 21, and 30 declines significantly in the sample, raising issues of potential bias due to attrition. Prior research has found that analysis with the MUSP data at later waves yields accurate and valid results [62]. One paper, in evaluating potential attrition bias in the panel, has found that attrition from the MUSP is associated with maternal education and ethnicity [63]. We have added these variables to control for these effects in our analysis, as was done with previously published research examining PI and cardiometabolic outcomes using the MUSP data [10].

While controlling for measures like education and ethnicity can help to ameliorate bias, an additional check may be used by comparing results from complete case analysis imputation using multiple imputation (MI) in our longitudinal analysis examining moderation patterns for BMI [64]. However, caution modeling interactions is warranted; by adding in random noise into interactions, multiple imputation is known to decrease the overall level of significance of moderating effects, thus potentially reducing accuracy by increasing the risk of type II error [65]. As such, we add interaction terms in multiple imputation, using a “just another variable” approach, to evaluate variations between complete case and MI analysis to assess the consistency of estimates. To further reduce risk of type II error from imputation of interaction models, we estimate models for cases where CBCL age 5 scores, parental imprisonment histories, and at least one non-missing BMI measure in three waves is present for respondents. To estimate models for multiple imputation, we use imputed chained equations (ice) in STATA to produce 75 imputed datasets, performing analysis using STATA's ‘mi estimate’ command [66].

RESULTS

[Table 1 About Here]

Table 1
Means and standard deviations for variables used in analysis, by parental history of imprisonment in males.

Male respondents [N = 1,884 at birth]							
	Parental Imprisonment			No Parental Imprisonment			
	N	Mean/%	SD	N	Mean/%	SD	p-value
Dependent Variables							
Age 14							
BMI	67	20.29	4.44	1,598	20.22	3.52	0.875
Age 21							
BMI	58	24.13	4.31	1,029	24.08	4.28	0.931
Age 30							
BMI	33	27.70	5.98	604	27.19	4.91	0.561
DBP	34	75.35	8.55	591	74.85	9.42	0.762
SBP	34	131.44	11.58	591	129.75	13.03	0.461
Waist Circumference	33	94.25	14.06	590	94.22	13.09	0.990
CBCL age 5 problem behaviors							
SAT	89	5.70	3.35	1,793	5.04	3.09	0.049
Internalizing	89	4.21	3.17	1,795	3.79	2.94	0.192
Aggression	89	7.15	3.51	1,794	6.27	3.59	0.023
Depression	89	3.93	2.88	1,795	3.50	2.85	0.169
Controls							
Pregnancy age 14	89	0%		1,795	0%		
Pregnancy age 21	58	0%		1,029	0%		
Pregnancy age 30	33	0%		604	0%		
Respondent Indigenous	89	4.5%		1,747	3.8%		0.753
Respondent Asian	89	0%		1,747	4.1%		0.051
Mother tertiary education	89	21.3%		1,792	19.1%		0.597
Mother non-secondary education	89	27.0%		1,792	15.1%		0.003
Mother’s age	89	23.01	4.28	1,795	25.65	5.02	0.000
Mother’s pre-pregnancy BMI	89	22.10	3.94	1,795	21.91	3.82	0.650
Child birth weight (kg)	89	3.37	0.55	1,795	3.47	0.53	0.064

Notes: Sample size presented as the total number of respondents with non-missing data for the variable, by parental imprisonment. BMI = Body Mass Index; DBP = Diastolic Blood Pressure; SBP = Systolic Blood Pressure; CBCL = Child Behavioral Checklist; SAT = Social-Attention-Thought Disorder.

[Table 2 About Here]

Table 2
Means and standard deviations for variables used in analysis, by parental history of imprisonment in females.

Female respondents [N = 1,758 at birth]							
	Parental Imprisonment			No Parental Imprisonment			
	N	Mean/%	SD	N	Mean/%	SD	p-value
Dependent Variables							
Age 14							
BMI	66	21.61	4.62	1,466	20.94	3.90	0.171
Age 21							
BMI	48	25.04	6.45	1,069	24.14	5.28	0.249
Age 30							
BMI	39	29.15	8.77	805	26.59	6.43	0.017
DBP	37	72.45	10.34	779	68.95	9.21	0.025
SBP	37	117.14	13.63	779	110.54	12.63	0.002
Waist Circumference	37	91.34	16.87	779	86.59	15.05	0.063
CBCL age 5 problem behaviors							
SAT	75	5.52	3.24	1,678	4.36	2.95	0.001
Internalizing	76	4.33	2.85	1,682	3.65	2.91	0.045
Aggression	75	6.67	3.95	1,678	5.58	3.32	0.006
Depression	76	4.18	2.86	1,682	3.44	2.80	0.025
Controls							
Pregnancy age 14	76	0%		1,682	0%		
Pregnancy age 21	51	5.9%		1,090	3.7%		0.418
Pregnancy age 30	40	10.0%		836	11.0%		0.843
Respondent Indigenous	75	9.3%		1,643	3.9%		0.021
Respondent Asian	75	1.3%		1,643	3.35%		0.337
Mother tertiary education	76	10.5%		1,671	20.9%		0.028
Mother non-secondary education	76	21.1%		1,671	15.5%		0.194
Mother’s age	76	24.74	5.56	1,682	25.67	4.95	0.114
Mother’s pre-pregnancy BMI	76	22.19	5.58	1,682	21.87	3.84	0.482
Child birth weight (kg)	76	3.28	0.55	1,682	3.35	0.48	0.194

Notes: Sample size presented as the total number of respondents with non-missing data for the variable, by parental imprisonment. BMI = Body Mass Index; DBP = Diastolic Blood Pressure; SBP = Systolic Blood Pressure; CBCL = Child Behavioral Checklist; SAT = Social-Attention-Thought Disorder.

Table 1 (males) and Table 2 (females) contains the means, standard deviations, and p-values for tests for variables used in the analysis. These analyses find that cardiometabolic risk measures do not differ by PI among male respondents, while PI is associated with higher BMI ($p < 0.05$) and SBP ($p < 0.05$) at age 30 among women. PI is associated with higher behavioral problems in both male and female respondents. Among controls, for both males and females, PI occurs more frequently among those reporting Indigenous ancestry, and is associated with lower maternal educational attainment, and a younger maternal age at birth. PI is associated with slightly lower birth weight among males, but not females in the sample.

