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Friends With Health Benefits: The Long-Term Benefits of Early Peer Social Integration for Blood Pressure and Obesity in Midlife

Jenny M. Cundiff[1] and Karen A. Matthews[2,3]

[1]Department of Psychological Sciences, Texas Tech University; [2]Department of Psychiatry, University of Pittsburgh; and [3]Department of Psychology, University of Pittsburgh

Abstract

In adults, greater social integration is associated with reduced risk of cardiovascular disease, including hypertension. Social integration earlier in life may be similarly associated with cardiovascular risk. Using a longitudinal sample of 267 Black and White men, we examined whether greater social integration with peers during childhood and adolescence, assessed by parent report, prospectively predicts lower blood pressure and body mass index two decades later in adulthood and whether these effects differ by race, given well-documented racial disparities in hypertension. Boys who were reported by their parents to be more socially integrated with peers evidenced lower blood pressure and body mass index in adulthood, and this effect was not accounted for by body mass index in childhood, childhood socioeconomic status, childhood hostility, childhood physical health, extraversion measured in adolescence, or concurrent adult self-reports of social integration. Results did not differ by race, but analyses were not powered to detect interactions of small effect size.

Keywords

cardiovascular, social integration, peer relationships, longitudinal, physical health

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Greater social support and integration are associated with decreased risk of morbidity and mortality in humans (for a meta-analysis, see Holt-Lunstad, Smith, & Layton, 2010) as well as in nonhuman primates (e.g., Archie, Tung, Clark, Altmann, & Alberts, 2014; Nation et al., 2008). This association is not simply cross-sectional. A number of longitudinal studies in adult populations show that social integration may be health protective (e.g., Berkman et al., 2004; Cohen, 2004; Yang, Li, & Ji, 2013).

Cardiovascular disease (CVD) is the leading cause of death in the United States across racial and ethnic groups, with approximately one in every four deaths being attributable to CVD (Centers for Disease Control and Prevention, 2017). Although clinical CVD is typically diagnosed starting in middle and older age, risk for CVD begins much earlier and accumulates over the life course. Risk factors that occur early in life can also influence cardiovascular health (e.g., Galobardes, Lynch, & Smith, 2008; Lloyd-Jones et al., 2010). Logically, the earlier risk factors emerge, the longer individuals are exposed to these risk factors, and the more likely they are to contribute to the accumulation of CVD risk over time.

Much work on early social relationships and health focuses on parents and caregivers, and some strong studies in this area are promising. For example, experimental manipulations show that improvements in the parent-child relationship can result in significant reductions in child and adolescent blood pressure (Brotman et al., 2012; Campbell et al., 2014, males only). However, beyond caregiver and family relationships, there

Corresponding Author:
Jenny M. Cundiff, Department of Psychological Sciences, Texas Tech University, Box 42051, Lubbock, TX 79409
E-mail: jennycundiff@gmail.com

has been increasing interest in whether the presence and quality of peer relationships early in life may also influence physical health years later. In a few large White cohorts from outside of the United States, isolation from peers has been shown to be associated with increased cardiovascular risk decades later (Caspi, Harrington, Moffitt, Milne, & Poulton, 2006; Gustafsson, Janlert, Theorell, Westerlund, & Hammarström, 2012). More recent work in a large, primarily White sample from the United States also found that adolescent peer relationships are associated with cardiovascular risk, but only for females who reported close friendships with males, perhaps suggesting the importance of early romantic bonds (Ehrlich, Hoyt, Sumner, McDade, & Adam, 2015). Another recent study, examining informant ratings of peer relationships in a smaller but more racially diverse sample, found that peer relationships at age 13 prospectively predicted better physical-health-related quality of life in adulthood, an important, if biologically nonspecific, indicator of physical health (Allen, Uchino, & Hafen, 2015). Thus, early social relationships with peers may presage poor cardiovascular health later in life. However, available longitudinal data are sparse, primarily based on White samples, and assessed via self-reports of peer relationships, and there is some indication that associations may be significant only in women (when assessed during adolescence).

Race is an important demographic consideration when examining psychosocial risk for CVD. Although Black Americans as a group evidence higher blood pressure and greater risk for the adverse sequelae of hypertension than non-Hispanic White Americans (Flack, Ferdinand, & Nasser, 2003), current prospective data on early peer relationships and cardiovascular risk are based on samples that are either entirely or primarily White (e.g., Caspi et al., 2006). Understanding whether mutable risk factors such as social integration with peers show similar associations across racial lines and whether they could plausibly contribute to racial disparities in blood pressure is useful in determining which psychosocial risk factors appear to be important and for whom.

