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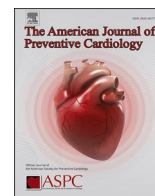
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Short Report

Higher blood pressure and weight observed among early adolescents during the COVID-19 pandemic

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ABSTRACT

The COVID-19 pandemic led to significant disruptions in the lifestyle behaviors of adolescents; however, there is a paucity of data on objective changes in health indicators of adolescents such as blood pressure, hypertension, and weight. The aim of this study is to quantify differences in blood pressure and weight before and during the COVID-19 pandemic among a demographically diverse national sample of early adolescents. We analyzed cross-sectional data from 2018 to 2020, corresponding to the second follow-up year (Year 2) of the Adolescent Brain Cognitive Development (ABCD) Study. Among 4,065 early adolescents (mean age 12.00, 49.4% female, 55.5% white), 3.4% vs 6.4% of adolescents had hypertension pre-pandemic vs during the pandemic ($p < 0.001$). The pandemic was associated with a 4.65 percentile (95% CI 2.65, 6.66) higher diastolic blood pressure, and a 1.68 kg (95% CI 0.51, 2.85) higher weight when adjusting for covariates. The pandemic was associated with a 1.97 higher odds of hypertension (95% CI 1.33, 2.92) compared to pre-pandemic when adjusting for covariates. Future studies should explore mechanisms and longitudinal trends in blood pressure among adolescents as they return to pre-pandemic lifestyle behaviors.

1. Introduction

Stay-at-home orders, school closures, cancellation of activities, and the ongoing nature of the COVID-19 pandemic led to an unprecedented increase in the global level of stress from health-, economic-, and social-related sources [1,2]. Several changes in the habits of adolescents, including sleep, physical activity, eating, and social interaction have been reported [1,2]. Given that lifestyle behaviors can influence risk for cardiovascular disease, with risk starting in childhood [3,4], it is vital that we better understand how the pandemic affected cardiovascular health metrics in adolescents, including blood pressure. Studies have shown higher levels of both systolic and diastolic blood pressure among US adults during the pandemic [5], but, to our knowledge, no studies have investigated blood pressure levels of US adolescents during this time. One study examining blood pressure trends from 1999 to 2018

found that both mean systolic and diastolic blood pressure were lower among US adolescents sampled between 1999–2002 compared to 2015–2018, suggesting a downward trend in blood pressure prior to the pandemic [6]. The aim of this study is to quantify differences in blood pressure before and during the COVID-19 pandemic among a demographically diverse national sample of early adolescents. A secondary aim was to explore differences in weight before and during the pandemic, as weight can contribute to differences in blood pressure [7].

2. Methods

We analyzed cross-sectional data from 2018 to 2020, corresponding to the second follow-up year of the Adolescent Brain Cognitive Development (ABCD) Study (4.0 release; ages 10–14 years) using Stata 15.1. The ABCD study is a demographically diverse, national, longitudinal

Abbreviations: ABCD, Adolescent Brain Cognitive Development; IRB, institutional review board.

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Table 1Sociodemographic, blood pressure, and weight characteristics of adolescent brain cognitive development (ABCD) study participants (Year 2, 2018–2020, $N = 4065$).

| Sociodemographic and health characteristics | Total $N = 4065$ Mean (SD) /% | Pre-COVID-19 pandemic ^a $n = 2966$ Mean (SD) /% | During COVID-19 pandemic $n = 1099$ Mean (SD) /% | p |
|---|-------------------------------------|--|--|--------|
| Age (years) | 12.0 (0.67) | 11.9 (0.66) | 12.1 (0.69) | <0.001 |
| Sex (%) | | | | |
| Female | 49.4% | 50.4% | 47.0% | 0.072 |
| Male | 50.5% | 49.6% | 53.0% | |
| Race/ethnicity (%) | | | | |
| White | 55.5% | 56.4% | 52.9% | 0.005 |
| Latino / Hispanic | 16.7% | 16.6% | 17.0% | |
| Black | 16.5% | 15.1% | 20.8% | |
| Asian | 5.7% | 6.2% | 4.2% | |
| Native American | 4.0% | 3.9% | 4.2% | |
| Other | 1.6% | 1.8% | 0.9% | |
| Household income (%) | | | | |
| Less than \$75,000 | 46.7% | 45.9% | 49.0% | 0.115 |
| \$75,000 and greater | 53.3% | 54.1% | 51.0% | |
| Parents' highest education (%) | | | | |
| High school education or less | 16.0% | 14.9% | 18.1% | 0.037 |
| College education or more | 84.0% | 85.1% | 81.9% | |
| Blood pressure percentile | | | | |
| Systolic | 42.1 (29.4) | 41.9 (29.1) | 42.8 (30.2) | 0.462 |
| Diastolic | 44.5 (24.5) | 43.1 (23.9) | 47.2 (26.2) | <0.001 |
| Hypertension | | | | |
| Yes | 4.2% | 3.4% | 6.4% | <0.001 |
| Weight (kg) | 49.5 (14.3) | 48.8 (13.7) | 51.8 (15.9) | <0.001 |

ABCD propensity weights were applied based on the American Community Survey from the US Census. SD = standard deviation.

