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Associations of connectedness and parental behaviors with adolescent physical activity and mental health during COVID-19: A mediation analysis using the 2021 adolescent behaviors and experiences survey

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ABSTRACT

The purpose of this study was to examine the associations of connectedness and parental behaviors with adolescent physical activity (PA) and mental health during COVID-19. Participants were a representative sample of US high school students who completed the 2021 Adolescent Behaviors and Experiences Survey (ABES; $N = 7705$; 50.4% female). ABES was completed online during the spring of 2021 and data were analyzed during the spring of 2022. Independent variables were items asking about perceived school and virtual connectedness, parental emotional abuse, and parental monitoring. Latent variables represented both PA and mental health. Two weighted structural equation models tested the associations between connectedness, parental behaviors, and mental health mediated through PA (Model 1) and between connectedness, parental behaviors, and PA mediated through mental health (Model 2) with indirect effect confidence intervals obtained using Monte Carlo simulations. School connectedness directly associated with better mental health in Model 1 ($\beta = 0.17$, $p < 0.001$) and with higher PA in Model 2 ($\beta = 0.19$, $p < 0.001$) while virtual connectedness directly associated with higher PA in Model 2 ($\beta = 0.08$, $p < 0.001$). Parental emotional abuse directly associated with poorer mental health in Model 1 ($\beta = -0.43$, $p < 0.001$). Standardized indirect effects to better mental health mediated through higher PA were observed for school connectedness (IE = 0.017, $p < 0.001$) and virtual connectedness (IE = 0.007, $p < 0.001$) and indirect effects to lower PA mediated through poorer mental health were observed for parental emotional abuse (IE = -0.050, $p < 0.001$). Perceptions of school and virtual connectedness and parental emotional abuse both directly and indirectly impacted adolescent PA and mental health during the COVID-19 pandemic.

1. Introduction

Physical activity (PA) has numerous benefits for adolescents and contributes to healthy physical and emotional development (Hallal et al., 2006; Kumar et al., 2015; Janssen and Leblanc, 2010). Despite these benefits, adolescents tend to have low levels of PA that can track into adulthood (Barnes et al., 2018; Telama et al., 2014). Not meeting the recommended 60 min of PA per day has been associated with lower health-related fitness and lower levels of well-being (Morrow Jr et al., 2013; Sampasa-Kanyinga et al., 2020). PA also positively correlates with other health behaviors, such as a healthy diet and sleep (Maier and Barry, 2015; Master et al., 2019), and negatively correlates with risk behaviors (Miller et al., 2019; Thompson et al., 2020). Previous work has shown that during COVID-19, youth engaged in lower levels of PA (Chaffee et al., 2021; Kiss et al., 2022). To improve health behaviors within the pandemic climate, some PA interventions have shown associations with improved health behaviors in young adults (Pfledderer et al., 2022), but more PA interventions targeting adolescents are needed (Nagata et al., 2022). Indeed, fluctuating school environments and schedules due to social and physical distancing behaviors and lockdown mandates have contributed to a relative lack of effective adolescent PA promotion efforts (Rahman and Chandrasekaran, 2021).

Feeling connected to one's environment is a key component of health behavior change theories and plays an important role in PA motivation, engagement, and adherence in all populations, including adolescents (Ryan and Deci, 2000; McNeill et al., 2006; Davis et al., 2015; Wray et al., 2020). Connectedness can manifest from both school and virtual environments (Perkins et al., 2021; Hertz et al., 2022). Although

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connectedness has been previously shown to correlate positively with health behaviors (Yang et al., 2014; Umberson et al., 2010), school connectedness may have been compromised during COVID-19; therefore, virtual connectedness may have played a greater role (Perkins et al., 2021; Hertz et al., 2022). Despite the potential negative effects of excessive screen use (Twenge and Campbell, 2018; Li et al., 2021), connectedness within the virtual environment during COVID-19 may have positively impacted mental health. Although several research studies have found that PA can positively influence mental health in adolescents (Bailey et al., 2018; Biddle and Asare, 2011; Spruit et al., 2016), other work has shown a bidirectional association between PA and mental health (Kiss et al., 2022; Gunnell et al., 2016; Vella et al., 2017; van Woudenberg et al., 2020). Thus, during COVID-19, connectedness from either the school or virtual environments may positively impact mental health mediated through PA or increase PA mediated through mental health.