Current Study

In the current study, we examined whether time spent with friends during childhood and adolescence is prospectively associated with blood pressure and body mass index (BMI) almost 20 years later. We examined these prospective associations in a sample of currently middle-age Black and White men who have participated in a longitudinal study since early childhood. Time spent with friends could be negatively construed if friends are assumed to be a negative influence on health. However, given the evidence reviewed above as well as many other studies showing beneficial associations between social relationships on cardiovascular health, we expected that time spent with friends would be similarly associated with better cardiovascular health. Our hypotheses were that higher levels of social integration with peers (e.g., more time with friends) would be associated with lower blood pressure and BMI at follow-up, two decades later. We also capitalized on the characteristics of this unique sample to examine whether race may moderate the prospective association between early social integration with peers and later blood pressure and BMI in adulthood. We examined whether prospective associations were robust to potential confounds such as socioeconomic status (SES) and childhood physical health and BMI, as well as psychosocial factors considered potential risk factors for CVD, which may also correlate with peer social integration (e.g., hostility, extraversion).

Method

Participants

Participants for this study were drawn from the Pittsburgh Youth Study (PYS). The PYS is a population-based longitudinal study of boys who were initially recruited from Pittsburgh public schools. The current study includes the youngest cohort of the PYS, which began in 1987–1988 and initially included 503 boys. This cohort was selected from a larger pool of 1,165 children registered to attend the first grade; 849 children were randomly selected to undergo a multi-informant (i.e., parent, teacher, child report) screening that assessed early conduct problems (e.g., fighting, stealing). Boys identified at the top 30% on the screening risk measure (n = 256), and a roughly equal number of boys randomly selected from the remainder (n = 247), were selected for longitudinal follow-up (N = 503). The follow-up sample was not significantly different from the random screening sample in terms of race, family composition, or California Achievement Test reading scores.

The boys' mean age at screening was 6.2 years and mean age at first assessment was 6.7 years. Racial composition was predominately White (40.6%) and Black (55.7%). Nearly all primary caregivers were biological mothers (92%), with 45.3% cohabiting with a partner and 16.9% completing fewer than 12 years of schooling at study entry. More than half of families (61.3%) were receiving public financial assistance (e.g., food stamps) at study entry. Following screening, boys in the PYS were assessed every 6 months for the first 4 years and then annually for 9 years. Interviews were conducted separately with parents and children, typically within the participants' homes. Phone interviews were conducted

with families who moved outside of a reasonable driving distance. Greater detail on participant selection and sample characteristics is available elsewhere (Loeber, Farrington, Stouthamer-Loeber, & White, 2008).

Men in the PYS were recontacted in adulthood to participate in a follow-up study called Pathways to Healthy Hearts that examined early factors related to the development of adult physical health problems. More specifically, letters were sent inviting the men to be in the project, and nonresponses were followed up by phone. At the time of the assessment in adulthood, 18 men were deceased, 44 had dropped out of the study at an earlier assessment, 4 were severely mentally disabled, and 42 were incarcerated. Of the remaining 394 men, 312 participated in some or all of the protocol (79% of those eligible). Of the 82 men who were eligible but did not participate, 22 men declined participation, 19 failed to respond to contact attempts or missed appointments, and 41 could not be located. From the sample of 312 men who participated, 267 men had complete data for the current analyses; many of the men who did not participate in the laboratory portion of the study no longer lived in Pittsburgh or were not willing to come to Pittsburgh for the clinic evaluation. The final sample of 267 men did not differ from the rest of the men in the initial PYS sample on race, risk group stratification for conduct problems, or baseline SES (all *p*s > .05). This study was reviewed and approved by the University of Pittsburgh Institutional Review Board.

