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Connection to Nature Boosts Adolescents' Mental Well-Being during the COVID-19 Pandemic

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Abstract: Growing evidence suggests that connection to nature may be linked to mental health and well-being. Behavioral changes brought about by the COVID-19 pandemic could negatively affect adolescents' connection to nature, subsequently impacting health and well-being. We explored the relationship between connection to nature and well-being before and during the pandemic through a nationally representative survey of adolescents across the United States ($n = 624$) between April and June 2020. Survey items focused on connection to nature, mental well-being, and participation in outdoor activities before and during the pandemic. Paired-sample t -tests revealed declines in connection to nature, mental well-being, and participation in outdoor activities during the pandemic. Multiple linear regression analyses examining connection to nature's mediating role between outdoor activity participation and mental well-being indicated that connection to nature fueled higher levels of mental well-being at both time intervals. Z scores comparing connection to nature's mediating role between outdoor activity participation and mental well-being between time intervals indicate that during the pandemic, the direct effect of outdoor activities on mental well-being increased, generating a greater impact than before the pandemic. This study illustrates how the health and well-being benefits associated with adolescents' outdoor activities are reinforced when those activities also foster a stronger connection to nature.

Keywords: connection to nature; COVID-19; adolescence; outdoor activity participation; mental well-being; multiple linear regression; mediation analysis



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1. Introduction

The COVID-19 pandemic has had a profound impact on people around the world. In addition to the range of physical health complications associated with contracting the coronavirus, the pandemic has also impacted mental well-being by changing daily routines and increasing stress and uncertainty [1–4]. This may be particularly true for adolescents [5], the group of youth who are 10–19 years old [6]. Because adolescents' daily routines have become increasingly organized and scheduled in recent years [7–9], disruptions to daily life may hold potential for high levels of pandemic-related stress. Such disruptions may have long-term impacts on adolescent development and well-being, as adolescence is a key developmental stage when activity patterns develop and solidify, setting trends that persist into adulthood [10–15]. Research exploring impacts associated with the pandemic show that adolescents increased their participation in sedentary activities [16] and decreased participation in outdoor activities, resulting in declines in their overall mental well-being [17]. Adolescence is also recognized as a life stage when individuals are more susceptible to the impacts of trauma and stress [18,19]. Increased stress during adolescence can predispose

individuals to greater susceptibility to stress later in life [19], potentially contributing to the development of stress-related health disorders [20]. Further exploration of these impacts may provide insights into how best to support adolescents during times of increased stress.

One important and understudied aspect of the pandemic is its impact on adolescents' connection to nature [21]. Defined as a cognitive, affective, and experiential relationship with nature, a connection to nature develops through regular contact with nature [22–24]. A strong connection to nature is linked to participation in more outdoor activities [22,23,25] and a commitment to environmental conservation [24,26–28]. Exposure to outdoor environments during childhood is recognized as a key antecedent to the development of a connection to nature [10,14,29], and there is evidence that once developed, connection to nature is relatively stable. For instance, research investigating fluctuations in adult attitudes towards appreciation for nature and environmental protection indicate such attitudes were stable over a span of more than two years [30]. In part, this may be because the link between nature-based activities and connection to nature is self-reinforcing. For example, participation in outdoor and nature-related activities contributes to the development of a connection to nature [22,23], which in turn serves as a motivator for continued time spent in nature [25,31,32]. Accordingly, developing a connection to nature through outdoor experiences early in life may have lifelong benefits [13].

Contact with nature has also been shown to enhance health and well-being [22,28,33]. Well-being benefits linked to contact with nature include improved physical health [34–37]; however, many findings relate to improved mental well-being [33,38–43]. Mental well-being benefits linked to contact with nature, such as restoration from stress [44,45] and increased resilience to negative health outcomes associated with stress [46,47], are of great interest [36], particularly during the pandemic [17,21,48]. While individuals can obtain these well-being benefits from exposure to nature without a connection to nature [49–51], previous research points to the development of a psychological connection to nature as important for realizing the full potential of contact with nature [22,29,52]. Research exploring connection to nature's role in driving improved health and well-being highlights its potential for improving mental health [13,21,53,54]. However, the specific impacts of connection to nature on mental health and well-being remain understudied [55]. Emergent research exploring the potential for changes in young children's connection to nature during the pandemic found a majority of children in their UK sample reported an increased connection to nature, which was associated with improved well-being as evidenced by reduced behavioral and emotional problems [21].

Fluctuations in connection to nature during the COVID-19 pandemic may provide insights into the stability of adolescent connection to nature during a time when participation in outdoor and nature-related activities has declined [16,17]. Investigating impacts to connection to nature also allows for further exploration of the role that connection to nature plays in enhancing the mental well-being benefits associated with nature contact, providing insights into connection to nature's capacity to improve adolescents' resilience during the pandemic. Previous studies investigating the relationship between nature contact, connection to nature, and mental well-being demonstrate that connection to nature mediates the relationship between nature contact and improved mental well-being [22,25,33]. Evaluating connection to nature's mediating role both before and during the pandemic provides a unique and novel approach to understanding the degree to which this mediating effect may fluctuate in predicting mental well-being during the pandemic.

While the pandemic is likely impacting all adolescent's contact with nature, connection to nature, and mental well-being to some degree, its effects may be more pronounced for certain demographic groups [56]. Characterizing these effects across demographic groups (gender, age, race, household income, community type, and region of the country) is critical to understanding inequities in access to nature and how such inequities may impact mental well-being. Friedman et al. (2021) found that pandemic-related changes in young children's connection to nature and well-being was directly associated with socio-economic status (SES), highlighting potential barriers to the development and maintenance of a connection

to nature for individuals of lower SES. Research exploring trends in outdoor activity patterns in the United States before the pandemic showed that girls, Black youth, and older adolescents spent less time outside and more time on electronic devices [57], underscoring trends that may be exacerbated during the pandemic. Additionally, adolescents in urban environments are at an increased risk of contracting COVID-19, and there is less nearby nature available compared to more rural environments [48,58]. The greater number of people seeking nearby nature in urban areas may further limit access to outdoor leisure opportunities due to social distancing policies, park closures, and citywide lockdowns in areas with high infection rates [59,60].