School and virtual environments facilitate adolescent peer-to-peer connection. During COVID-19, parent-child connection, which has previously been shown to predict adolescent mental health, may have had increased importance in determining PA behavior (Ackard et al., 2006; Rapp et al., 2021; Chung et al., 2020). However, higher levels of stress and the changing work environments during COVID-19 may have negatively influenced how parents interacted with their children. It has been shown that COVID-19 associated with higher levels of parental emotional abuse (Chung et al., 2020; Du et al., 2021), and changing work environments and schedules may have altered how parents monitored their children during the pandemic (Chung et al., 2020; Du et al., 2021; Chen and Harris, 2019).

It is unknown how perceived connectedness and parental behaviors associated with adolescent PA and mental health during COVID-19. Possible direct and indirect associations between perceived connectedness and parent behavior with PA and mental health have not been previously examined. Results from this study help clarify the necessary targets to improve adolescent PA within a predominantly virtual pandemic climate. Results will also provide information on the determinants of PA and mental health during COVID-19. Therefore, the purpose of this study was to examine the associations of school connectedness, virtual connectedness, and parental behaviors with PA and mental health during COVID-19 using a representative sample of adolescents who participated in the Adolescent Behavior and Experiences Survey (ABES).

2. Methods

2.1. Adolescent behaviors and experiences survey

Data were obtained from the ABES, which was administered by the Centers for Disease Control and Prevention (CDC) during the Spring of 2021 (Adolescent Behaviors and Experiences Survey (ABES), 2022; Rico et al., 2022). ABES collected information on health-related experiences and behaviors during COVID-19. ABES is structurally like the Youth Risk Behavior Survey (YRBS) but with an additional 23 questions. ABES was completed within out-of-school settings using a secure web-based platform (Adolescent Behaviors and Experiences Survey (ABES), 2022; Rico et al., 2022). The ABES protocol was approved by Institutional Review Boards at CDC and student participation was voluntary and anonymous (Adolescent Behaviors and Experiences Survey (ABES), 2022; Rico et al., 2022). ABES data were publicly available and anonymized, and the current study was determined to be non-human subjects research by the University of Utah Institutional Review Board (IRB_00154548).

2.2. Sampling strategy

Participants were recruited using a three-stage cluster sampling design with a target population of all public, Catholic, and other private US high school students. Schools were systematically selected with the probability of selection proportional to enrollment. Systematic equal probability sampling with a random start was employed to select classes from each school and all students within each selected class who could complete ABES without assistance were eligible. One-hundred and twenty-eight schools participated from the sampled 339 schools (37.8% school response rate) and 7998 of the sampled 16,037 students submitted questionnaires with 7705 questionnaires being usable after data editing (48.0% student response rate). The overall ABES response rate was 18.1%. A weight based on sex, race/ethnicity, and grade level was applied to each participant to adjust for nonresponse and oversampling of Black and Hispanic students (Adolescent Behaviors and Experiences Survey (ABES), 2022; Rico et al., 2022).

2.3. Data processing

Physical Activity. A PA latent variable was indicated from three items. The first item asked "During the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day? (Add up all the time you spent in any kind of physical activity that increased your heart rate and made you breathe hard some of the time.)", with responses ranging from 0 days to 7 days. The second item asked "During the past 12 months, on how many sports teams did you play? (Count any teams run by your school or community groups.)", with responses ranging from 0 teams to 3 or more teams. The third item asked, "During the past 7 days, on how many days did you do exercises to strengthen or tone your muscles, such as push-ups, sit-ups, or weightlifting?", with responses ranging from 0 days to 7 days. The internal consistency across the 3 PA items was alpha = 0.70. Single item PA questionnaires like the PA YRBS/ABES item were previously shown to have acceptable test-retest reliability and concurrent validity against an accelerometer criterion within the adolescent population (Scott et al., 2015).

Mental Health. A mental health latent variable was indicated from three items. The first item asked, "During the past 30 days, how often was your mental health not good? (Poor mental health includes stress, anxiety, and depression.)" with responses ranging from 1 = Never to 5 = Always. A second item asked, "During the COVID-19 pandemic, how often was your mental health not good? (Poor mental health includes stress, anxiety, and depression.)", with responses ranging from 1 = Never to 5 = Always. A third item asked, "During the past 12 months, did you ever feel so sad or hopeless almost every day for two weeks or more in a row that you stopped doing some usual activities?" with a dichotomous response of 1 = Yes and 2 = No. All responses were reverse coded prior to analysis so that high scores indicated good mental health. Although extensive psychometric information of the specific single item mental health questionnaires is lacking, similarly structured single item mental health items have been used in prior population-based research (Rohrer et al., 2005), and have correlated with multi-item measures of mental health (Ahmad et al., 2014).