Cross-Sectional Analyses

[Table 3 About Here]

Table 3
Main and moderating effects of CBCL measures at age 5 on parental imprisonment predicting cardiometabolic disease risk in men

	BMI, Age 14		**BMI, Age 21**		**BMI, Age 30**		**DBP, Age 30**		**SBP, Age 30**		**Waist Circumference, Age 30**	
CBCL scales at age 5	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
SAT												
PI	-0.06	1.07	-0.17	0.31	0.27	2.18	0.43	1.55	2.23	3.90	0.03	5.41
	[-0.90, 0.77]	[-0.59, 2.74]	[-1.31, 0.96]	[-1.87, 2.49]	[-1.47, 2.00]	[-1.63, 5.99]	[-2.90, 3.75]	[-5.77, 8.87]	[-2.33, 6.80]	[-6.16, 14.0]	[-4.56, 4.63]	[-4.68, 15.5]
SAT	0.02	0.02	0.02	0.02	-0.04	-0.02	0.11	0.12	0.19	0.20	0.06	0.10
	[-0.04, 0.07]	[-0.03, 0.08]	[-0.07, 0.10]	[-0.07, 0.11]	[-0.17, 0.09]	[-0.16, 0.11]	[-0.14, 0.37]	[-0.14, 0.38]	[-0.16, 0.54]	[-0.16, 0.56]	[-0.29, 0.41]	[-0.26, 0.45]
PI x SAT		-0.20		-0.09		-0.38		-0.22		-0.32		-1.06
		[-0.46, 0.05]		[-0.41, 0.24]		[-1.04, 0.29]		[-1.48, 1.04]		[-2.05, 1.41]		[-2.83, 0.71]
Internalizing												
PI	-0.05	0.43	-0.16	-0.65	0.23	-0.55	0.42	-1.30	2.23	-0.96	-0.03	1.01
	[-0.89, 0.79]	[-1.02, 1.88]	[-1.29, 0.98]	[-2.43, 1.13]	[-1.50, 1.96]	[-3.53, 2.42]	[-2.90, 3.75]	[-7.09, 4.49]	[-2.34, 6.79]	[-8.91, 6.98]	[-4.61, 4.56]	[-6.89, 8.91]
Internalizing	-0.05	-0.04	-0.04	-0.05	-0.15*	-0.16*	-0.01	-0.03	-0.02	-0.06	-0.35	-0.34
	[-0.11, 0.01]	[-0.10, 0.01]	[-0.13, 0.05]	[-0.14, 0.04]	[-0.28, -0.02]	[-0.29, -0.02]	[-0.26, 0.25]	[-0.29, 0.24]	[-0.37, 0.33]	[-0.42, 0.30]	[-0.70, 0.00]	[-0.70, 0.02]
PI x Internalizing		-0.12		0.12		0.21		0.45		0.84		-0.28
		[-0.40, 0.17]		[-0.21, 0.46]		[-0.44, 0.86]		[-0.79, 1.70]		[-0.87, 2.55]		[-2.01, 1.45]
Aggression												
PI	-0.09	0.72	-0.19	-0.73	0.29	-0.82	0.30	0.90	2.13	-0.11	0.15	-0.24
	[-0.92, 0.75]	[-1.25, 2.69]	[-1.32, 0.94]	[-3.07, 1.61]	[-1.44, 2.03]	[-4.49, 2.84]	[-3.03, 3.63]	[-6.21, 8.00]	[-2.45, 6.71]	[-9.88, 9.65]	[-4.46, 4.75]	[-9.95, 9.47]
Aggression	0.05	0.05*	0.04	0.04	-0.03	-0.04	0.13	0.13	0.12	0.10	-0.10	-0.10
	[0.00, 0.09]	[0.00, 0.10]	[-0.03, 0.11]	[-0.04, 0.11]	[-0.14, 0.08]	[-0.15, 0.08]	[-0.09, 0.35]	[-0.09, 0.36]	[-0.18, 0.42]	[-0.21, 0.41]	[-0.40, 0.20]	[-0.41, 0.21]
PI x aggression		-0.11		0.08		0.16		-0.08		0.31		0.06
		[-0.36, 0.14]		[-0.22, 0.37]		[-0.30, 0.61]		[-0.96, 0.79]		[-0.89, 1.52]		[-1.16, 1.27]
Depression												
PI	-0.05	0.94	-0.16	-0.06	0.22	0.09	0.42	0.99	2.23	1.59	-0.04	2.14

Notes: Tables report main effect and 95% confidence intervals. All models contain controls for race/ethnicity of respondent, maternal education at birth, age of mother at birth, mother's pre-pregnancy BMI, and respondent's birth weight. Presented moderators interact parental imprisonment with child age 5 CBCL measures. Sample size varies by wave and cardiometabolic outcome due to missing data. All measures for child behavioral issues are based on maternal CBCL scores at age 5. PI = Parental Imprisonment; SAT = Social-Attention-Thought Disorder; CBCL = Child Behavioral Checklist.

Significance levels (two-tailed): *p < 0.05 **p < 0.01 ***p < 0.001

	BMI, Age 14		BMI, Age 21		BMI, Age 30		DBP, Age 30		SBP, Age 30		Waist Circumference, Age 30	
	[-0.89, 0.79]	[-0.49, 2.37]	[-1.29, 0.97]	[-1.90, 1.78]	[-1.50, 1.95]	[-2.93, 3.11]	[-2.91, 3.74]	[-4.88, 6.87]	[-2.34, 6.79]	[-6.48, 9.65]	[-4.62, 4.54]	[-5.87, 10.2]
Depression	-0.04	-0.03	-0.04	-0.04	-0.16*	-0.17*	-0.05	-0.04	-0.03	-0.03	-0.37*	-0.35
	[-0.10, 0.02]	[-0.09, 0.03]	[-0.13, 0.05]	[-0.13, 0.06]	[-0.30, -0.03]	[-0.30, -0.03]	[-0.31, 0.22]	[-0.31, 0.23]	[-0.39, 0.34]	[-0.41, 0.34]	[-0.74, -0.01]	[-0.72, 0.02]
PI x depression		-0.25		-0.03		0.04		-0.17		0.18		-0.64
		[-0.55, 0.04]	0.04	[-0.42, 0.36]		[-0.69, 0.77]		[-1.56, 1.23]		[-1.73, 2.10]		[-2.58, 1.30]
Sample Size	1,619	1,619	1,058	1,058	623	623	611	611	611	611	610	610

Notes: Tables report main effect and 95% confidence intervals. All models contain controls for race/ethnicity of respondent, maternal education at birth, age of mother at birth, mother's pre-pregnancy BMI, and respondent's birth weight. Presented moderators interact parental imprisonment with child age 5 CBCL measures. Sample size varies by wave and cardiometabolic outcome due to missing data. All measures for child behavioral issues are based on maternal CBCL scores at age 5. PI = Parental Imprisonment; SAT = Social-Attention-Thought Disorder; CBCL = Child Behavioral Checklist.

Significance levels (two-tailed): *p < 0.05 **p < 0.01 ***p < 0.001

In Table 3, where effects are reported for males, no significant main effects for PI and interactions for PI and child behavioral problems are observed.