This study addresses gaps in our understanding of the impacts of the COVID-19 pandemic on adolescent connection to nature by testing the following hypotheses. First, in line with previous studies [17], (H1) we hypothesized that adolescent outdoor activity participation and mental well-being declined during the pandemic, along with connection to nature. Next, (H2) we hypothesized that adolescent declines in mental well-being would be predicted by declines in connection to nature. Because a connection to nature may enhance mental well-being benefits associated with outdoor and nature-related activity participation [22], (H3) we also hypothesized that connection to nature mediates the relationship between participation in outdoor activities and mental well-being during the COVID-19 pandemic so that higher levels of connection to nature mitigate decreases in mental well-being. Additionally, as connection to nature is thought to be a relatively stable trait that supports well-being, (H4) we hypothesized that connection to nature will play a more important role in driving improved mental well-being during the COVID-19 pandemic. In addition to addressing these hypotheses, we also explored differences in connection to nature across gender, age, race, household income, and community type as they represent demographic variables of interest that may highlight inequities in connection to nature.

2. Materials and Methods

2.1. Data Collection

Our study utilized a stratified convenience sampling approach using an online Qualtrics XM panel. A Qualtrics panel was used as it allowed for demographic quotas and, compared to other online panel providers, Qualtrics samples came closest to a national probability sample in terms of demographic representativeness [61]. Qualtrics also allows for rapid data collection—an essential need for our COVID-19-oriented study—as it compiles panel respondents from a range of other panel recruiting firms [61]. The Qualtrics panel provided for this study pulled from a national pool (50 states, Puerto Rico) with demographic quotas for gender (male, female, non-binary and other), race (White, Black, Hispanic, Asian/Pacific Islander, Native American, other), and community type (rural area, small city or town, suburb near a large city, and large city) representative of the 2019 U.S. census data. Parents and their children between the ages of 10 and 18 years old were included in the sample for this study. This age range was selected because adolescents are particularly vulnerable to stress associated with global health crises [62,63], as well as being old enough to understand the survey.

Data collection started on 30 April 2020, and ended on 15 June 2020. Data collection took place through separate but linked parent and child survey instruments that were designed and administered using the Qualtrics XM platform. Surveys were administered to qualifying parents who completed the parent version of the survey before being asked to hand their device to their qualifying child to complete the adolescent version of the survey. Before starting the survey, parents were given an online downloadable consent form acknowledging their consent to participate and their consent for their child to participate. Adolescents were also given an age-appropriate assent form acknowledging their consent to participate.

2.2. Survey Instrument

The adolescent questionnaire contained 30 self-reported items covering three main constructs, all assessed before (via participant recall) and during the COVID-19 pandemic: participation in nature experience and outdoor play activities, connection to nature, and mental well-being. Adolescents were also asked demographic questions including their gender, race, and age. The parent questionnaire included annual household income, community type, and state of residence.

Nature experience and outdoor play activity items were aimed at determining frequency of engagement in specific nature experience and outdoor play activities. Adolescents were asked “How often did you participate in the following activities this time last year and now, after you have been asked to practice social distancing because of the coronavirus outbreak?”. Responses for both the retrospective and current version of the items used a three-point Likert scale including “Never”, “Every now and then”, and “Often”. A shortened response scale was used for this construct as our research questions are aimed at determining directional trends instead of specific measures of intensity or extremity [64]. Seven nature experience activities focused on activities occurring in more natural settings (paddling, hunting, camping, fishing, hiking, wildlife viewing, and playing in the woods) were included, as well as five outdoor play activities that could be carried out in less natural outdoor environments (bicycling outside, playing sports outside, going for walks or runs outside, swimming outside, and skating outside), resulting in a total of 12 different activities. Activities were selected based on retrospective qualitative interviews carried out with young adults (18–35 years old) during the summer of 2019. Interviews were focused on childhood experiences that shaped respondent’s connection to nature, as well as previous studies about adolescent participation in outdoor and physical fitness activities [65].

Connection to nature was assessed using a modified version of the six-item nature relatedness scale, which incorporates items measuring the degree of nature relatedness to ‘self’ and ‘experience’ [57,66]. Although a number of scales have been developed to measure constructs such as connectedness to nature [23], connectivity with nature [67], and environmental identity [68], the six-item nature relatedness scale was selected for this study due to its brevity, acceptability for use with youth, and its previous applications in understanding differences in individuals’ connection to nature and subjective well-being [24,42,66,69]. We made two additional modifications to the scale. First, as we were interested in connection to nature before and during COVID-19, we modified the question stem to measure respondents’ connection to nature prior to being asked to practice social distancing as well as after: “How much did you disagree or agree with the following statements, both before and after you were asked to practice social distancing because of the coronavirus outbreak?” Lastly, to reduce the burden on respondents, we modified the response items to be three-point Likert scales containing the responses “disagree”, “neither/neutral”, and “agree”.

Mental well-being was measured using a modified four-item version of the World Health Organization’s (WHO) five-item subjective health and well-being index [70–72], which has been utilized internationally as a measure of the subjective well-being (SWB) of both children and adults [71]. Often described as a measure of happiness, the WHO SWB index represents a unidimensional measure of an individual’s mental health with high predictive validity [71]. While measures of SWB might be impacted by the momentary mood of a respondent at the time of their response, previous studies highlight that the use of a multi-item scale is less susceptible to such distortion [73,74]. Measures of recalled mood and emotions are fairly stable and reliable over periods of time ranging from 2 weeks to 3 months [74,75], which was the approximate time frame required for adolescents to recall their pre-pandemic SWB in our study. Although acute events experienced by individuals may impact reported SWB, these individual events do not impact inferences drawn from the overall sample unless they are experienced systematically by relatively large numbers of respondents. Three modifications were made to the scale. First, as we were interested in

SWB before and during COVID-19, we modified the question stem to assess respondents' health before being asked to practice social distancing as well as after: "How did you feel both before and after you were asked to practice social distancing because of the coronavirus outbreak?" Additionally, as this survey was aimed at adolescents, we omitted one item and modified the wording on the remaining items to be appropriate for younger audiences. Lastly, to reduce the burden on respondents, we modified the response items to be four-point Likert scales containing the responses "at no time", "some of the time", "most of the time", and "all of the time".