School and Virtual Connectedness. The school connectedness item asked, "Do you agree or disagree that you feel close to people at your school?", with responses ranging from 1 = Strongly agree to 5 = Strongly disagree. The responses were reverse coded prior to analysis so that higher scores indicated better perceived school connectedness. The virtual connectedness item asked, "During the COVID-19 pandemic, how often were you able to spend time with family, friends, or other groups, such as clubs or religious groups, by using a computer, phone, or other device? (Do not count attending school online.)", with responses ranging from 1 = Never to 5 = Always.

Parental Behaviors. The parental emotional abuse item asked, "During the COVID-19 pandemic, how often did a parent or other adult in your home swear at you, insult you, or put you down?", with responses ranging from 1 = Never to 5 = Always. The general parental monitoring item asked, "How often do your parents or other adults in your family know where you are going or with whom you will be?", with responses ranging from 1 = Never to 5 = Always.

Demographic Covariates. Demographic covariates included self-reported age, sex, race/ethnicity, and BMI %tile. Race/ethnicity was a merged variable from two separate items separately asking students about their race and ethnicity. BMI %tile was calculated from self-reported height and weight and the 2000 Centers for Disease Control and Prevention Growth Charts (Kuczmarski et al., 2000).

2.4. Statistical analysis

The complex ABES multi-stage cluster sampling design was accounted for in all analyses using Stata's "svy:" prefix command to obtain valid variance estimates. Because of the potential bidirectional association between PA and mental health, the primary analysis consisted of two weighted structural equation models (SEMs). The first SEM tested the associations between connectedness, parental behaviors, and mental health and the mediating effect of PA (Model 1). The second SEM tested the associations between connectedness, parental behaviors, and PA and the mediating effect of mental health (Model 2). Specifically, connectedness and parental behavior variables were treated as exogenous independent variables that were associated with either the PA or mental health latent mediating variable and either the mental health or adolescent PA latent dependent variable. The SEMs were adjusted for age, sex, race/ethnicity, and BMI %tile. Full information maximum likelihood was utilized to conduct available case analyses and to produce unbiased estimates and standard errors in the presence of missing data (Lee and Shi, 2021). Unweighted overall model fit was determined using the Root Mean Square Error of Approximation (RMSEA; acceptable fit≤0.08, excellent fit≤0.05), the Tucker-Lewis Index (TLI; acceptable fit≥0.90, excellent fit≥0.95), and the Comparative Fit Index (CFI; acceptable fit≥0.90, excellent fit≥0.95) (Hu and Bentler, 1999; Xia and Yang, 2019). Weighted model fit was assessed using the coefficient of determination (R (Kumar et al., 2015)). Weighted SEMs were constructed for the total sample and within sex-specific groups with the sex-specific results reported within the Supplemental Material.

Indirect (mediation) effects for both SEM models were calculated using Stata's "medsem" package, which used a post-estimation command after structural equation modeling to obtain standardized indirect effect estimates and confidence intervals across an N number of Monte Carlo simulations (Mehmetoglu, 2018). Mediation effect sizes were calculated using ratios of indirect effect / total effect (RIT). The RIT indicated the % of the total effect of an independent variable on the dependent variable that was mediated by either PA or mental health (Mehmetoglu, 2018). A RIT below 1 indicated partial mediation, an RIT equal to 1 indicated full mediation, and a RIT score above 1 with an operator sign of the indirect effect opposite of the direct effect that indicated "inconsistent mediation" and a suppressive effect of the mediator variable (MacKinnon et al., 2007). All analyses were conducted using Stata v17.0 statistical software package (Statacorp., College Station, Texas, USA) and utilized an alpha level of $p < 0.05$.

3. Results

3.1. Participant characteristics

Participant demographic characteristics were presented within Table 1. Missing data on the demographic variables ranged from 0.2% (age) to 10.5% (BMI %tile). Approximately 50.4% of the sample was female. Approximately 50.2% of the sample was characterized as being of a racial/ethnic minority and 20% of the sample had obesity based on self-reported height and weight with a mean BMI %tile of 65.6 ± 29.4%. Differences between the sexes on all the observed variables are presented within Table 2.