[Table 4 About Here]

Table 4
Main and moderating effects of age 5 CBCL measures on parental imprisonment predicting cardiometabolic disease risk in females

	BMI, Age 14		**BMI, Age 21**		**BMI, Age 30**		**DBP, Age 30**		**SBP, Age 30**		**Waist Circumference, Age 30**	
CBCL scales at age 5	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
SAT												
PI	0.56	-0.64	0.48	-2.23	2.02	-4.25*	2.76	1.33	5.96**	9.56*	4.17	-4.66
	[-0.35, 1.46]	[-2.40, 1.12]	[-0.99, 1.95]	[-5.18, 0.71]	[-0.03, 4.06]	[-8.19, -0.31]	[-0.37, 5.89]	[-4.80, 7.45]	[1.66, 10.3]	[1.15, 18.0]	[-0.64, 8.98]	[-14.1, 4.73]
SAT	0.04	0.03	0.16**	0.13*	0.20**	0.14	0.25*	0.23*	0.14	0.17	0.40*	0.31
	[-0.02, 0.11]	[-0.03, 0.10]	[0.05, 0.26]	[0.03, 0.24]	[0.05, 0.34]	[-0.01, 0.28]	[0.02, 0.47]	[0.00, 0.46]	[-0.17, 0.44]	[-0.14, 0.49]	[0.05, 0.74]	[-0.04, 0.66]
PI x SAT		0.22		0.50*		1.18***		0.28		-0.69		1.70*
		[-0.06, 0.51]		[0.03, 0.98]		[0.55, 1.82]		[-0.74, 1.29]		[-2.08, 0.70]		[0.15, 3.25]
Internalizing												
PI	0.58	-1.49	0.54	-2.19	1.98	-1.52	2.85	4.48	5.69**	11.45**	3.83	-3.37
	[-0.33, 1.48]	[-3.15, 0.16]	[-0.93, 2.01]	[-4.77, 0.39]	[-0.04, 4.00]	[-4.98, 1.93]	[-0.25, 5.94]	[-0.92, 9.89]	[1.46, 9.93]	[4.05, 18.8]	[-0.91, 8.57]	[-11.6, 4.90]
Internalizing	0.03	0.01	0.11*	0.08	0.08	0.04	0.01	0.03	0.00	0.07	0.30	0.22
	[-0.04, 0.09]	[-0.06, 0.08]	[0.01, 0.22]	[-0.03, 0.19]	[-0.07, 0.24]	[-0.12, 0.20]	[-0.23, 0.25]	[-0.21, 0.27]	[-0.32, 0.33]	[-0.26, 0.40]	[-0.06, 0.67]	[-0.15, 0.59]
PI x Internalizing		0.48**		0.62*		0.91*		-0.41		-1.44		1.81*
		[0.16, 0.81]		[0.14, 1.11]		0.18	1.64	[-1.52, 0.70]		[-2.97, 0.08]		[0.10, 3.51]
Aggression												
PI	0.51	-1.52	0.47	-2.70	2.05*	-3.13	2.97	4.78	6.10**	11.37**	4.25	-6.16
	[-0.40, 1.41]	[-3.26, 0.23]	[-1.00, 1.94]	[-5.53, 0.14]	[0.02, 4.08]	[-6.85, 0.58]	[-0.17, 6.10]	[-1.09, 10.6]	[1.80, 10.4]	[3.34, 19.4]	[-0.54, 9.04]	[-15.1, 2.77]
Aggression	0.09**	0.07*	0.12*	0.09	0.24***	0.18**	0.03	0.05	-0.03	0.03	0.44**	0.33*
	[0.04, 0.15]	[0.02, 0.13]	[0.03, 0.21]	[-0.01, 0.18]	[0.11, 0.37]	[0.05, 0.31]	[-0.17, 0.23]	[-0.16, 0.26]	[-0.30, 0.25]	[-0.26, 0.31]	[0.14, 0.75]	[0.02, 0.65]
PI x aggression		0.31**		0.46*		0.82**		-0.29		-0.85		1.68**
		[0.08, 0.54]	0.54	[0.11, 0.81]		[0.33, 1.32]		[-1.09, 0.51]		[-1.94, 0.24]		[0.46, 2.89]
Depression												
PI	0.57	-1.07	0.51	-2.00	1.97	-0.27	2.88	4.40	5.74**	11.81**	3.83	-0.27

Notes: Tables report main effect and 95% confidence intervals. All models contain controls for race/ethnicity of respondent, maternal education at birth, age of mother at birth, mother's pre-pregnancy BMI, respondent's birth weight, and respondent's pregnancy status. Presented moderators interact parental imprisonment with child age 5 CBCL measures. Sample size varies by wave and cardiometabolic outcome due to missing data. All measures for child behavioral issues are based on maternal CBCL scores at age 5. PI = Parental Imprisonment; SAT = Social-Attention-Thought Disorder; CBCL = Child Behavioral Checklist. Significance levels (two-tailed): *p < 0.05 **p < 0.01 ***p < 0.001

	BMI, Age 14		BMI, Age 21		BMI, Age 30		DBP, Age 30		SBP, Age 30		Waist Circumference, Age 30	
	[-0.33, 1.47]	[-2.64, 0.50]	[-0.96, 1.99]	[-4.43, 0.43]	[-0.05, 3.99]	[-3.69, 3.15]	[-0.22, 5.97]	[-0.86, 9.66]	[1.50, 9.98]	[4.62, 19.0]	[-0.91, 8.58]	[-8.33, 7.79]
Depression	0.04	0.03	0.14*	0.11	0.08	0.05	-0.05	-0.03	-0.08	-0.01	0.27	0.22
	[-0.02, 0.11]	[-0.04, 0.09]	[0.03, 0.25]	[-0.01, 0.22]	[-0.08, 0.24]	[-0.11, 0.21]	[-0.29, 0.19]	[-0.27, 0.21]	[-0.41, 0.24]	[-0.34, 0.33]	[-0.09, 0.64]	[-0.15, 0.60]
PI x depression		0.40*		0.60*		0.60		-0.40		-1.59*		1.08
		[0.09, 0.72]		[0.14, 1.06]		[-0.14, 1.34]		[-1.51, 0.71]		[-3.12, -0.07]		[-0.63, 2.78]
Sample Size	1,489	1,489	1,091	1,091	821	821	789	789	789	789	789	789

Notes: Tables report main effect and 95% confidence intervals. All models contain controls for race/ethnicity of respondent, maternal education at birth, age of mother at birth, mother's pre-pregnancy BMI, respondent's birth weight, and respondent's pregnancy status. Presented moderators interact parental imprisonment with child age 5 CBCL measures. Sample size varies by wave and cardiometabolic outcome due to missing data. All measures for child behavioral issues are based on maternal CBCL scores at age 5. PI = Parental Imprisonment; SAT = Social-Attention-Thought Disorder; CBCL = Child Behavioral Checklist. Significance levels (two-tailed): *p < 0.05 **p < 0.01 ***p < 0.001

Table 4 contains main and moderating effects for PI, child behaviors, and controls for females. Results vary by age of respondent and behavioral outcome, but show a fairly consistent pattern that age 5 behavioral problems either moderate or mediate cardiometabolic risk. For example, with CBCL aggression, increasing CBCL scores for females experiencing PI are associated with an increased BMI at ages 14, 21, and 30, higher SBP, and increased waist circumference; with a 1-point increase in CBCL aggression associated with an increased BMI of 0.82 kg/m^2 ($p < 0.001$) and waist circumference increase of 0.34 cm ($p < 0.05$).