2.3. Data Preparation and Scale Development

Listwise deletion was used to remove 257 straight-line (answering the same for all questions) or nonsensical text (related to open text questions) responses, resulting in a final sample of 624 youth. Parent and child surveys were linked using Qualtrics embedded dyad codes. When a survey response was removed from the sample, the corresponding parent or child survey was also removed. Survey item responses were coded for statistical analysis (See Table A1 for response item coding). Regions of the country were determined by organizing state of residence data into geographic regions delineated by the U.S. Census Bureau, with Alaska and Hawaii being added to the West region and Puerto Rico being added to the South region, i.e., South: AL, AR, DC, DE, FL, GA, KY, LA, MD, MS, NC, OK, PR, SC, TN, TX, VA, WV; Northeast: CT, ME, MA, NH, NJ, NY, PA, RI, VT; Midwest: IL, IN, IA, KS, MI, MN, MO, NE, ND, OH, SD, WI; West: AK, AZ, CA, CO, HI, ID, MT, NV, NM, OR, UT, WA, WY [76]. The cleaned dataset was analyzed with Stata 14.1.

We selected nature experience and outdoor play activities for each grouping a priori and measured the validity of these groupings using exploratory factor analysis (principal component factor analysis, or PCF) with an orthogonal varimax rotation to determine the dimensionality and internal consistency of all individual pre COVID-19 activities (Table 1). The analysis supported a two-factor structure explaining 56% of the variance. These factors were 'nature experience activities' (7 items, $\alpha = 0.86$) and 'outdoor play activities' (5 items, $\alpha = 0.78$). All activity groupings showed acceptable convergence (all activities loaded with eigenvalues > 1.0). Composite scores were created for each activity grouping by averaging responses. PCF was also used to determine the dimensionality and internal consistency of our modified before COVID-19 six-item nature relatedness scale (Table 2). The analysis supported a unidimensional factor structure explaining 63% of the variance. The scale also demonstrated high internal consistency ($\alpha = 0.88$), and acceptable convergence (all items loaded with eigenvalues > 1.0). All six items were averaged to create before and during COVID-19 connection to nature composite scores. We again used PCF to assess the dimensionality and internal consistency of our modified before COVID-19 four-item WHO SWB scale (Table 3). The analysis supported a unidimensional factor structure that explained 70% of the variance. The scale also demonstrated high internal consistency ($\alpha = 0.85$) and acceptable convergence (all items loaded with eigenvalues > 1.0). All four items were averaged to create before and during COVID-19 mental well-being composite scores.

Table 1. Principal component factor analysis of adolescent nature experience and outdoor play activity participation items before COVID-19.

Items	Activity Means	Nature Experience Factor Loadings	Outdoor Play Factor Loadings
Nature experience activities before COVID-19	0.68		
Paddling (canoeing, kayaking)	0.51	0.78	0.21
Hunting	0.36	0.78	0.03
Camping	0.71	0.74	0.22
Fishing	0.66	0.73	0.17
Hiking	0.82	0.67	0.29
Wildlife viewing	0.81	0.69	0.25

Table 1. *Cont.*

Items	Activity Means	Nature Experience Factor Loadings	Outdoor Play Factor Loadings
Playing in the woods (building forts, playing games in the woods)	0.88	0.54 *	0.51 *
Outdoor play activities before COVID-19	1.2		
Bicycling outside	1.22	0.22	0.76
Playing sports outside	1.42	0.07	0.70
Going for walks or runs outside	1.36	0.17	0.75
Swimming outside	1.16	0.16	0.67
Skating (skateboard, rollerblades, scooter)	0.84	0.42	0.61
Eigenvalues		5.23	1.52
% of variance explained		31.5%	24.8%
Cronbach's alpha		0.86	0.78

Response scale items included: never = 0, every now and then = 1, often = 2. * Cross-loaded items.

Table 2. Principal component factor analysis of adolescent nature relatedness items before COVID-19.

Items	Nature Relatedness Means	Nature Relatedness Factor Loadings
Nature relatedness scale before COVID-19	0.38	
My relationship to nature is an important part of who I am.	0.24	0.85
I feel very connected to all living things and the Earth.	0.28	0.85
My favorite places are outside in nature.	0.36	0.82
I think about how what I do affects the Earth.	0.31	0.79
I spend time outdoors whenever I can.	0.45	0.77
I enjoy being outside in nature.	0.65	0.71
Eigenvalue		3.81
% of variance explained		63%
Cronbach's alpha		0.88

Response scale items included: Disagree = −1, Neither/neutral = 0, Agree = 1.

Table 3. Principal component factor analysis for adolescent subjective well-being items before COVID-19.

Items	Subjective Well-Being Means	Subjective Well-Being Factor Loadings
SWB scale before COVID-19	2.21	
Cheerful and in good spirits	2.25	0.87
Calm and relaxed	2.13	0.84
Active and full of energy	2.60	0.82
Interested and curious about the world around me	2.19	0.80
Eigenvalue		2.78
% of variance explained		70%
Cronbach's alpha		0.85

Response scale items included: at no time = 0, some of the time = 1, most of the time = 2, all of the time = 3.

2.4. Hypothesis Testing

To evaluate our first hypothesis, we ran paired-sample *t*-tests to explore differences in nature experience and outdoor play activity groups, connection to nature, and mental well-being before and during COVID-19. We used Bonferroni correction to address family-wise error rates associated with conducting multiple tests of significance [77].

To address our second and third hypotheses, we used stepwise multiple linear regression to conduct mediation analyses using the causal steps approach [78]. We created a

total of four mediation models to determine whether connection to nature mediated the relationship between participation in activity groups and mental well-being both before and during COVID-19. Each mediation model was conducted in three steps: step 1) testing in sequence the relationship between activity participation and its relationship with connection to nature scores (Figure 1, path A); step 2) testing the relationship between activity participation and mental well-being (Figure 1, path C); and step 3) testing the relationship between activity participation and mental well-being, controlling for connection to nature (Figure 1, path B and C'). Mediation models one and two explored the degree to which connection to nature scores mediated the relationship between participation in nature experience activities and mental well-being scores both before (model 1; Table A2) and during (model 2; Table A3) the pandemic. Mediation models three and four explored the degree to which connection to nature scores mediated the relationship between outdoor play activities and mental well-being scores before (model 3; Table A4) and during (model 4; Table A5) the pandemic. Step 3 measuring paths C and C' in models 2 and 4 addressed our second hypothesis, while the set of analyses as a whole addressed our third hypothesis. In addition to running stepwise multiple linear regressions to test H3, we also used 5000 bootstrapped repetitions of our sample to generate an empirically derived representation of the sampling distribution of the indirect effect (path AB) for each model, increasing the power and accuracy of our inferences [79–81]. The indirect effect (path AB), sometimes referred to as the mediating effect, provides a measure of the degree to which a relationship is mediated and can be calculated by multiplying path A and path B, or by subtracting the total effect (path C) from the direct effect (path C') [81].