3.1.1. Model 1: physical activity mediator to mental health

Model Fit. The SEM for the PA mediator model was displayed within Fig. 1 and showed acceptable fit (RMSEA = 0.055, 90%CI:0.052–0.067; CFI = 0.94, TLI = 0.92). When sampling weights were applied to the model, 41% of the variance in mental health was explained (R (Kumar et al., 2015) = 0.41). The SEM using the sample of females was displayed within Supplemental Fig. S1 and for the sample of males within Supplemental Fig. S2.

Table 1
Sample demographic statistics.

Variable	Level	N	Weighted %
Sex	Female	3999	50.4%
	Male	3678	49.6%
Race/ethnicity	White	3461	49.8%
	American Indian/Alaskan native	83	0.7%
	Asian	350	4.9%
	Black or African American	1189	12.9%
	Native Hawaiian/Pacific islander	31	0.5%
	Hispanic/Latino	616	8.0%
	Multiple races-Hispanic/Latino	1422	17.4%
	Multiple races-non-Hispanic/Latino	480	5.8%
Weight status	Non-obese	5563	80.0%
	Obese	1335	20.0%

Table 2
Descriptive statistics for the observed variables (presented as means and standard deviations or as counts and weighted %s).

Variable	Total sample	Sample of females	Sample of males
Frequency of 60 min of PA/day (0–7 days/week)	3.6 (2.5)	3.1 (2.4)	**4.0*** (2.5)**
Number of sports teams (0–3 or more teams)	0.8 (1.0)	0.7 (1.0)	**0.9*** (1.1)**
Frequency of muscle strengthening activity (0–7 days/week)	2.5 (2.5)	1.9 (2.1)	**3.1*** (2.5)**
Current mental health (1–5 scale)	3.2 (1.7)	2.9 (1.2)	**3.6*** (1.2)**
COVID-19 mental health (1–5 scale)	3.0 (1.2)	2.6 (1.2)	**3.5*** (1.3)**
Not feeling sad or hopeless	4303 (55.8%)	1777 (44.7%)	**2519*** (68.9%)**
School connectedness (1–5 scale)	3.2 (1.2)	3.0 (1.2)	**3.4*** (1.2)**
Virtual connectedness (1–5 scale)	3.1 (1.1)	3.1 (1.1)	3.1 (1.2)
Parental emotional abuse (1–5 scale)	2.0 (1.2)	**2.2*** (1.2)**	1.8 (1.1)
General parental monitoring (1–5 scale)	4.3 (1.0)	**4.5*** (0.8)**	4.2 (1.1)

Note: PA stands for physical activity; bold denotes statistical significance, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Direct Effects. Direct effects for the PA mediator model are showed within Table 3 and Fig. 1. School connectedness (β = 0.15, $p < 0.001$) and virtual connectedness (β = 0.02, $p = 0.042$) positively associated with mental health and parental emotional abuse (β = −0.43, $p < 0.001$) negatively associated with mental health. Sex-specific direct effects are reported in Supplemental Table S1 and Supplemental Figs. S1 and S2.

Indirect Effects. Indirect effects are presented within Table 3. Significant indirect effects were observed for school connectedness (IE = 0.017, $p < 0.001$), virtual connectedness (IE = 0.007, $p < 0.001$), and parental emotional abuse (IE = -0.004, $p = 0.006$). Mediation effect sizes were relatively large for school connectedness and virtual connectedness as 10% and 24% of the total effect on mental health was partially mediated through PA, respectively. Mediation effect sizes were small for parental emotional abuse as 1% of the total effect on mental health was partially mediated through PA. Sex-specific indirect effects are reported in Supplemental Table S1.