[Figure 1A About Here]

[Figure 1B About Here]

Figures 1 and 2 show the change in BMI and waist circumference associated with increasing CBCL aggression by PI status for females at age 30. At the 0th percentile of aggression in Fig. 1, predicted BMI is 22.43 (95% CI: 18.8, 26.05) for PI and 25.6 [95% CI: 24.7, 26.4) for those not experiencing PI; at the 90th percentile for aggression, at a score of 11, BMI is 33.5 [95% CI: 30.5. 36.4] for PI vs. 27.5 [95% CI: 26.7, 28.4] for females not experiencing PI. For waist circumference in Fig. 2, at the 0th percentile for CBCL aggression, the predicted WC is 78.4 [95% CI: 69.7, 87.0] for those experiencing PI and 84.5 [95% CI: 82.5, 86.6] for those not experiencing PI; at the 90th percentile for aggression, predicted waist circumference is 100.5 cm [95% CI: 93.2, 107.8] for PI vs. 88.2 cm [95% CI: 86.2, 90.8] for females not experiencing PI. Both BMI and WC increase from the 0th to the 90th percentile for females irrespective of experiencing PI; however, PI at the 90th percentile for aggression has a 5 kg/m^2 increase for BMI and a 12.3 cm increase for WC, compared to those without histories of mother-reported PI. Examining moderation patterns for SAT, Internalizing, and Depression, where significant, yield patterns similar to those shown Fig. 1 and Fig. 2. These plots are not included due to space constraints, but are available upon request.

Longitudinal Analyses

[Table 5 About Here]

Table 5

Longitudinal moderating effect of age 5 CBCL measures on parental imprisonment predicting BMI for females at ages 14, 21, and 30

CBCL scales at age 5	Main effect	Interaction effect
SAT		
PI	0.66	-1.87
	[-0.37, 1.70]	[-3.90, 0.15]
SAT	0.11**	0.09*
	[0.04, 0.19]	[0.02, 0.16]
PI x SAT		0.47**
		[0.15, 0.79]
Internalizing		
PI	0.66	-1.68
	[-0.37, 1.69]	[-3.53, 0.17]
Internalizing	0.06	0.04
	[-0.01, 0.14]	[-0.03, 0.12]
PI x Internalizing		0.55**
		[0.19, 0.92]
Aggression		
PI	0.63	-2.35*
	[-0.40, 1.66]	[-4.34, -0.35]
Aggression	0.14***	0.12***
	[0.08, 0.21]	[0.05, 0.18]
PI x aggression		0.45***
		[0.19, 0.71]
Depression		
PI	0.65	-1.27
	[-0.38, 1.68]	[-3.05, 0.52]
Depression	0.07	0.05
	[0.00, 0.15]	[-0.03, 0.13]
PI x depression		0.47*
		[0.11, 0.82]
Number of observations	3,400	3,400
Number of respondents	1,710	1,710

Notes: Tables report beta-coefficients and 95% confidence intervals. All models contain controls for race/ethnicity of respondent, maternal education at birth, age of mother at birth, mother's pre-pregnancy BMI, respondent's birth weight, and if the respondent was pregnant at wave of interview. The interaction terms interact parental imprisonment with child age 5 CBCL measures. All measures for child behavioral issues are based on maternal CBCL scores at age 5. PI = Parental Imprisonment; SAT = Social-Attention-Thought Disorder; CBCL = Child Behavioral Checklist.

Significance levels (two-tailed): *p < 0.05 **p < 0.01 ***p < 0.001

Table 5 contains the longitudinal associations between PI and BMI for female respondents. The longitudinal patterns show that Age 5 CBCL measures for SAT, Internalizing, aggression, and depression are significant moderators of the association between BMI and PI. The general pattern within the data is that a 1-point increase in a CBCL score is associated with an increase in BMI of ~ 0.50 kg/m^2, with all interaction coefficients significant at $p < 0.01$ or lower.

[Figure 3 About Here]

Figure 3 shows the longitudinal relationship between PI and CBCL Aggression for respondents at ages 14, 21, and 30. The longitudinal association shows that PI and increasing CBCL Aggression are associated with increasing BMI. For those not experiencing PI, increasing CBCL aggression is linked with higher BMI, though the magnitude of the association is significantly less than for those experiencing PI. The pattern is similar to the one shown in Fig. 1A; similar associations linking PI and high behavioral issues with higher BMI, available upon request, are found for other reported interactions in Table 5 for CBCL SAT, Internalizing, and Depression.

[Table 6 About Here]

Table 6
Comparison of complete case and imputed models for the longitudinal analysis

CBCL scales at age 5	Complete case	Imputed
SAT		
PI	-1.87	-1.94
	[-3.90, 0.15]	[-4.10, 0.23]
SAT	0.09*	0.11**
	[0.02, 0.16]	[0.03, 0.19]
PI x SAT	0.47**	0.44*
	[0.15, 0.79]	[0.09, 0.78]
Internalizing		
PI	-1.68	-1.47
	[-3.53, 0.17]	[-3.44, 0.50]
Internalizing	0.04	0.05
	[-0.03, 0.12]	[-0.03, 0.13]
PI x Internalizing	0.55**	0.47*
	[0.19, 0.92]	[0.08, 0.86]
Aggression		
PI	-2.35*	-2.41
	[-4.34, -0.35]	[-4.54, -0.29]
Aggression	0.12***	0.13***
	[0.05, 0.18]	[0.06, 0.20]
PI x aggression	0.45***	0.43**
	[0.19, 0.71]	[0.15, 0.71]
Depression		
PI	-1.27	-1.05
	[-3.05, 0.52]	[-2.98, 0.87]
Depression	0.05	0.06
	[-0.03, 0.13]	[-0.02, 0.14]
PI x depression	0.47*	0.38*
	[0.11, 0.82]	[-0.01, 0.77]
Number of observations	3,400	5,274
Number of respondents	1,710	1,758

Notes: Tables report beta-coefficients and 95% confidence intervals. All models contain controls for race/ethnicity of respondent, maternal education at birth, age of mother at birth, mother's pre-pregnancy BMI, respondent's birth weight, and if the respondent was pregnant at wave of interview. The interaction terms interact parental imprisonment with child age 5 CBCL measures. PI = parental imprisonment; SAT = Social-Attention-Thought disorders. All measures for child

behavioral issues are based on maternal CBCL scores at age 5. PI = Parental Imprisonment; SAT = Social-Attention-Thought Disorder; CBCL = Child Behavioral Checklist.