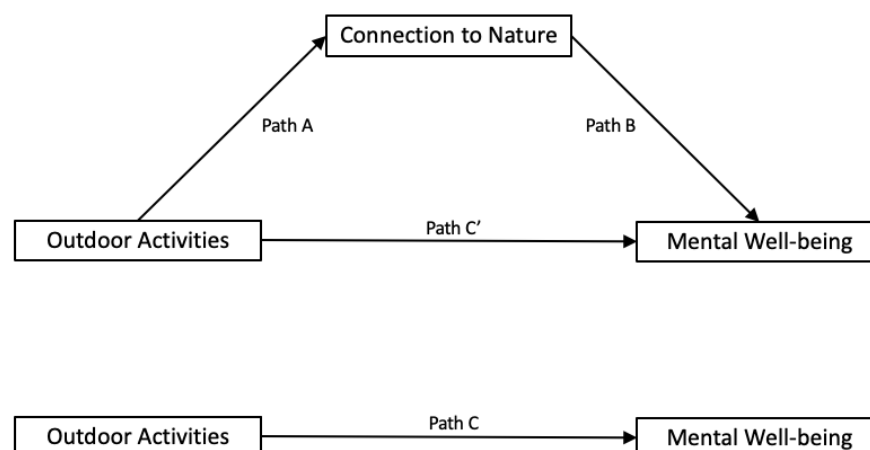


Figure 1. Conceptual mediation model illustrating the causal steps approach to mediation used in this study.

We controlled for gender (with males as the reference group), race (with white as the reference group), age, household income (with households making less than \$30,000 as the reference group), community type (with rural areas as the reference group), and geographic region (with South as the reference group) in each model. These reference groups were selected as they represent the groups with the highest sample size in their respective categories with the exception of the variables household income and community type. Households' making less than \$30,000 was selected as a reference group for household income because it was the base group for the category. Rural areas were selected as the reference group for community type as they represent the category that likely offers the greatest degree of nature contact for residents.

To address our fourth hypothesis, we calculated differences between before and during COVID-19 mediation analyses for each activity group by comparing mediation pathway coefficients using Z tests [82]. The formula $Z = \frac{B_1 - B_2}{\sqrt{(SEB_1)^2 + (SEB_2)^2}}$ was used with (B_1) representing the before COVID-19 unstandardized path coefficient and (B_2) representing

the during COVID-19 unstandardized path coefficient and SEB representing the standard error of the unstandardized path coefficient. This allowed us to compare changes for each pathway between before and during the pandemic mediation analyses. The unstandardized coefficients for path A, B, C (total effect), C' (direct effect), and AB (indirect effect) from before the pandemic (model 1 and 3) were compared to the corresponding coefficients from during the pandemic (model 2 and 4). Finally, to see if differences in connection to nature varied across age, race, gender, annual household income, and community type, we also conducted a series of ANOVA tests with Bonferroni adjustments.

3. Results

3.1. Sample

Our sample ($n = 624$) was comprised of an equal gender ratio, was 60% White, and included adolescents ranging from 10 to 18 years old with relatively equal splits across ages ($M = 13.85$, $SD = 2.54$). Household income was normally distributed, and the Southern region of the United States had the greatest number of respondents (40%), with suburbs of large cities being the most common community type (37%) (Table 4).

Table 4. Sample demographics ($N = 624$).

Variable		N	%
Gender	Male	306	49.0%
	Female	314	50.3%
	Non-binary	3	0.5%
Race	White	373	59.8%
	Black	71	11.4%
	Hispanic	78	12.5%
	Asian/Pacific Islander	42	6.7%
	Native American	6	1.0%
	Other	6	1.0%
	Two or more races	45	7.2%
Age	10 years	78	12.5%
	11 years	70	11.2%
	12 years	63	10.1%
	13 years	79	12.7%
	14 years	77	12.3%
	15 years	53	8.5%
	16 years	81	13.0%
	17 years	76	12.2%
	18 years	47	7.5%
Income	Less than \$30,000	60	9.6%
	\$30,000–\$49,999	87	13.9%
	\$50,000–\$74,999	114	18.3%
	\$75,000–\$99,999	114	18.3%
	\$100,000–\$149,999	136	21.8%
	\$150,000 or more	94	15.1%
Community	Rural area	126	20.2%
	Small city or town	126	20.2%
	Suburb near a large city	228	36.5%
	Large city	144	23.1%
Region	South	252	40.4%
	West	136	21.8%
	Midwest	106	17.0%
	Northeast	130	20.8%

The category *prefer not to answer* is not included in this table for gender, race, and income, resulting in the % for those categories not adding up to 100.

3.2. Activity Participation, Connection to Nature, and Mental Well-Being

We found support for H1, as adolescents reported a 41% decline in nature experience activities ($t(623) = 13.666, p < 0.001$; Figure 2, Table 5) and a 43% decline in outdoor play activities ($t(623) = 18.333, p < 0.001$; Figure 2, Table 5) during the pandemic. Similarly, we observed a 45% decline in connection to nature scores ($t(623) = 7.253, p < 0.001$; Figure 2, Table 5) and a 21% decline in mental well-being scores ($t(623) = 14.870, p < 0.001$; Figure 2, Table 5) during the pandemic. Declines in nature experience activities were reported by 55% of adolescents, with 11% reporting increases; declines in outdoor play activities were reported by 64% of adolescents, with 12% reporting increases. Declines in connection to nature were reported by 34% of adolescents, with 17% reporting increases. Declines in mental well-being were reported by 52% of adolescents, with only 10% reporting increases.