3.1.2. Model 2: Mental health mediator to physical activity

Model Fit. The SEM for the mental health mediator model was

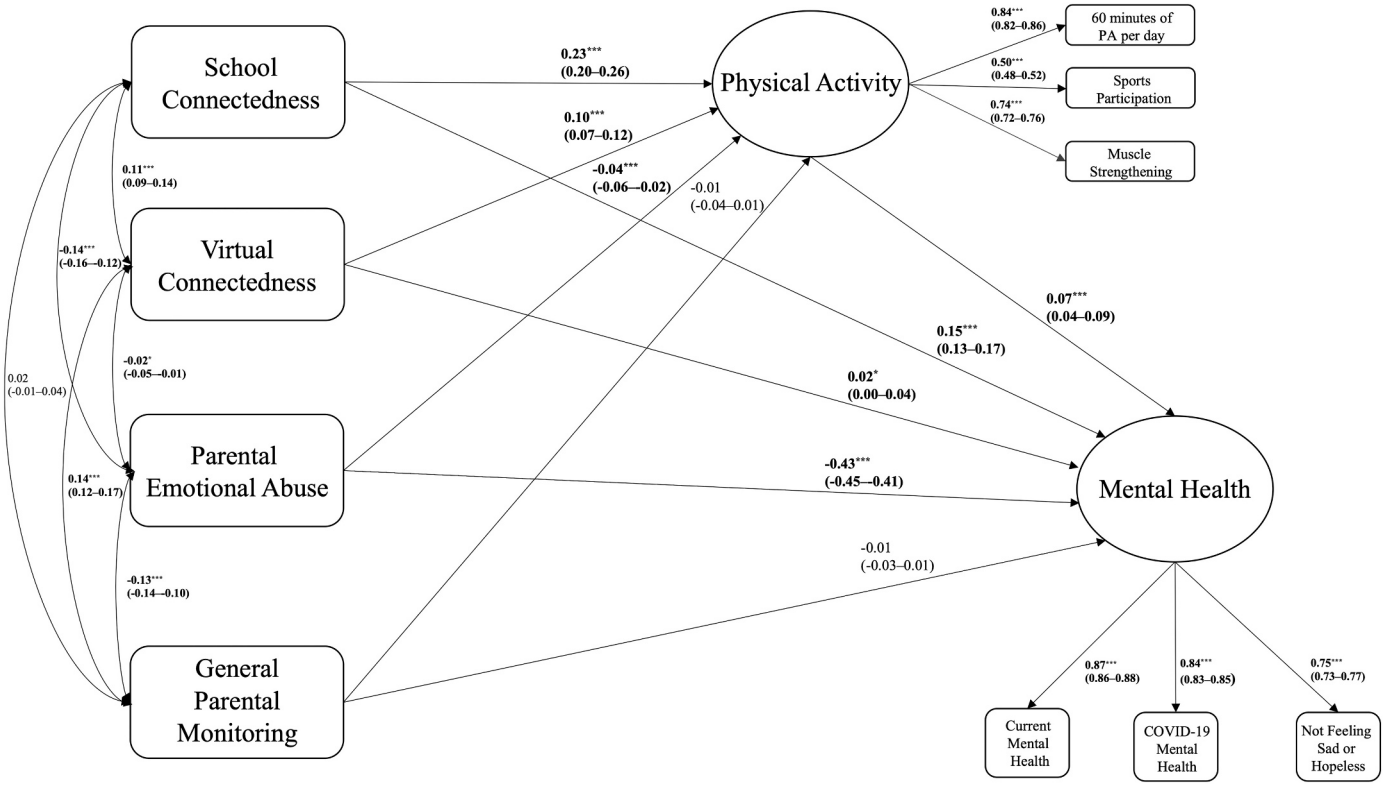

Fig. 1. Structural equation model using the total sample showing the direct effects and mediating effect of adolescent physical activity on the associations of school and virtual connectedness, parental emotional abuse, and general parental monitoring with mental health.
Note: Rectangles are observed variables and ovals are latent variables; curved lines are covariances and straight lines are direct paths; all coefficients were standardized; model was adjusted for age, sex, racial/ethnic minority status, and BMI %tile; bold denotes statistical significance, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3
Standardized total effects, indirect effects, and direct effects for both adolescent physical activity and mental health mediator models.

Dependent variable	Independent variable	Total Effect (95% CI[a])	Physical activity Indirect effect (95% CI[a])	Direct Effect (95% CI[a])	RIT[b]
Mental health	School connectedness	**0.17*** (0.15–0.20)**	**0.017*** (0.010–0.022)**	**0.15*** (0.13–0.17)**	0.10
	Virtual connectedness	**0.03*** (0.01–0.05)**	**0.007*** (0.004–0.010)**	**0.02* (0.00–0.04)**	0.24
	Parental emotional abuse	**−0.44*** (−0.46–-0.41)**	**−0.004** (−0.006–-0.001)**	**−0.43*** (−0.45–-0.41)**	0.01
	General parental monitoring	−0.01 (−0.03–0.01)	−0.000 (−0.003–0.001)	−0.01 (−0.03–0.01)	0.00
Dependent variable	Independent variable	Total Effect (95% CI[a])	Mental health Indirect effect (95% CI[a])	Direct Effect (95% CI[a])	RIT[b]
Adolescent physical activity	School connectedness	**0.19*** (0.16–0.22)**	**0.020*** (0.013–0.027)**	**0.17*** (0.14–0.20)**	0.11
	Virtual connectedness	**0.09*** (0.06–0.12)**	**0.003* (0.001–0.006)**	**0.08*** (0.06–0.11)**	0.03
	Parental emotional abuse	**−0.02** (−0.04–0.00)**	**−0.050*** (−0.065–-0.031)**	0.03 (0.00–0.06)	2.50
	General parental monitoring	0.01 (−0.12–0.14)	**−0.006*** (−0.009–-0.003)**	0.02 (−0.11–0.05)	0.60