Measures

Early social integration with peers. Social integration is often assessed in adult populations by asking about frequency of contact across multiple social roles (family, friends, church). There is no similar measure of social integration for use in younger samples, and here, we assessed social integration specifically with peers. Peer social integration was assessed annually between the ages of 7 and 16 years by asking parents, "Over the past year, how much time has your son spent with his friends during an average week?" Response options were as follows: < 1 hr per week, 1 to 5 hr per week, 6 to 10 hr per week, 11 to 20 hr per week, and > 20 hr per week. This one-item measure showed strong test-retest reliability across childhood and adolescence in this sample (Cronbach's α = .79), and responses on annual assessments were aggregated. Further, this measure was not simply a proxy for parental monitoring during childhood (ages 7–12 years; $r = -.05$, $p = .46$) or adolescence (ages 13–16 years; $r = .06$, $p = .38$), nor was it a proxy for sports involvement (measured once during adolescence; $r = -.002$, $p = .97$).

Blood pressure in adulthood. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were assessed using a CARESCAPE Dinamap V100 Vital Signs Monitor (GE Medical Systems Information Technologies, Wauwatosa, WI) with a standard occluding cuff placed on each participant's nondominant arm. Blood pressure was assessed every 2 min for 10 min while the participant was seated and at rest, and the three readings taken during the last 5 min were aggregated.

BMI in adulthood. BMI was calculated on the basis of objective measurements taken by staff (weight in kg, height in m^2).

Covariates. Childhood BMI was calculated by averaging parental reports of the height and weight of their children from the ages of 7 to 9 years (weight in kg, height in m^2). Childhood SES was calculated by averaging responses from ages 7 to 9 years and measured using the two-indicator Hollingshead index, which is calculated on the basis of an individual's highest education attained and current occupational prestige (Hollingshead, 1975). At each annual assessment, the Hollingshead index was calculated for the primary female or male caretaker in the home. When two caretakers were present, SES was indexed using the higher of the two scores. Concurrent social integration in adulthood was measured using the social network index (Cohen, 1991), which assesses regular participation (face-to-face or phone contact at least once every 2 weeks) in 12 categories of social relationships (e.g., friends, work colleagues, parents). Levels of participant hostility at the beginning of the study in childhood were assessed by parent reports of the boy's hostility, calculated by averaging responses from ages 7 to 9 years. This measure has been used previously and shown to have good internal consistency in childhood (Byrd, Hawes, Loeber, & Pardini, 2016). The personality facet of extraversion was assessed once at age 16 years by a well-validated parent report of the Big Five personality dimensions adapted to adolescents (Lynam et al., 2005). This was the only time that personality was assessed in this sample. Children's physical health at age 7 years was assessed by asking parents to report whether their son had experienced a number of different physical health problems, and endorsed items were summed (Cundiff, Boylan, Pardini, & Matthews, 2017).

Statistical analyses

All analyses were conducted using SPSS. First, means and standard deviations were examined for variables of interest along with basic correlations among these variables. Next, regression analyses were used to examine the

predictive utility of social integration with peers on blood pressure and BMI in adulthood. We also performed regression analyses to examine whether aspects of personality or health in childhood may confound associations between social integration with peers and adult blood pressure and BMI, as well as whether controlling for antihypertensive medication use may influence our results.

If we obtained an association with peer social integration across ages 7 to 16 years, then we examined whether peer social integration showed differential associations with adult health outcomes across early development (e.g., whether there is a sensitive period for these prospective associations). We used results from regression analyses to compute adjusted effect sizes (squared semipartial correlations) for the unique prospective association of social integration with peers on adult health outcomes across statistical models. The squared semipartial correlation is equivalent to the unique change in R^2 due to early peer social integration, over and above the other covariates in a given model, thus providing a clear estimate of the percentage of unique variance accounted for by early peer social integration in each model. Prior to beginning the project, power was calculated on the basis of a sample of 300 participants. Because only 267 participants were included in the current analyses, we reestimated power using PROC POWER in SAS, assuming a target sample of 267 participants, two-tailed tests, and a Type I error rate of .05. Power calculations took into account standard covariates and tested for significant main effects and interactions. The results revealed that we would have sufficient power (> 95%) to detect a variable with a median (f^2 = .15) or large (f^2 = .35) effect size in a multiple linear regression model but would have only 63% power to detect a variable (or an interaction) with a small effect size (Cohen's f^2 = .02).

Results

Descriptive statistics

The current follow-up sample was 56% Black and 44% White, with a mean age of 32 years. Means, standard deviations, and intercorrelations for the primary variables of interest are presented in Table 1. Of note, greater early social integration with peers was correlated with lower blood pressure and BMI in adulthood. However, early social integration with peers was not related to BMI or SES in childhood, and social integration in adulthood was not significantly correlated with concurrent blood pressure or BMI. Further, early social integration with peers was not significantly correlated with social integration in adulthood (age = ~32 years).