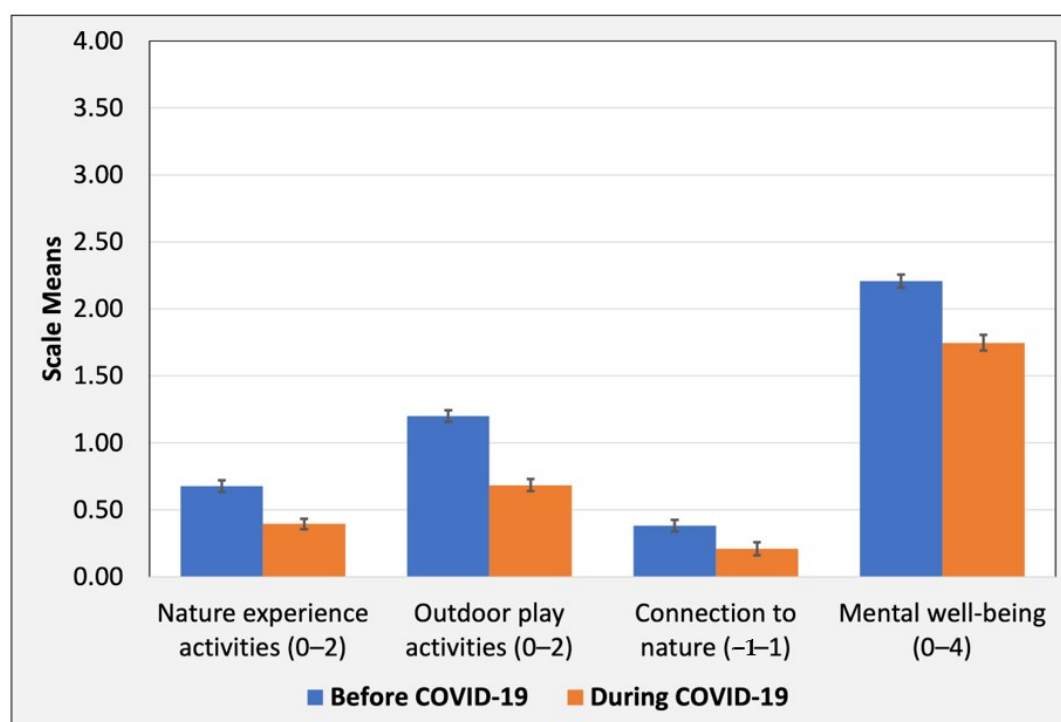


Figure 2. Adolescent participation in different types of activities, connection to nature, and mental well-being before and during the COVID-19 pandemic (error bars represent 95% confidence intervals).

Table 5. COVID-19-related changes in adolescent nature experience and outdoor play activity groups, connection to nature, and mental well-being.

Variable	Before COVID-19		During COVID-19		Paired <i>t</i> Test	
	Mean	SD	Mean	SD	<i>t</i>	<i>p</i>
Nature experience activities (range 0–2)	0.68	0.55	0.40	0.50	13.666	<0.001
Outdoor play activities (range 0–2)	1.20	0.55	0.68	0.57	18.333	<0.001
Connection to nature (range –1–1)	0.38	0.56	0.21	0.61	7.253	<0.001
Mental well-being (range 0–4)	2.21	0.62	1.75	0.75	14.870	<0.001

Response scale items for nature experience activities and outdoor play activities: never = 0, every now and then = 1, often = 2. Response items for connection to nature: disagree = 0, neither/neutral = 1, agree = 2. Response items for mental well-being: at no time = 0, some of the time = 1, most of the time = 2, all of the time = 3. All *t*-tests were significant after Bonferroni correction to family-wise error rates ($p = 0.007$) [77].

3.3. Mediation Analyses

We found support for H2, as mediation analyses indicate direct relationships between during COVID-19 declines in mental well-being and declines in connection to nature when

controlling for participation in either nature experience ($B = 0.41, p < 0.001$; Table A3) or outdoor play activities ($B = 0.33, p < 0.001$; Table A5).

We found support for H3, as both before and during COVID-19, connection to nature mediated the relationship between participation in both activity groups and mental well-being. Before the pandemic, connection to nature had the greatest impact on mental well-being when coupled with participation in nature experience activities, accounting for 70% of the total effect on mental well-being. Connection to nature played a reduced role in driving improved mental well-being for individuals participating in outdoor play activities before the pandemic, accounting for 32% of the total effect on mental well-being. Before COVID-19, there was no direct relationship between participation in nature experience activities and mental well-being scores when controlling for connection to nature ($B = 0.07, p = 0.153$; Figure 3, Table A2), indicating that connection to nature fully mediated the relationship between nature experience activities and mental well-being scores before the pandemic. There was a direct relationship between participation in outdoor play activities and mental well-being scores when controlling for connection to nature ($B = 0.26, p \leq 0.001$; Figure 4, Table A4), indicating that connection to nature partially mediated the relationship between outdoor play activities and mental well-being scores before the pandemic.

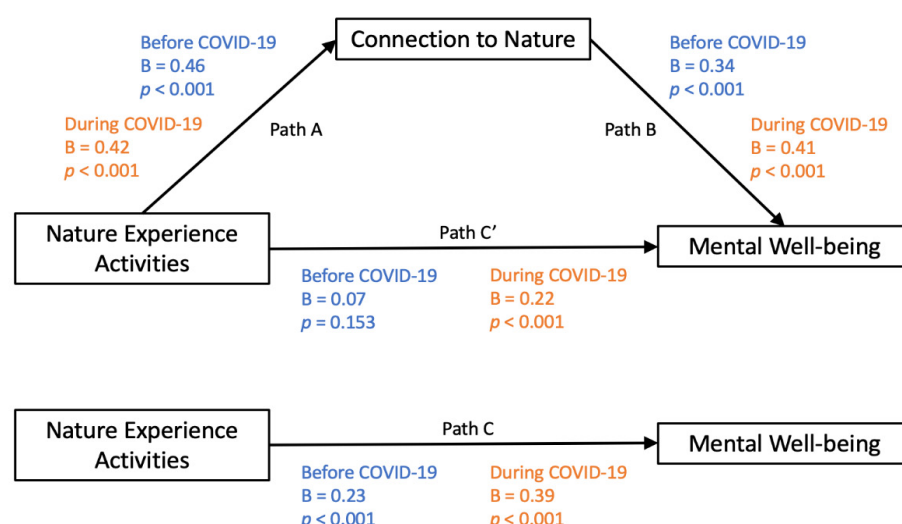


Figure 3. Connection to nature as a mediator between nature experience activities and mental well-being before and during COVID-19.