Significance levels (two-tailed): *$p < 0.05$ **$p < 0.01$ ***$p < 0.001$

We use multiple imputation to examine if missing data may significantly alter the patterns shown in Table 5 using complete case analysis. A comparison of the models is shown in Table 6, where data is imputed for individuals who have non-missing CBCL age 5 scores, PI histories, and had biometric data taken for at least one wave when respondents were ages 14, 21, and 30. The interactions using these imputed data increased the number of observations by 55% (3,400 to 5,277), yielding substantially similar results to the complete case analysis.

[Table 7 About Here]

Table 7
Longitudinal moderating effect of age 5 CBCL measures on parental imprisonment predicting BMI for females by respondent age

CBCL scales at age 5	SAT	Aggression
Interaction Coefficients		
PI	1.66	-0.96
	[-2.06, 5.38]	[-4.58, 2.66]
CBCL Behavior	-0.10	-0.07
	[-0.24, 0.04]	[-0.19, 0.05]
Age	0.33***	0.32***
	[0.30, 0.36]	[0.28, 0.35]
PI x CBCL Behavior	-0.44	0.03
	[-1.03, 0.16]	[-0.45, 0.50]
PI x Age	-0.18*	-0.07
	[-0.34, -0.02]	[-0.22, 0.09]
CBCL Behavior X Age	0.01***	0.01***
	[0.00, 0.02]	[0.00, 0.01]
PI x CBCL Behavior x Age	0.05***	0.02*
	[0.02, 0.07]	[0.00, 0.04]
Number of observations	3,402	3,402
Number of respondents	1,710	1,710
Notes: Tables report main effect and 95% confidence intervals. All models contain controls for race/ethnicity of respondent, maternal education at birth, age of mother at birth, mother’s pre-pregnancy BMI, respondent’s birth weight, and if the respondent was pregnant at wave of interview. The interaction terms interact parental imprisonment with child age 5 CBCL measures. All measures for child behavioral issues are based on maternal CBCL scores at age 5. PI = Parental Imprisonment; SAT = Social-Attention-Thought Disorder; CBCL = Child Behavioral Checklist.		
Significance levels (two-tailed): *p < 0.05 **p < 0.01 ***p < 0.001		

[Figure 4 About Here]

One final set of analyses examined the degree to which longitudinal associations observed in Table 5 varied by age of the respondent. Adding an interaction term for age to the models in Table 6, Table 7 shows the coefficients and standard errors for significant interactions between PI, CBCL behaviors, and Age. The 3-way interaction terms for SAT ($p < 0.001$) and aggression ($p < 0.05$) show age varying effects. As shown in Fig. 4, the association between CBCL SAT problems and BMI for those experiencing PI is not significant at age 14. However, at age 21, the association between high CBCL scores and increased BMI for those experiencing PI is observed. The magnitude of this association increases at age 30. No significant 3-way interactions for PI, age, and CBCL behaviors were observed for internalizing and depression.

DISCUSSION

In this study, we have used prospective cohort data to examine the association between PI, early childhood behaviors, and cardiometabolic risk in an Australian sample. In cross-sectional analysis, we have found that controlling for early childhood problem behaviors leads to an association between PI and SBP, while high levels of childhood problem behaviors moderate the association between PI and increased risk of BMI and waist circumference. The moderating effect of early childhood behaviors is observed in longitudinal analyses for BMI, showing that increasing scores for CBCL SAT, aggressive, depressive, and internalizing behaviors at age 5 are associated with higher BMIs for females experiencing PI,. For CBCL SAT and aggressive behaviors, these longitudinal associations emerge in early adulthood and increase in magnitude by age 30.These patterns are observed for female respondents, but no associations between PI and early childhood behaviors on cardiometabolic risk measures are observed among male respondents through age 30.

These patterns help to advance existing research in several significant ways. The MUSP provides a unique ability to prospectively combine both maternal reports of imprisonment and early childhood behaviors with later biomarkers of cardiovascular risk in adolescence and adulthood, bringing together separate bodies of research linking PI with childhood behavioral problems and cardiometabolic risk in females in a way that better addresses causality. [9, 10, 47] The use of longitudinal and growth-curve-modeling to examine these changes over time to better establish causality, a major limitation of existing studies examining PI and health outcomes [13, 67]. The consistency and significance ($p < 0.01$) of a 1-point increase in a CBCL problem behavior score with ~ 0.50 kg/m^2 in BMI at ages14, 21, and 30 suggests that high levels of CBCL problems are a potential risk marker for obesity and high BMI in females experiencing PI. Findings are robust to controls for attrition and hold using multiple imputation, increasing confidence in the study's findings. The findings that increased BMI associated with PI in females emerges in early adulthood and continues to develop is observed in one other study using American data by Roettger et al [37] is notable given the general pattern of increasing BMI levels in the general population during the second and third decades of life [68]. Our findings suggest that cardiometabolic disease is a potentially hidden health risk which may be observed decades later in the life course after PI is experienced by females as children and adolescents.

The findings by gender are consistent across multiple studies and suggest that PI is associated with observed cardiovascular risk in females, but not males. Some pooled findings have linked parental imprisonment to elevated C-Reactive Protein, blood pressure and BMI, but these pooled effects have been shown to be attributed to heightened risk in females, but not males in two separate studies [9, 10, 37, 69]. While direct studies have not identified the cause for these variations, evidence for sex-based variations in behavioral stress response, where men/males are more likely to externalize stress and women/females are more likely to internalize behaviors is suggestive [9, 10, 70]. Males who experience parental imprisonment are more likely to be delinquent, engage in substance use, and be involved in the criminal justice system, while females are more likely to have higher rates of mental illness [1]. Delinquency and imprisonment are associated with lower BMI during these periods for males, the "healthy prisoner hypothesis" in prison research postulates that a certain level of fitness is needed to engage in delinquent and antisocial behavior [37, 71]. In one recent study, females who experience parental imprisonment and are delinquent also experience this trend, while, in contrast, females who experience parental imprisonment and are not delinquent have a higher BMI [37]. Compared to males, cardiovascular risk is delayed prior to menopause, with females more likely to experience hypertension and obesity as potential pathways to cardiometabolic diseases [72, 73]. This suggests that parental imprisonment may increase cardiometabolic diseases via risk factors for increased BMI and blood pressure, both of which are observed in the current study.