Note: Effects are standardized; [a] 95% CI stands for 95% Confidence Interval; [b] RIT stands for ratio of indirect to total effect; bold denotes statistical significance, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

displayed within Fig. 2 and showed acceptable fit (RMSEA = 0.062, 90% CI:0.059–0.065; CFI = 0.92, TLI = 0.90). When sampling weights were applied to the model, 38% of the variance in PA was explained (R (Kumar et al., 2015) = 0.38). The SEM using the sample of females was displayed within Supplemental Fig. S3 and for the sample of males within Supplemental Fig. S4.

Direct Effects. Direct effects are presented within Table 3 and Fig. 2. School connectedness (β = 0.17, $p < 0.001$) and virtual connectedness (β = 0.08, $p < 0.001$) positively associated with PA. Sex-specific direct effects are reported in Supplemental Table S2 and Supplemental Figs. S3 and S4.

Indirect Effects. The standardized indirect effects are presented within Table 3. Significant indirect effects were observed for school connectedness (IE = 0.020, $p < 0.001$), virtual connectedness (IE =

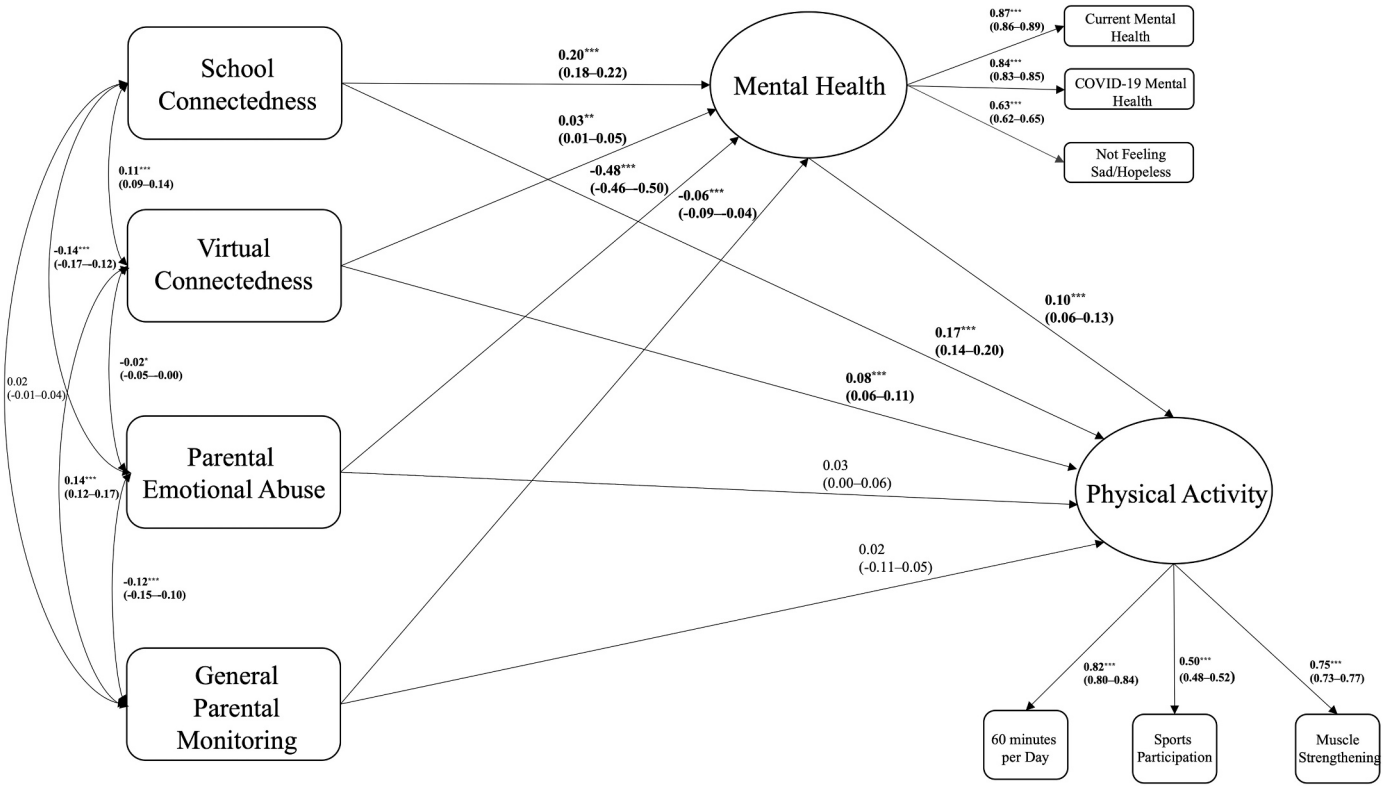

Fig. 2. Structural equation model using the total sample showing the direct effects and mediating effect of mental health on the associations of school and virtual connectedness, parental emotional abuse, and general parental monitoring with adolescent physical activity.
Note: Rectangles are observed variables and ovals are latent variables; curved lines are covariances and straight lines are direct paths; all coefficients were standardized; model was adjusted for age, sex, racial/ethnic minority status, and BMI %tile; bold denotes statistical significance, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

0.003, $p = 0.007$), parental emotional abuse (IE = -0.050, $p < 0.001$), and general parental monitoring (IE = -0.006, $p < 0.001$). Mediation effect sizes were relatively small for school connectedness and virtual connectedness as 11% and 3% of the total effect on PA was mediated through mental health, respectively. Mediation effect sizes were relatively large for parental emotional abuse and general parental monitoring as 250% and 60% of the total effect on PA was mediated though mental health, respectively. Of note was that mental health was found to have a suppressive effect on the relationship between parental emotional abuse and PA. This suggests that the negative mediated effect of mental health negated the positive direct association between parental emotional abuse and PA, thus lowering the magnitude of the total effect. Sex-specific indirect effects are reported in Supplemental Table S2.

4. Discussion

The purpose of this study was to examine the associations of connectedness and parental behaviors with adolescent PA and mental health during COVID-19. The results indicated that higher levels of both school and virtual connectedness associated with higher PA and better mental health and that these associations were partially mediated through better mental health and higher PA, respectively. The results also indicated that higher levels of parental emotional abuse directly associated with poorer mental health and that higher levels of parental emotional abuse associated with lower PA through the mediated effect of poorer mental health. A discussion of the findings and practical implications are provided further.