Is social integration with peers prospectively associated with blood pressure and BMI in adulthood?

Table 2 shows the results of multivariate regression analyses examining the prospective association between early social integration with peers and later blood pressure and BMI. Model 1 controlled for race, childhood SES, and BMI, as well as risk stratification group because it was part of the original study design. Despite the null simple correlation (see Table 1), Model 2 additionally controlled for concurrent social integration in adulthood to rule out the possibility that observed associations could be due to concurrent social integration rather than social integration with peers, measured during childhood and adolescence, establishing the importance of temporal precedence in the assessment of social integration.

Table 1. Means, Standard Deviations, and Intercorrelations Among Primary Study Variables

				Correlations							
Variable	*M*	*SD*	Range	1	2	3	4	5	6	7	8
1. Childhood SES	35.8	10.3	6–66	—	−.11	−.03	.26*	.05	.03	.05	.00
2. Childhood BMI	20.3	5.2	12.1–41.2		—	.04	−.12	−.01	.24*	.21*	.05
3. Peer social integration	8.95	1.98	4.6–13.8			—	−.03	−.10	−.13*	−.17*	−.16*
4. Adult SES	30.7	14.5	6–66				—	.47*	−.04	.03	.05
5. Adult social integration	16.71	8.52	0–53					—	−.01	.02	.08
6. Adult BMI	29.5	7.2	17.6–63.1						—	.54*	.32*
7. Adult SBP	122.4	12.5	99.7–180.0							—	.75*
8. Adult DBP	72.2	9.5	52.7–104.3								—

Note: SES = socioeconomic status, as measured by the Hollingshead (1975) index; BMI = body mass index, as measured by parent report in childhood and objectively measured in adulthood; SBP = systolic blood pressure; DBP = diastolic blood pressure.
*p < .05.

Table 2. Results of Regression Analyses Examining Prospective Associations Between Social Integration With Peers During Childhood and Adolescence and Blood Pressure and Body Mass Index (BMI) in Adulthood

	Systolic blood pressure			Diastolic blood pressure			(ln)BMI		
Model and predictor	*b*	β	*SE*	*b*	β	*SE*	*b*	β	*SE*
Model 1									
Race	−3.36	−0.13*	1.74	−3.49	−0.18*	1.35	0.02	0.05	0.03
Peer social integration (ages 7–16 years)	**−0.89**	**−0.14***	0.43	**−0.66**	**−0.13***	0.33	**−0.02**	**−0.18***	0.007
Stratification group (age 6 years)	−0.94	−0.04	1.65	−0.94	−0.05	1.27	0.000	0.000	0.03
Socioeconomic status (ages 7–9 years)	0.11	0.09	0.08	0.03	0.03	0.06	0.001	0.06	0.001
Childhood BMI (ages 7–9 years)	0.50	0.20*	0.16	0.06	0.03	0.12	0.01	0.29*	0.003
Model 2									
Race	−3.3	−0.13*	1.76	−3.45	1.35*	1.35	0.02	0.05	0.03
Peer social integration (ages 7–16 years)	**−0.93**	**−0.14***	0.43	−0.64	−0.13†	0.33	**−0.02**	**−0.18***	0.007
Stratification group (age 6 years)	−0.92	−0.04	1.66	−0.94	−0.04	1.27	0.00	−0.001	0.029
Socioeconomic status (ages 7–9 years)	0.10	0.08	0.081	0.03	0.03	0.06	0.001	0.06	0.001
Childhood BMI (ages 7–9 years)	0.49	0.20*	0.16	0.06	0.03	0.125	0.013	0.29*	0.003
Social integration in adulthood (age 32 years)	−0.03	−0.02	0.095	0.05	0.04	0.073	0.00	−0.02	0.002

Note: For Model 1, the R^2 values for systolic blood pressure, diastolic blood pressure, and BMI were .09, .06, and .11, respectively. For Model 2, the R^2 values were also .09, .06, and .11, respectively. Standard errors are for the unstandardized coefficients. Boldface type indicates the predictor variable of interest and statistically significant associations between this variable and the specified outcomes; (ln)BMI is the natural log transformation of BMI.
†$p = .06$. *$p < .05$.