These analyses also suggest that policies and interventions may target issues linked with both PI and childhood behavioral problems to reduce cardiometabolic disease risk. Interventions to treat childhood behaviors may improve health, but long term outcomes from established interventions are generally unknown [74]. As mentioned in the introduction, PI is classified as both an ACE and a component of the stress process leading to early biological aging; ameliorating these stressors may help to reduce cardiometabolic risk in later life [15, 49, 75]. Parental imprisonment may be both a direct risk factor for cardiometabolic disease and part of a "package of risks" that lead to cardiometabolic diseases in later adulthood [18, 25, 76]. Interventions and policies which target psychosocial and ecological risks linked to PI and cardiometabolic diseases, including poor diet, sedentary behaviors, education, access to health care and learning healthy behaviors, and substance use disorders, may reduce cardiometabolic and other health risks [14, 23, 77–79]. As noted by Roettger and Dennison [17], the breadth of issues among children who experience parental imprisonment may require complex, multi-prong interventions and policies to holistically address these issues, thereby improving both child health and reducing broader risk for disadvantage in the life course.

We note that these results need to be considered in the context of several limitations. The attrition in the study and relatively small number of respondents in the sample with histories of parental imprisonment may lead to these findings being a data artifact. The study lacks specific timing data for parental imprisonment and childhood behavioral problems, so we were unable to examine if timing of parental imprisonment and childhood behavioral problems is causally linked with cardiometabolic risk. Our study identifies individuals based on biological sex at birth and not gender identity which may lead to differences in risk. Due to small sample size, the study is unable to investigate if these patterns may vary across racial and ethnic groups. This study focused on examining the potential patterns between childhood behavioral problems, parental imprisonment and subsequent cardiovascular risk, foregoing evaluation of the role of risk and protective factors, such as economic deprivation or close familial ties that might influence these risks. Lastly, this study is unable to follow individuals into later periods of the life course when cardiovascular and metabolic diseases may be directly observed.

Future research is needed in this topical area to confirm the overall general pattern of findings, including examining outcomes by racial and ethnic status, cross-national research to validate findings, and greater understanding of the mechanisms which may lead to increased cardiometabolic risk over time. The lack of prospective cohort data with measures of childhood behavior and adult biometric data is a currently major limiting issue in research on parental imprisonment and child health; the addition of administrative data on parental imprisonment, collection of biometric data in social science surveys, and the extension of cohort studies are examples of potential way to address this limitation. While research has linked parental imprisonment with early mortality and disability [11, 12], examining death records for cause of death and health records in older populations would help to link parental imprisonment to the burden of cardiovascular and metabolic diseases in later life. Current studies on parent and familial imprisonment have generally found that cardiometabolic disease and risk is found primarily in females, but it remains unclear if increased risk for cardiometabolic diseases associated with parental imprisonment emerge for males in later life; however, the strong link between PI and child imprisonment, along with an increase in cardiovascular diseases and imprisonment in later life are suggestive that PI is potentially associated with cardiometabolic disease in men [80–82]. Lastly, examining factors leading to resiliency to cardiometabolic diseases among those who have experienced PI may aid in promoting health.

CONCLUSION

Using a prospective birth cohort, the present study finds that early childhood problem behaviors mediate the associate between PI and SBP and moderate the associations between PI and BMI and waist circumference among female respondents in cross-sectional analyses. These moderation patterns hold in time-varying models for BMI, with social-attention-thought and aggressive behavioral problems found to emerge in young adulthood for female respondents at age 21 and 30. No associations are found for male respondents. These findings suggest that policies and interventions targeting parental imprisonment and childhood behavioral problems may help to mitigate cardiometabolic disease as females progress through the life course. Future research may help to identify potential underlying causal mechanisms and examine if differing pathways between parental imprisonment and cardiovascular risk by sex and gender.

Abbreviations

ACE= Adverse Childhood Experience; BMI= Body Mass Index; CBCL= Child behavioral checklist; cm=centimeter; DBP= Diastolic Blood Pressure; kg=kilogram; m=meter; MI= multiple imputation; mmHG= millimeters of mercury; PI=parental imprisonment; SAT=Social-Attention-Thought; SBP= Systolic Blood Pressure

Declarations

DATA AVAILABILITY

Data from the Mater Hospital-University of Queensland Study of Pregnancy (MUSP) are not publicly freely available due to privacy and ethical issues. Researchers wishing to access the MUSP data may apply for data access via the study website maintained by the University of Queensland at: https://social-science.uq.edu.au/mater-university-queensland-study-pregnancy?p=9#9

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

All stages of the MUSP project (development, screening, intervention, follow-up) were conducted in accordance with relevant guidelines and regulations. Ethics approval was received from relevant committees at The University of Queensland and the Mater Misericordiae Hospital, South Brisbane, Australia. Informed consent was obtained from all subjects and/or their legal guardian(s). The present study uses de-identified secondary data analysis and is exempt from human ethics research approval.