A salient finding was that higher levels of school connectedness both directly and indirectly associated with higher PA and better mental health. Previous work has shown the benefits of social connectedness with health behaviors in adolescents (Mendonça et al., 2014; Eather et al., 2013). In the current study, school connectedness also associated with better mental health during COVID-19, partially through a mediating effect of higher PA. Although the PA and mental health mediator models yielded similar model fit indices supporting a potential bidirectional association between the constructs, the PA mediator model showed slightly better fit. This finding supports previous work showing that higher PA can lead to better mental health (Lubans et al., 2016a), and supports a behavioral mechanism by which school connectedness can lead to better mental health. It was also observed that school connectedness tended to more strongly directly associate with both PA and mental health compared to virtual connectedness. A potential reason for this is that excessive screen use may have diluted the positive effect of virtual connectedness, given that screen use has been shown to associate with poorer mental health in youth (Twenge and Campbell, 2018; Li et al., 2021).

Compared to the direct effects, the indirect (mediating) effects were relatively weak for both connectedness variables. A potential reason for the relative weak mediating effects is that psychosocial variables such as self-efficacy or enjoyment may be stronger mediators, as seen in other work (Ren et al., 2020; Budd et al., 2018). Additionally, these associations were examined during a COVID-19 climate when both PA and mental health were lower compared to non-pandemic climates. Lower PA and poorer mental health may have weakened the association between the variables and ultimately lowered the magnitude of any mediating effects between connectedness and a respective outcome.

Because the COVID-19 pandemic caused changes in work schedules and elevated stress in adults, parents may have altered how they interacted with their children, possibly increasing abusive behaviors (Brown et al., 2020). The current study showed that there was a relatively strong direct association between higher levels of parental emotional abuse and poorer adolescent mental health. The association between parental emotional abuse and mental health was the strongest association

observed in both SEM analyses. Despite the strong association with the mental health outcome, there were no significant direct effects observed between either parental emotional abuse or general parental monitoring with PA. Only parental emotional abuse showed a significant total effect with PA that was mediated by mental health, suggesting that higher levels of parental emotional abuse associated with poorer mental health that subsequently associated with lower PA. This finding highlights that parents' relationships with their children are crucial for healthy child development (McAdams et al., 2017; Pérez-Fuentes et al., 2019; Pinto Pereira et al., 2014), and that abusive behaviors from parents may lead to worse mental health and lower levels of PA in adolescents.