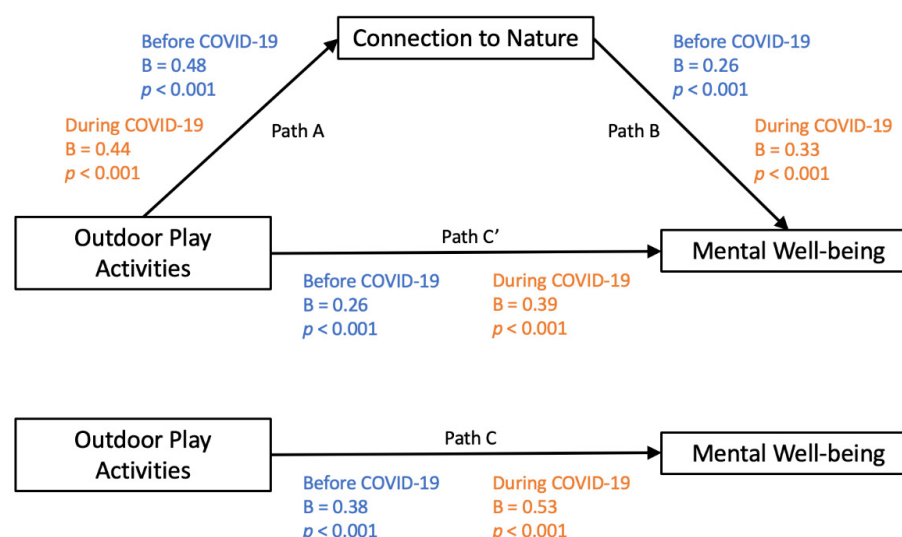


Figure 4. Connection to nature as a mediator between outdoor play activities and mental well-being before and during COVID-19.

During COVID-19, connection to nature had the greatest impact on mental well-being when coupled with participation in nature experience activities, accounting for 45% of the total effect on mental well-being. Connection to nature played a reduced role in driving improved mental well-being for individuals participating in outdoor play activities, accounting for 27% of the total effect on mental well-being during the pandemic. There was a direct relationship between participation in nature experience activities and mental well-being scores when controlling for connection to nature ($B = 0.22$, $p \leq 0.001$; Figure 3, Table A3), indicating connection to nature partially mediated the relationship between nature experience activities and mental well-being scores during the pandemic. There was also a direct relationship between participation in outdoor play activities and mental well-being scores when controlling for connection to nature ($B = 0.39$, $p \leq 0.001$; Figure 4, Table A5), indicating connection to nature partially mediated the relationship between outdoor play activities and mental well-being scores during the pandemic.

Bootstrapping results provide further support for H3, as none of the confidence intervals for the indirect effect in any of our models included zero, indicating a significant indirect effect for each model (model 1: indirect effect = 0.160, 95% CI = [0.115, 0.212], $z = 6.44$, $p \leq 0.0001$), (model 2: indirect effect = 0.175, 95% CI = [0.123, 0.230], $z = 6.30$, $p \leq 0.0001$), (model 3: indirect effect = 0.123, 95% CI = [0.077, 0.171], $z = 5.08$, $p \leq 0.0001$), (model 4: indirect effect = 0.145, 95% CI [0.093, 0.199], $z = 5.36$, $p \leq 0.0001$).

3.4. Comparing Mediation Coefficients before and during COVID-19

While there were differences between before and during COVID-19 mediation models, we did not find support for H4, as the indirect path between activity participation and mental well-being increased in both models but was not significantly different from before the pandemic in either the nature experience activities model (path B: $z = -0.417$, $p = 0.338$; Table 6; Figure 3) or outdoor play activities model (path B: $z = -0.611$, $p = 0.271$; Table 6; Figure 4). Significant differences between before and during COVID-19 mediation path coefficients were limited to the direct path between activity participation and mental well-being, which increased during COVID-19 in models for nature experience activities (path C': $z = -1.992$, $p = 0.023$; Table 6; Figure 3) and outdoor play activities (path C': $z = -2.063$, $p = 0.020$; Table 6; Figure 4). While there were no other significant differences between before and during COVID-19 mediation coefficients, we did detect trends across models for both activity groups. The relationship between activity participation and connection to nature decreased in both the nature experience activities model (path A: $z = 0.709$, $p = 0.239$; Table 6; Figure 3) and outdoor play activities model (path A: $z = 0.600$, $p = 0.274$; Table 6; Figure 4). Similarly, the relationship between connection to nature and mental well-being increased in both the nature experience activities model (path B: $z = -1.063$, $p = 0.144$; Table 6; Figure 3) and outdoor play activities model (path B: $z = -1.111$, $p = 0.133$; Table 6; Figure 4). The total effect (direct and indirect) between activity and mental well-being increased in both the nature experience activities model (path C: $z = -1.182$, $p = 0.119$; Table 6; Figure 3) and the outdoor play activities model (path C: $z = -1.282$, $p = 0.100$; Table 6; Figure 4).

3.5. Demographic Differences in Connection to Nature

We observed demographic differences in connection to nature in both the regression models and the exploratory series of one-way ANOVAs, with regression models highlighting differences in age and community type and ANOVAs demonstrating differences in community type. We did not detect differences in connection to nature associated with race, gender, annual household income, or region of the country before or during the pandemic.

3.5.1. Differences in Connection to Natures across Age

Regression results show that older adolescents had higher connection to nature scores than younger adolescents before the pandemic when controlling for participation in both nature experience ($B = 0.02$, $p = 0.041$; model 1; Table A2) and outdoor play activities ($B = 0.02$, $p = 0.002$; model 3; Table A4). Older adolescents also had higher connection

to nature scores during the pandemic when controlling for participation in outdoor play activities ($B = 0.02$, $p = 0.041$; model 4; Table A5).

Table 6. Differences in connection to nature mediation pathway coefficients before and during COVID-19.