^a Pre-COVID-19 pandemic defined as before March 13, 2020.

study (baseline 2016–2018) of health, brain, and cognitive development in 11,875 children from 21 recruitment sites across the U.S. The study sample, recruitment, procedures, and measures have been previously described [8]. We included participants with complete blood pressure and covariate data for this analysis. Of the 4428 participants with blood pressure data, 363 had missing data for one or more covariates, leaving a final sample size of 4065. Centralized institutional review board (IRB) approval was acquired from the University of California, San Diego. A parent/guardian and the child gave written informed consent and assent.

2.1. Measures

Blood pressure was measured at the annual assessment (second year of follow-up) on a single day. Average blood pressure was calculated using the mean of three measurements separated by a 60 second interval from a factory-calibrated, Omron blood pressure monitor (MicroLife USA, Inc.; Dunedin, FL), after the participant rested for 5 min. Systolic and diastolic blood pressures were converted into percentiles and hypertension was determined based on the American Academy of Pediatrics guidelines [7]. Weight was measured after removing shoes and extra clothes, using two measured weights (or three if the initial two weights differed by >0.1 pounds). Weight was converted to kg and the mean of the two-to-three weights was calculated. Based on the visit date, responses were categorized as pre-COVID (before March 13, 2020) and during COVID. Covariates included age, sex, race/ethnicity, household income, and parents' highest education, which were reported by the parent, as well as study site. After the start of the pandemic, there were initial pauses in the annual visits, with variation in the timeframe of resumption of visits and modality (e.g., in person versus virtual) based on study site. Overall, 88% of participants completed the two-year follow-up visit; however, blood pressure and weight measurements were not collected in virtual visits.

2.2. Statistical analysis

Unadjusted comparisons of sociodemographic characteristics, blood

pressure percentile, hypertension, and weight were calculated using Chi-square tests (for categorical variables) and independent samples t-tests (for continuous variables). Multivariable linear regression models were constructed to determine the association between the pandemic and systolic and diastolic blood pressure percentiles and weight. Multivariable logistic regression analysis was conducted to calculate an odds ratio (OR) estimating the association between the pandemic and hypertension. Model 1 was unadjusted. Adjusted models (Model 2) accounted for age, sex, race/ethnicity, household income, parent education, and study site.

3. Results

Among 4065 adolescents (mean age 12.00, 49.4% female, 55.5% White), 73.0% of responses were collected pre-COVID, and 4.2% of adolescents had hypertension (Table 1), with 3.4% pre-pandemic and 6.4% during the pandemic ($p < 0.001$, Fig. 1). Average systolic blood pressure percentile was 42.1 (41.9 pre-pandemic versus 42.8 during the pandemic, $p < 0.001$), average diastolic blood pressure was 44.5 (43.1 pre-pandemic versus 47.2 during the pandemic, $p < 0.001$), and average weight was 49.5 kg (48.8 kg pre-pandemic versus 51.8 kg during the pandemic).

The pandemic was associated with a 4.65 percentile (95% CI 2.65, 6.66) higher diastolic blood pressure (Table 2) when adjusting for covariates. The pandemic was also associated with a 1.97 higher odds of hypertension (95% CI 1.33, 2.92) compared to pre-pandemic when adjusting for covariates. The pandemic was associated with a 1.68 kg (95% CI 0.51, 2.85) higher weight when adjusting for covariates.

4. Discussion

In this large, national sample of early adolescents, we found a greater risk of hypertension during the COVID-19 pandemic compared to the pre-pandemic period. In particular, diastolic blood pressure percentiles were significantly higher during the pandemic. Interestingly, previous studies have demonstrated that diastolic blood pressure (compared to systolic blood pressure) is a stronger predictor of CVD risk in adolescents