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Figures

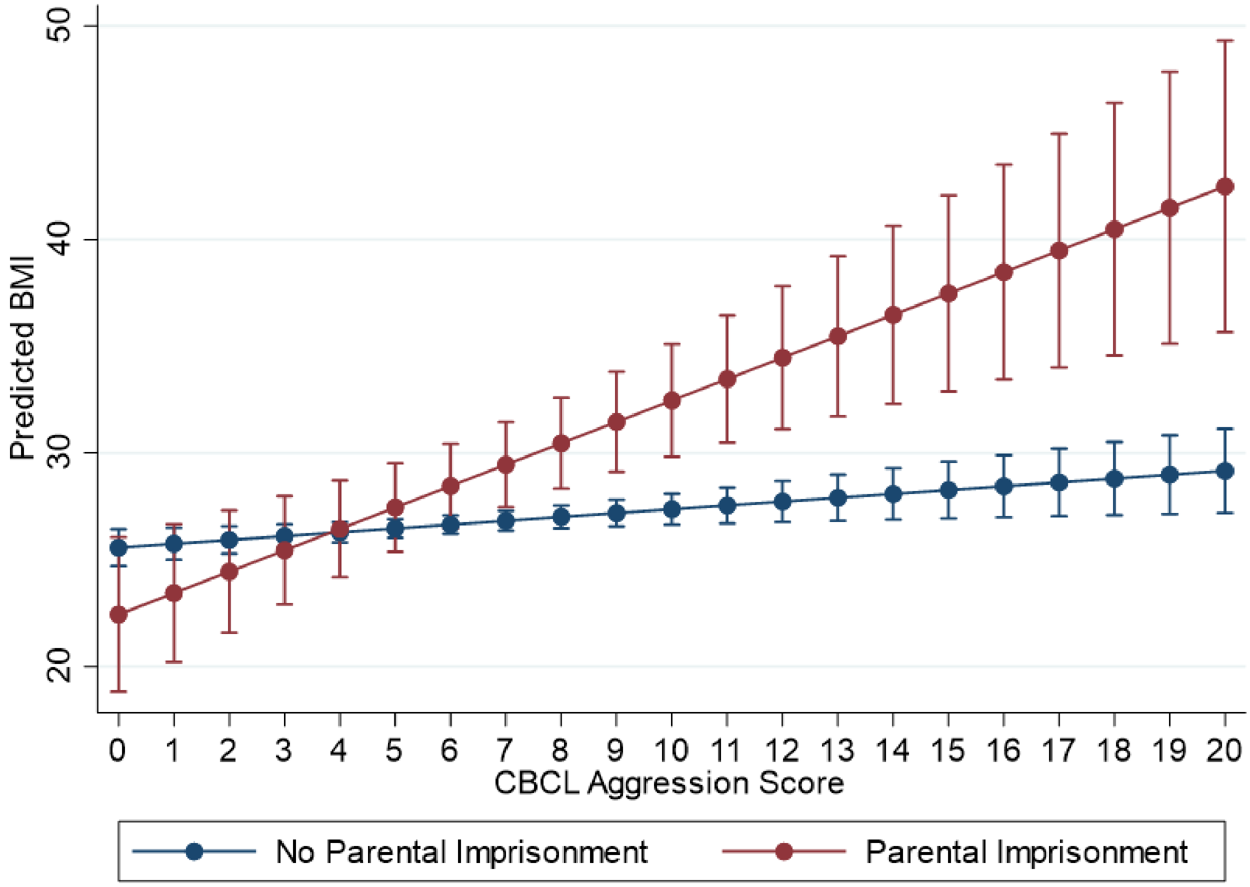

Figure 1

Associations between CBCL Aggression at age 5 and BMI at age 30, by parental imprisonment status among females

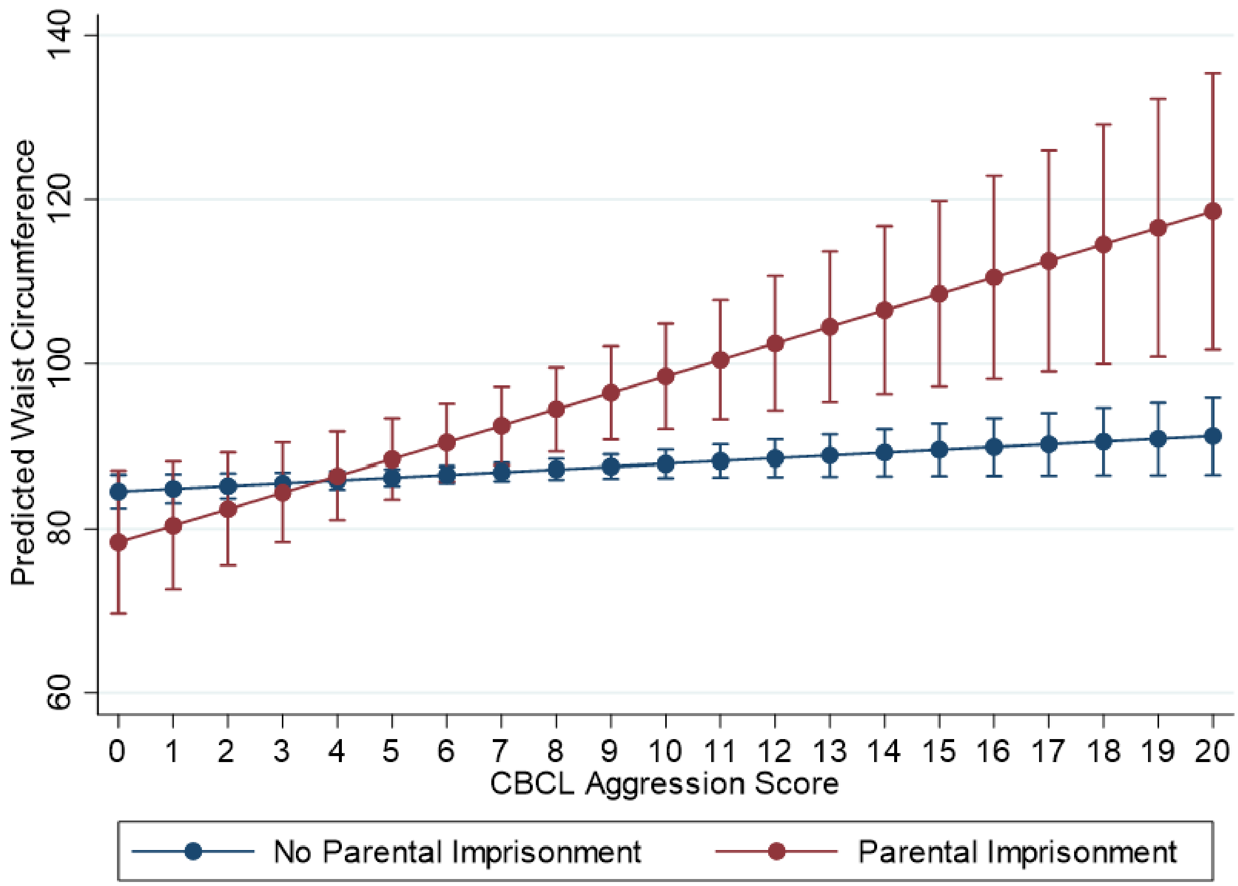

Figure 2

Associations between CBCL Aggression at age 5 and waist circumference at age 30, by parental imprisonment status among females