For SBP, results revealed that Black race, lower social integration with peers, and higher parent-reported childhood BMI were significantly associated with higher SBP in adulthood in both Models 1 and 2. For DBP, Black race and lower social integration with peers were significantly associated with higher DBP in Model 1. In Model 2, only race was significantly associated with DBP, and early social integration with peers approached statistical significance ($p = .055$). For BMI, lower social integration with peers and higher parent-reported childhood BMI were significantly associated with current adult BMI. Hence, as expected, Black men evidenced higher blood pressure than did White men, and BMI in childhood was significantly associated with BMI in adulthood. More interesting, in five of the six analyses, social integration with peers during childhood and adolescence was significantly associated with physical health in adulthood as measured by blood pressure and BMI.

Moderation by race

Although results revealed a main effect of race on blood pressure consistent with epidemiological data, we found no evidence of effect moderation by race. Race did not interact with early social integration with peers to differentially influence either blood pressure or BMI in adulthood (for all interaction terms, all βs < 0.50, $p > .18$). Hence, the influence of early social integration with peers on physical health in adulthood was similar for Black and White men in this sample. However, as noted above, we had only 63% power to detect small interaction effects. Thus, it is possible that a small interaction with race was present in this sample, but we were not able to detect it.

Additional potential confounds: hostility, extraversion, and baseline physical health

When hostility in childhood was added to the fully adjusted model (shown in Table 2, Model 2), results were largely unchanged though somewhat less strong for BMI (see Tables 3 and 4). Specifically, early social integration with peers and childhood BMI were prospectively associated with lower SBP and BMI, and only race significantly predicted DBP, with social integration with peers approaching conventional levels of significance for DBP ($p = .06$). Although there was a consistently negative and nonnegligible association between hostility in childhood and adult physical health in fully adjusted models (effect size range: $\Delta R^2 = .003–.010$), this effect was not statistically significant for blood pressure or BMI.

When extraversion at age 16 years was added to the fully adjusted model (shown in Table 2, Model 2), the sample size was decreased from 267 to 230, because this one-time assessment was not completed for all participants. In this reduced sample, results were mostly unchanged though were somewhat stronger for blood

Table 3. Results of Regression Analyses Examining Prospective Associations Between Social Integration With Peers and Physical Health, Controlling for Hostility, Extraversion, and Physical Health in Childhood (Age 7 Years)

	Systolic blood pressure			Diastolic blood pressure			(ln)BMI		
Control variable and predictor	*b*	β	*SE*	*b*	β	*SE*	*b*	β	*SE*
Hostility									
Race	−3.1	−0.12	1.8	−3.2	−0.16*	1.4	0.03	0.06	0.03
Peer social integration (ages 7–16 years)	**−0.91**	**−0.14***	0.43	−0.63	−0.13†	0.33	**−0.02**	**−0.17***	0.01
Stratification group (age 6 years)	−0.07	−0.003	1.8	−0.13	−0.01	1.4	0.01	0.02	0.03
Socioeconomic status (ages 7–9 years)	0.10	0.08	0.08	0.02	0.02	0.06	0.001	0.06	0.001
Childhood BMI (ages 7–9 years)	0.49	0.20*	0.16	0.05	0.03	0.12	0.01	0.29*	0.003
Social integration in adulthood (age 32 years)	−0.04	−0.03	0.10	0.04	0.04	0.07	0.00	−0.02	0.002
Hostility in childhood (ages 7–9 years)	−0.66	−0.10	0.45	−0.54	−0.11	0.35	−0.01	−0.06	0.008
Extraversion									
Race	−3.1	−0.12	1.8	−3.1	−0.16*	1.4	0.02	0.03	0.03
Peer social integration (ages 7–16 years)	**−1.1**	**−0.16***	0.45	**−0.84**	**−0.17***	0.34	**−0.02**	**−0.16***	0.008
Stratification group (age 6 years)	−1.1	−0.04	1.7	−1.1	−0.06	1.3	−0.01	−0.01	0.03
Socioeconomic status (ages 7–9 years)	0.11	0.09	0.08	0.03	0.03	0.06	0.002	0.07	0.001
Childhood BMI (ages 7–9 years)	0.47	0.19*	0.16	0.05	0.03	0.12	0.01	0.28*	0.003
Social integration in adulthood (age 32 years)	−0.06	−0.04	0.10	0.04	0.03	0.07	0.00	−0.001	0.002
Extraversion (age 16 years, parent report)	2.3	0.04	3.4	1.04	0.03	2.6	0.01	0.01	0.06
Child physical health									
Race	−3.2	−0.12	1.8	−3.4	−0.17*	1.4	0.02	0.05	0.03
Peer social integration (ages 7–16 years)	**−0.98**	**−0.15***	0.43	**−0.65**	**−0.13***	0.34	**−0.02**	**−0.18***	0.008
Stratification group (age 6 years)	−0.85	−0.03	1.7	−0.84	−0.04	1.3	0.000	0.00	0.03
Socioeconomic status (ages 7–9 years)	0.10	0.08	0.08	0.02	0.03	0.06	0.001	0.06	0.001
Childhood BMI (ages 7–9 years)	0.48	0.20*	0.16	0.05	0.03	0.13	0.01	0.29*	0.003
Social integration in adulthood (age 32 years)	−0.03	−0.02	0.10	0.05	0.04	0.07	0.00	−0.01	0.002
Physical health diagnoses (age 7 years)	−0.82	−0.05	1.2	−0.28	−0.02	0.90	0.01	0.02	0.02