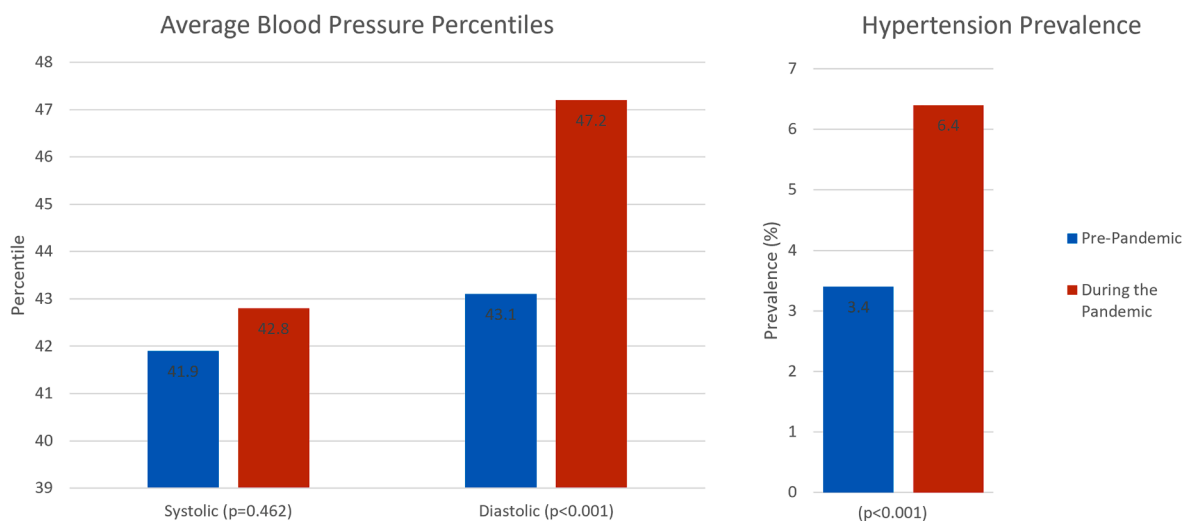


Fig. 1. Comparison of average blood pressure percentiles and hypertension prevalence pre-pandemic versus during the pandemic in the Adolescent Brain Cognitive Development (ABCD) Study.

Table 2

Associations between blood pressure, weight, and the COVID pandemic in the adolescent brain cognitive development (ABCD) study (N = 4065).

| | Model 1: Unadjusted | | Model 2: Adjusted ^a | |
|-------------------------------------|--|-------------------|--|------------------|
| | During pandemic (compared to pre-pandemic) | | During pandemic (compared to pre-pandemic) | |
| | B Coefficient | p | B Coefficient | p |
| Systolic blood pressure percentile | 0.85 (-1.42, 3.13) | 0.463 | 1.85 (-0.48, 4.20) | 0.120 |
| Diastolic blood pressure percentile | 4.03 (2.06, 6.01) | <0.001 | 4.65 (2.65, 6.66) | <0.001 |
| Weight | 2.94 (1.73, 4.16) | < 0.001 | 1.68 (0.51, 2.85) | 0.005 |
| | OR | p | AOR | p |
| Hypertension | 1.90 (1.32, 2.72) | <0.001 | 1.97 (1.33, 2.92) | 0.001 |

B = coefficient from linear regression. OR = odds ratio from logistic regression. AOR = adjusted odds ratio from logistic regression. Propensity weights from the Adolescent Brain Cognitive Development Study were applied based on the American Community Survey from the US Census.

^a Adjusted models represent the abbreviated output from regression models including covariate adjustment for age, sex, race/ethnicity, household income, parent education, and study site.

[9]. While multiple studies have documented the various ways the pandemic has affected adolescent behaviors [1,2], our study is the first to our knowledge to describe changes in hypertension among adolescents, an important and objective measure of cardiovascular health.

While these cross-sectional data cannot determine what factors contributed to the higher blood pressure levels in participants during the pandemic versus before, possible reasons include higher weight which we report here, in line with literature which demonstrated increases in weight among adolescents in a different cohort during the pandemic [10]. In addition, lower physical activity [2,11] and higher sedentary screen time [1] have been previously reported in the same ABCD Study cohort during the first year of the pandemic. Furthermore, prior studies demonstrated higher rates of stress experienced by adolescents during the pandemic [12], which could be explored in future research in relation to blood pressure trends.

Limitations of this study include its cross-sectional nature and the possibility of unmeasured confounders. Because each study participant only contributed blood pressure data collected from a single day, participants from whom data were collected before the pandemic may differ from participants from whom data were collected during the pandemic, which could introduce bias to the data. We attempted to control for this by adjusting for age, sex, race/ethnicity, household income, parent education, and study site in the regression models. Blood pressure data are only available through 2020; therefore, future research should examine longitudinal trends in blood pressure after 2020 as adolescents return to pre-pandemic habits.

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The funders had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Statement of authorship contributions

Jason Nagata conceptualized and designed the study, contributed to the data analysis, drafted the initial manuscript, and revised the manuscript.

Joanne Yang contributed to the data analysis, drafted the initial manuscript, and revised the manuscript.

Sana Alsamman drafted the initial manuscript and revised the manuscript.

Abubakr Al-shoaibi contributed to the data analysis and revised the manuscript.

Kyle Ganson and Kelley Pettee Gabriel critically reviewed and

revised the manuscript for important intellectual content.

Fiona Baker conceptualized the study, contributed to data collection and methodology, and critically reviewed and revised the manuscript for important intellectual content.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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