Mediation Pathway	Beta before	Std. Error before	Beta during	Std. Error during	Z-Score	<i>p</i>
Nature experience activities						
Path A	0.46	0.04	0.42	0.05	0.709	0.239
Path B	0.34	0.05	0.41	0.05	−1.063	0.144
Path C' (direct effect)	0.07	0.05	0.22	0.06	−1.992	0.023 *
Path C (total effect)	0.23	0.04	0.39	0.06	−1.182	0.119
Path AB (indirect effect)	0.16	0.02	0.17	0.03	−0.417	0.338
Outdoor play activities						
Path A	0.48	0.04	0.44	0.04	0.600	0.274
Path B	0.26	0.05	0.33	0.05	−1.111	0.133
Path C' (direct effect)	0.26	0.05	0.39	0.05	−2.063	0.020 *
Path C (total effect)	0.38	0.04	0.53	0.05	−1.282	0.100
Path AB (indirect effect)	0.12	0.02	0.15	0.03	−0.611	0.271

Path A = activity participation to connection to nature, Path B = connection to nature to mental well-being, Path C' = activity participation to mental well-being controlling for connection to nature, Path C = activity participation to mental well-being, Path AB = Path C' subtracted from Path C. * $p \leq 0.05$.

3.5.2. Differences in Connection to Nature across Community Type

Differences in connection to nature associated with community type were evident in both the regression models and ANOVA. Regression results indicate that during the pandemic, adolescents living in small cities and towns had lower connection to nature scores than those living in rural areas when controlling for participation in both nature experience ($B = -0.18$, $p = 0.015$; model 2; Table A3) and outdoor play activities ($B = -0.20$, $p = 0.005$; model 4; Table A5), and during the pandemic, adolescents living in large cities had lower connection to nature scores than those in rural areas when controlling for participation in nature experience activities ($B = -0.15$, $p = 0.049$; model 2; Table A3). ANOVA results correspond with our regression models, with Bonferroni post hoc analysis showing that adolescents in rural communities had higher connection to nature scores than adolescents in small cities and towns ($B = 0.292$, $p \leq 0.001$) and large cities ($B = 0.29$, $p \leq 0.001$). The ANOVA post hoc analysis also showed that adolescents' living in suburbs of large cities had higher connection to nature scores than adolescents in small cities and towns ($B = 0.23$, $p = 0.003$) and large cities ($B = 0.23$, $p = 0.003$).

3.5.3. Differences in Mental Well-Being across Community Type during the Pandemic

Our regression models show that during the pandemic adolescents living in small cities and towns had higher mental well-being scores than those living in rural areas when controlling for connection to nature and participation in both nature experience activities ($B = 0.20$, $p = 0.025$; model 2; Table A3) and outdoor play activities ($B = 0.20$, $p = 0.023$; model 4; Table A5).

3.5.4. Differences in Mental Well-Being across Age during the Pandemic

Our regression models also show that during the pandemic, older adolescents had lower mental well-being scores compared to younger adolescents when controlling for connection to nature and participation in nature experience ($B = -0.03$, $p = 0.009$; model 2; Table A3) and outdoor play activities ($B = -0.02$, $p = 0.041$; model 4; Table A5).

4. Discussion

Our findings indicate that during the COVID-19 pandemic, adolescent connection to nature, mental well-being, and participation in nature experience and outdoor play

activities declined. We also found that declines in connection to nature predicted declines in mental well-being, with connection to nature mediating the relationship between participation in either outdoor activity group and mental well-being both before and during the pandemic. Comparisons between the mediating role of connection to nature before and during the pandemic demonstrate that while connection to nature continues to play an important role in enhancing mental well-being, the role was reduced during the pandemic. Conversely, the direct effect of participation in outdoor activities played an increased role in driving improved adolescent mental well-being during the pandemic.

Declines in outdoor activity participation, connection to nature, and mental well-being observed in this study could be an unanticipated consequence of community health initiatives aimed at slowing the spread of the virus. Pandemic-related changes to adolescent daily routines such as the closure of schools, public parks, and recreation spaces, coupled with the cancellation of youth sports and clubs, have limited opportunities for adolescent contact with nature, as evidenced by COVID-19-related declines in participation in outdoor activities [17] and increases in sedentary activities [16]. As contact with nature diminished due to reduced participation in outdoor activities, connection to nature appears to have declined as well [83]. The widespread decline in adolescent connection to nature found in this study suggests that this trait might be less stable and more malleable in youth than it is in adults [30]. If these adverse shifts in adolescents' daily routines continue following the pandemic, they may contribute to lower levels of outdoor activity participation that persist across the lifespan [32,84,85], and further contribute to an 'extinction of (nature) experience' [86,87], highlighting the potential for long-term impacts to connection to nature and mental well-being.

The benefits of outdoor activities for mental well-being are well documented [25,36,88], but our results advance understanding of connection to nature's role in driving that relationship. Participation in either nature experience or outdoor play activities contributed to adolescent connection to nature and well-being, with connection to nature further enhancing the direct effects of participation in outdoor activities both before and during the pandemic. Connection to nature's increased effect on mental well-being when associated with nature experience activities compared to outdoor play activities can likely be attributed to differences in the environments that individuals are exposed to during participation in these activities. Previous research demonstrates that differences in environments yield differences in well-being outcomes, with exposure to natural environments providing greater mental well-being benefits than urban environments [44,45,50]. For example, Hartig et al. (2003) found that young adults experienced greater stress reduction and directed attention restoration in natural settings compared to urban settings. While our study did not quantify differences in the quality or quantity of nature present during participation in outdoor activities, nature experience activities typically occur in more natural environments, while outdoor play activities can be conducted in nearly any outdoor space. These differences highlight the importance of natural settings in promoting connection to nature and improved mental health.

While the mediating effect of connection to nature on mental well-being decreased during the pandemic, connection to nature remained an important contributor to improved mental well-being. Changes in the degree to which connection to nature mediated the relationship between participation in outdoor activities and improved mental well-being are a result of an increase in the direct effect of outdoor activity participation on mental well-being. This increased direct effect may be a result of pandemic-related changes to daily routines that extend beyond reduced outdoor activity participation. For example, prior to the pandemic, participation in outdoor activities likely represented only a portion of adolescents' opportunities to engage in behaviors associated with improved mental well-being. Daily routines that contribute to mental well-being such as physical activity [89,90] and social interaction [91] were likely reduced as adolescents shifted to online classes and refrained from excursions outside the home. During the pandemic, participation in outdoor activities may have represented one of the few opportunities' adolescents had to engage

in such behaviors, increasing outdoor activities' direct role in driving improved mental well-being during the pandemic. It is also possible that connection nature indirectly fueled the link between outdoor activities and well-being by inspiring and reinforcing higher levels of outdoor activity participation. Although this study did not explore the potential bi-directional relationship between connection to nature and contact with nature, previous studies have demonstrated connection to nature's role in driving continued contact with nature [25,31].