Note: For hostility, the R^2 values for systolic blood pressure, diastolic blood pressure; and body mass index (BMI) were .10, .07, and .11, respectively. For extraversion, the R^2 values were .10, .07, and .10, respectively. For child physical health, the R^2 values were .09, .06, and .11, respectively. Standard errors are for the unstandardized coefficients. Boldface type indicates the predictor variable of interest and statistically significant associations between this variable and the specified outcomes; (ln)BMI is the natural log transformation of BMI.
†$p = .06$. *$p < .05$.

pressure and less strong for BMI (see Tables 3 and 4). Specifically, early social integration with peers showed stronger associations with blood pressure when extraversion was included in models, and the association between early social integration and DBP again met conventional levels of statistical significance. Extraversion was not significantly associated with adult blood pressure or BMI in fully adjusted models (effect size range: $\Delta R^2 = .000–.002$).

When boys' physical health at baseline was added to the fully adjusted model (shown in Table 2, Model 2), results were again largely unchanged (see Tables 3 and 4). Specifically, early social integration with peers showed a small and reliable association with blood pressure and BMI in adulthood after controlling for physical health diagnoses at study entry. Associations with DBP again met conventional significance levels. Boys' physical health at baseline was not significantly associated with adult blood pressure or BMI in fully adjusted models. Tests of additional potential confounds (baseline depression, parent-child relationship quality, and neuroticism and agreeableness) can be found in Tables S1, S2, and S3, respectively, in the Supplemental Material available online.

Although our sample was relatively young, some of the men in our analytic sample self-reported taking medication to treat high blood pressure ($n = 14$). Researchers often disagree about how to handle such factors in analyses of blood pressure. On the one hand, this is a factor that should influence blood pressure and so should be statistically controlled, and on the other hand, having high blood pressure is simply an extreme version of the outcome of interest (difference in blood pressure) and so should not be statistically controlled. In the current sample, taking medication for high blood pressure was associated with higher SBP and DBP, $t(263)$s = 7.8 and 5.5, respectively, both ps < .001. Hence, those men with increased blood pressure were

Table 4. Comparison of the Effect Size (ΔR^2) of the Association Between Early Peer Social Integration and Later Adult Health Outcomes by Statistical Model

Regression model	Systolic blood pressure	Diastolic blood pressure	Body mass index
Model 1	.018*	.016*	.029*
Model 2	.018*	.015†	.029*
Model 2 + hostility	.018*	.015†	.029*
Model 2 + extraversion	.025*	.025*	.025*
Model 2 + physical health (age 7 years)	.021*	.016*	.029*
Model 2 + antihypertensive medications	.013*	.011	

†$p = .06$. *$p < .05$.

more likely to self-report taking antihypertensive medication. When a categorical variable indicating antihypertensive medication use was added to the fully adjusted models (see Table 2, Model 2) for SBP and DBP, the predictive utility of early social integration with peers for later blood pressure was largely unchanged though somewhat less strong (see Table 4). Specifically, early social integration was significantly associated with SBP ($\beta = -12$, $p = .05$), and associations with DBP remained below statistical significance ($\beta = -0.11$, $p = .09$).