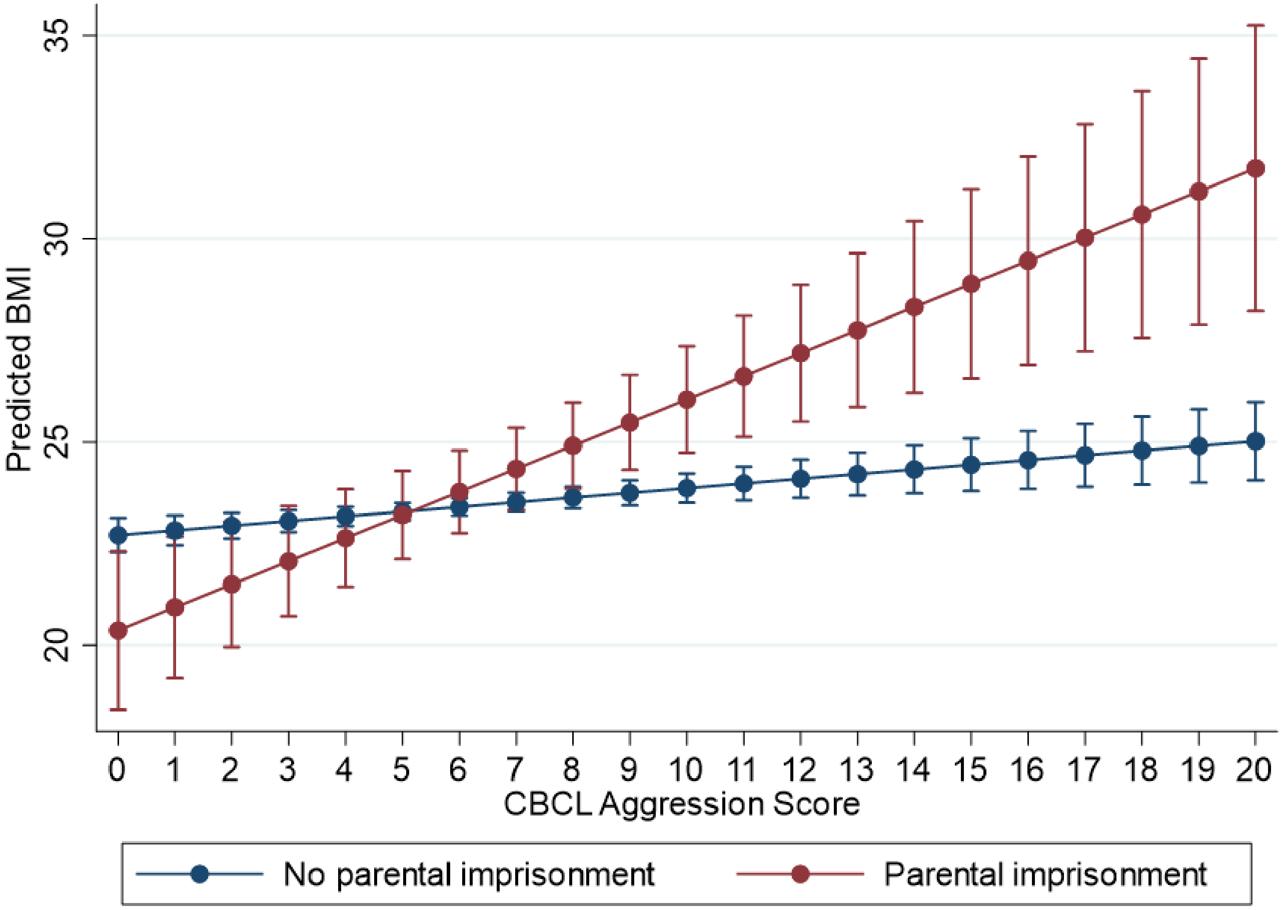

Figure 3

Longitudinal associations between CBCL Aggression at age 5 and BMI, by parental imprisonment status among females

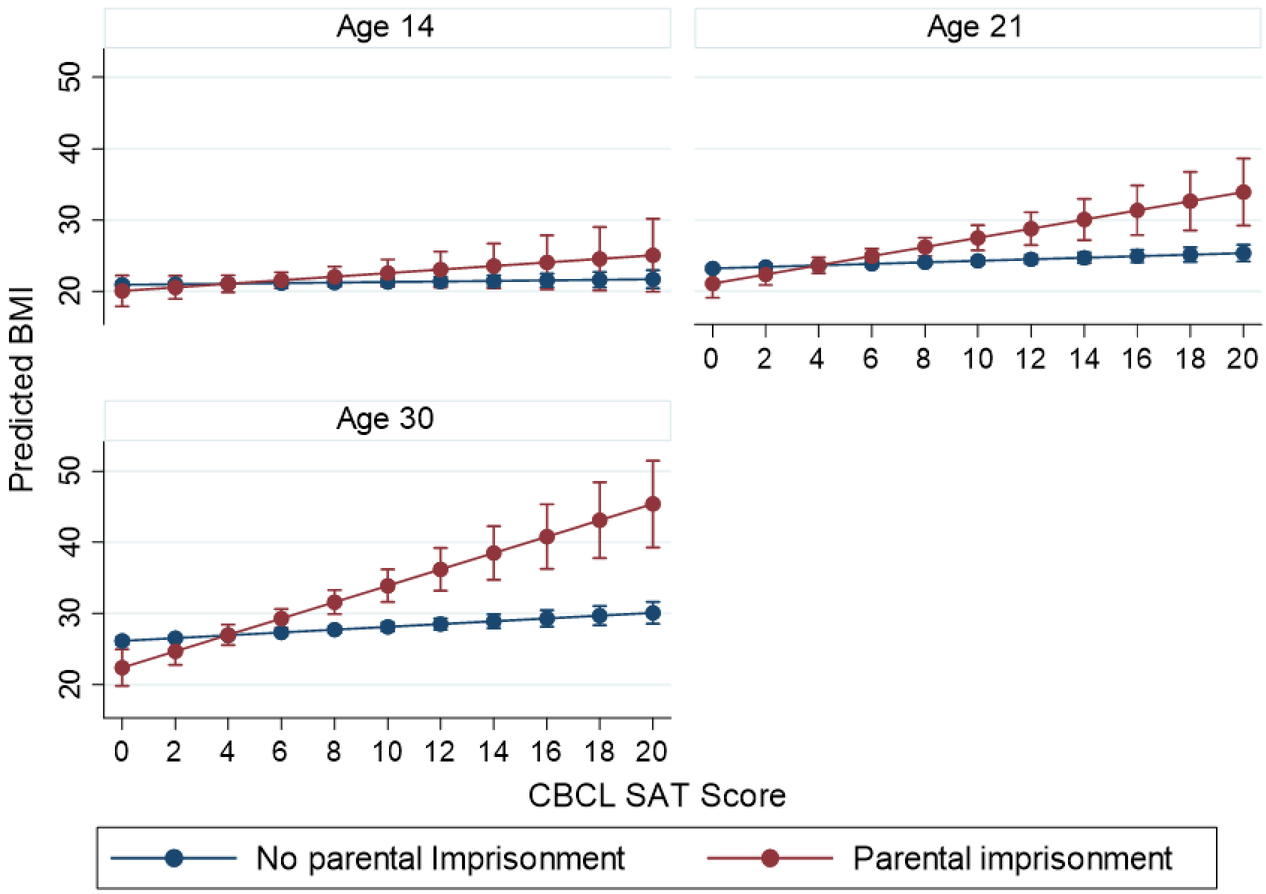

Figure 4

Longitudinal associations between CBCL SAT and BMI, by parental imprisonment status and age among females