There are several practical implications of this study that may help researchers and practitioners promote PA and mental in adolescents restricted to predominantly virtual settings. First, cultivating connectedness within the school environment is recommended to facilitate both higher PA and good mental health. Programs utilizing the Whole School, Whole Community, Whole Child models such as Comprehensive School Physical Activity Programs may be particularly useful for both facilitating school connectedness and improving PA by providing opportunities for student, teacher and staff interaction during different segments of the school day (Brusseau and Burns, 2020; Webster et al., 2020). Additionally, creating a positive school environment by improving school appearance, organization, resources, comfort, and social dimensions (e.g., equitable treatment of students and lowering the degree of social comparisons) may facilitate better perceptions of school connectedness (Kutsyuruba and Klinger, 2015; Wong et al., 2014; Dimitrova et al., 2020). During predominantly virtual settings, sharing PA experiences virtually can create a positive, healthy, and energetic personal image, gain recognition from others, and establish new interpersonal relationships (Zuo et al., 2021), which can subsequently positively affect mental health. Multiplayer options have previously been shown to be preferred in adolescents during exergaming and virtual reality (Farič et al., 2019), and co-participating in PA with family, friends, or peers using applications and smart devices may increase virtual connectedness. Indeed, combining school-based and virtual-based social support interventions has been previously shown to improve PA and may have great utility in hybrid learning environments (Rose et al., 2017; Lubans et al., 2016b). Additionally, although parent's physical and mental health are also compromised during pandemics, they should be cognizant that the negative effect of emotional abuse on their child may extend beyond mental health but also to behaviors affecting physical health. Parental support of PA through co-engagement, transportation, purchasing sports equipment, and watching of events have all correlated with higher child PA in prior work and should be provided during both pandemic and non-pandemic climates (Beets et al., 2010; Doggui et al., 2021; Huffman et al., 2018). Interestingly, males from the current study's sample tended to have stronger direct associations between parental monitoring and PA. Although this association was relatively weak, there could be conceptual commonality between parental monitoring and watching/supervision of sports/activity events that associate with higher adolescent PA among males. Previous work has shown that parental watching is preferred by males as a mode of providing non-verbal form of approval or support for PA (Beets et al., 2010; Wright et al., 2010). Conversely, previous work has shown that verbal encouragement correlated stronger with PA behavior in females (Mendonça and Júnior, 2015; Dozier et al., 2020). These parental behaviors may be useful to promote PA during pandemic and non-pandemic climates.

Limitations to this study included the secondary analysis of a cross-sectional data set that precludes making causal inferences. Variables examined in this study were collected using self-report methods; therefore, there was a risk of social desirability bias. The virtual connectedness item specifically asked about time spent with others and may not entirely reflect connectedness. The sports team participation item only asked about participation in team sports; therefore, it is unknown if individual sports or different types of team sports would have had a differential influence on mental health. Data were also collected during COVID-19; thus, the results are questionable if they are to be generalized to behaviors during a non-pandemic climate. Mental health is a broad construct, and it is unclear what dimension of mental health contributed to the adolescents' responses. Finally, although connectedness and parental behaviors are variables that may have been adversely affected by COVID-19, there are many other determinants of both PA and mental health that were not included within ABES, making the relative importance of the observed variables unclear for adolescent PA and mental health promotion.

5. Conclusion

Higher levels of school and virtual connectedness associated with higher PA and better mental health during COVID-19. School connectedness had stronger direct associations with PA than virtual connectedness and higher PA partially mediated the association between connectedness variables and better mental health. Overall, both school and virtual connectedness associated more strongly with higher PA than parental behaviors during the COVID-19 pandemic, but poorer mental health mediated the associations between parental emotional abuse and lower PA. These results highlight the importance of connectedness and parental behaviors to sustain high levels of PA and good mental health during pandemics and possible implications for predominantly virtual learning environments. Cultivating social connection, especially in school environments, and minimizing parental emotional abuse during pandemics may help facilitate higher PA and good mental health in adolescents.

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CRediT authorship contribution statement

Ryan D. Burns: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Supervision. **Jason A. Armstrong:** Conceptualization, Investigation, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare no real or perceived competing financial interests or relationships that influenced the work reported in this manuscript.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2022.107299.

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