Comparison of effect sizes (ΔR^2)

To aid in understanding the strength and consistency of the association between social integration with peers and adult health outcomes across the models tested here, we present effect sizes and statistical significance for each outcome by model in Table 4. As can be seen, the prospective association between early peer social integration and blood pressure and BMI in adulthood was similar across models, accounting for 1.5% to 3% of the variance in outcomes, with control for antihypertensive medication somewhat reducing associations with blood pressure.

Exploratory analyses examining developmental timing

The nature of the data allowed us to examine whether the timing of peer social integration influenced observed associations with cardiovascular outcomes. To examine this question, we aggregated ratings of peer social integration into three approximately equivalent time periods by age (7–9, 10–12, and 13–16 years). These time periods were highly correlated, with correlations ranging from .46 to .62. Each time period was individually analyzed in relation to outcomes to compare associations across developmental timing. Results of effect sizes and significance levels (see Table 5) revealed that each time period showed significant effects on BMI, although the earliest time period showed the largest effect. None of the three time periods showed a significant association with DBP, although effect sizes for the two later time periods were similar to effects seen in our original analyses (i.e., Model 2). The first and second time periods showed reliable associations with SBP, although the last time period did not and evidenced an effect size of approximately zero. Overall, results seem to suggest that peer integration in early and middle childhood (ages 7–12 years) may be more strongly and reliably associated with cardiovascular health in young adulthood, at least compared with peer integration during adolescence (see also the Growth Models section in the Supplemental Material).

Discussion

Men who were reported by their parents to be more socially integrated with peers during childhood and adolescence evidenced lower blood pressure and BMI almost 20 years later. This effect was not accounted for by parent-reported childhood BMI, childhood SES, concurrent self-reports of social integration in adulthood, hostility in childhood, extraversion assessed at age 16 years, physical health conditions present at the beginning of the study (age 7 years), or concurrent use of antihypertensive medication in adulthood. Although there was a main effect of race on blood pressure in some instances, we did not find evidence that race moderated the effect of social integration with peers on later adult blood pressure or BMI. There is some indication that peer social integration is more closely associated with cardiovascular health when assessed at earlier ages (see Table 5).

These results provide strong evidence that integration with peers early in life is associated with physical health in adulthood, specifically risk for hypertension

Table 5. Comparison of the Effect Size (ΔR^2) of the Association Between Early Peer Social Integration and Later Adult Health Outcomes by Statistical Model

Regression model by developmental timing	Systolic blood pressure	Diastolic blood pressure	Body mass index
Model 2 using peer integration from ages 7–16 years	.018*	.015†	.029*
Model 2 using peer integration from ages 7–9 years	.014†	.007	.026*
Model 2 using peer integration from ages 10–12 years	.022*	.011	.017*
Model 2 using peer integration from ages 13–16 years	.004	.012	.018*

†$p = .06$. *$p < .05$.

and obesity. The findings here are consistent with past prospective population-based research on White men and women outside of the United States, which evidenced associations between early social isolation from peers and negative health outcomes (e.g., Caspi et al., 2006). However, here, we did not examine an extreme group of boys who were socially isolated from peers but, rather, a continuous measure of the extent to which boys are socially integrated with peers during early development, finding that variation on this malleable positive construct is prospectively associated with objective health outcomes. Additionally, results in this entirely male sample are not consistent with some previous findings that suggested that peer relationships are predictive only of cardiovascular health in women (Ehrlich et al., 2015; Gustafsson et al., 2012). However, there are a number of significant methodological differences between those two studies and this one. For example, control variables differed (e.g., neither of the other studies controlled for social integration or a similar variable at follow-up and both controlled for a number of likely mediators), and social integration with peers was measured once by teacher report of isolation and popularity at age 16 years (Gustafsson et al., 2012) or by self-report of whether participants engaged in certain activities with their best male and female friends (Ehrlich et al., 2015). By contrast, the current study controlled for concurrent social integration and measured time spent with friends by parent report and at multiple time points across childhood and adolescence.

Both Black and White men participated in this study in roughly equal numbers and were all recruited from the same urban city (Pittsburgh, Pennsylvania), allowing us the opportunity to examine for the first time whether race may moderate the link between early peer integration and later adult health in similar samples of Black and White men. Although Black participants as a group showed both higher DBP and lower levels of social integration with peers, results do not support a significant interaction between race and social integration with peers on adult cardiovascular health. Hence, lower social integration with peers during childhood and adolescence may contribute to well-documented racial disparities in blood pressure because the negative impact of lower social integration appears to be similar for both Blacks and Whites, but Blacks evidence a higher level of risk (e.g., lower integration, on average).

These findings suggest that the ability to form and maintain social relationships with peers outside of the family at early stages of development, well before diseases become clinically apparent, is reliably associated with observable biological differences in cardiovascular health by early adulthood. Although this study could not determine the psychobiological mechanisms that may explain this relationship, it does establish that peer social integration is a potentially viable and nonnegligible (see Table 4) early correlate of common forms of poor physical health in adulthood in Black and White men. Further study of acute biological and behavioral processes associated with social integration with peers in early life may help us understand this prospective association. Interestingly, there appears to be mixed evidence concerning whether or not peers, like attachment figures, could influence physical health through the buffering of physiological stress responses (e.g., Gunnar & Hostinar, 2015). Hence, if there are within-person benefits to early peer social integration consistent with the between-person associations shown here, such benefits may be conferred through psychobiology beyond the use of that network for social support during times of stress.

Limitations

There are many methodological strengths to the current study, such as multiple assessments and informant ratings of key variables that reduce error and bias in measurement, as well as a prospective design that establishes temporal precedence. Despite these strengths, causality cannot be inferred from the current nonexperimental data. Additionally, childhood BMI was

assessed by parent report of the child's height and weight, which likely contains more measurement error than if childhood BMI were objectively measured by study staff. As noted previously, social integration was measured specifically in the context of time spent with peers. A broader measurement of social integration could yield different results. Further, this study used a one-item measure asking parents how much time their child spent with his friends during an average week. Although this one-item measure was assessed at multiple time points, a more thorough multi-item measure may be superior in terms of assessment of the construct or predictive utility. The sample was also limited geographically in that all participants grew up in and around the city of Pittsburgh. Although this may be a strength in terms of comparison of racial groups, it is clearly a limitation in terms of geographic generalizability (e.g., findings may not extend to rural populations). Further, although we found no evidence that associations between peer social integration and cardiovascular health varied by race, analyses had only 63% power to detect small interaction effects. Thus, it is possible that a small interaction with race was present in this sample but we were not able to detect it. Last, although our sample was diverse in terms of race, we studied only men. Although previous research has found similar prospective associations in women, participants have been primarily White; thus, generalizability seems most in question with respect to Black women.

Conclusion

Boys who were reported by their parents to spend more time with friends during childhood and adolescence evidenced lower blood pressure and BMI at age 32 years, approximately 16 years after the last assessment of peer social integration. These are the first data to our knowledge prospectively linking multiple assessments and informant reports of early peer social integration with objective markers of physical health in adulthood, and we show that these associations are similar across a large sample of Black and White men. More broadly, these findings contribute to the growing body of evidence supporting the idea that early social experiences may be relevant to physical health later in life and provide support for the importance of not only family but also peer relationships during childhood and adolescence. The longitudinal and non-self-report nature of the data, additional controls, and the inclusion of multiple assessments of social integration with peers increase confidence in the reliability and strength of the findings presented here. Experimental data evidencing concurrent or prospective cardiometabolic effects of increased peer social integration are needed to better understand the viability of peer relationships as an intervention target to reduce cardiovascular risk later in life.

Action Editor

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Author Contributions

J. M. Cundiff analyzed and interpreted the data in consultation with K. A. Matthews. J. M. Cundiff drafted the manuscript, and K. A. Matthews provided critical revisions. K. A. Matthews developed the concept and design of the follow-up study, Pathways to Healthy Hearts. Both authors approved the final manuscript for publication.

ORCID iD

Jenny M. Cundiff https://orcid.org/0000-0002-4477-3262

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Declaration of Conflicting Interests

The author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

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Supplemental Material

Additional supporting information can be found at http://journals.sagepub.com/doi/suppl/10.1177/0956797617746510

Open Practices

The parent study, the Pittsburgh Youth Study, has restricted public use data scores (see www.icpsr.umich.edu/icpsrweb/NACJD/studies/36453). The health data in adulthood is owned by the University of Pittsburgh. Interested parties will need to obtain permission from the University of Pittsburgh Office of Legal Affairs to use the data.

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