Our findings suggest that although the pandemic impacted connection to nature and mental well-being for almost all adolescents, some groups were impacted more than others. The higher connection to nature scores found in older adolescents before and during the pandemic are similar to findings from an earlier study that found connection to nature fluctuated during childhood and adolescence, with youth under the age of 12 exhibiting higher connection to nature scores than youth 15–16 years of age, and then increasing again for older adolescence [92]. Age-based shifts in youth connection to nature may also help to explain the differences between the decline in connection to nature during the pandemic measured in our study and the increases in young children's connection to nature found by Friedman et al. (2021). Younger children are just developing their relationship with nature [93], possibly contributing to higher connection to nature scores. The young children reporting high levels of connection to nature in the Friedman et al. (2021) study were mostly affluent as well, which might have generated more opportunities for nature-based experiences. Differences in age may also play a role in how parents might spend time with their children during the pandemic, with parents of younger children having greater freedom in educational approaches and content, potentially allowing for more outdoor opportunities. Hughes et al. (2019) suggests that changes in connection to nature during adolescence may be a result of life-stage differences, with older adolescents having increased freedom and agency to explore compared to younger youth. Despite older adolescents having higher connection to nature scores in our study, they also exhibited lower mental well-being scores compared to younger adolescents, demonstrating that other factors may outweigh the mental well-being benefits associated with connection to nature. This is further supported by research indicating that older adolescents experienced increased anxiety during the pandemic [94], which may be at least partially due to uncertainties regarding college and work following secondary school [95].

Inequities in connection to nature were particularly evident across different community types, with adolescents living in small cities and towns and large cities experiencing greater declines in connection to nature compared to adolescents in rural areas and suburbs of large cities. Differences between community types can likely be attributed to reduced access to nature due to increased risk of infection in urban areas early in the pandemic [96], the reduced access to natural spaces in more urban areas [48,97], and increased crowding in urban outdoor areas that remained open [59,60]. Despite having higher connection to nature scores than adolescents from small cities and towns, adolescents in rural areas also exhibited reduced mental well-being scores compared to those in small cities and towns during the pandemic. This particular finding aligns with previous research that suggests connection to nature may be associated with increased stress, anxiety, and depression due to increased environmental awareness and concern within the context of increasing environmental degradation [55]. Despite this finding, the bulk of our results point to a positive relationship between connection to nature and improved mental well-being. Increasing and promoting access to nearby nature is one approach that may ameliorate inequities in connection to nature and mental well-being during the pandemic [83], as well as times of relative normalcy.

Recommendations for Future Research

This study highlights a need for additional research exploring connection to nature's role in enhancing the mental well-being of adolescents. In addition to conducting similar studies with large representative samples, future efforts should also consider including

respondents from outside of the United States to explore pandemic-related impacts across cultural contexts. Additional research on how these trends may change as a pandemic or similar global stressor event progresses could shed light on both the immediate and cumulative benefits of outdoor activity participation and connection to nature for mental well-being during times of crisis. Future studies should also explore the bi-directional relationship between outdoor activity participation and connection to nature, as a deeper understanding of the drivers of adolescent nature engagement may illuminate strategies for increasing participation in activities that positively impact mental well-being. A better understanding of what specific activities contribute to connection to nature and improved mental well-being would be valuable both within the context of COVID-19, as well as more broadly in efforts to address the growing disconnect between humans and nature [87].

Future research should also explore different study designs, as well as different measures of psychological well-being. While this study relied on short-term recall of respondents' mental well-being before the pandemic, recalled measures of mood, emotions, and subjective well-being can become unstable over longer periods of time [75,98]. Longitudinal studies that assess mental well-being at individual moments in time could address this limitation. Continued exploration of changes in the relationship between outdoor activity participation, connection to nature, and mental well-being beyond the COVID-19 pandemic is also important, as environmental determinants of health are nonstationary and continued exploration of these variables may increase the efficacy of future health intervention measures [99]. Future studies could also explore pandemic-related impacts to connection to nature, outdoor activity participation, and mental well-being through a qualitative lens, as it may provide a deeper understanding of the mechanisms driving observed relationships.

5. Conclusions

This study contributes to growing evidence (e.g., Friedman et al., 2021) supporting the value of connection to nature in maintaining adolescents' mental well-being before and during the COVID-19 pandemic. Our findings indicate that declines in adolescent mental well-being can be reversed through increased participation in outdoor activities, which encourage development of a connection to nature. Connection to nature further enhances mental well-being by mediating the relationship between outdoor activity participation and mental well-being. Although we found that connection to nature enhanced mental well-being outcomes linked to both nature experience and outdoor activities, connection to nature played a larger role in driving improved mental well-being for nature experience activities. The decreased indirect effect of connection to nature found during the pandemic appears to be a result of an increased importance in outdoor activity participation in the absence of other recreation alternatives, rather than a decrease in connection to nature's importance. Efforts to improve adolescent mental health and well-being, especially during times of crisis, could focus on promoting and improving access to nearby nature, allowing for increased outdoor experiences that helps to fuel connection to nature.

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Institutional Review Board Statement: This study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board of North Carolina State University (IRB Protocol #16606; approved 30 April 2020).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are openly available from the Dryad Data Repository at doi:10.5061/dryad.d2547d821.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Survey item responses and coding.

Survey Scales	Survey Response Items	Coding for Response Items
Nature Experience and Outdoor Play Activity Participation	Never	0
	Now and then	1
	Often	2
Connection to Nature (Nature Relatedness scale)	Disagree	−1
	Neither/neutral	0
	Agree	1
Mental Well-Being (Subjective Well-Being scale)	At no time	1
	Some of the time	2
	Most of the time	3
	All of the time	4
Gender	Male	0
	Female	1
	Non-binary	2
	Identify another way	3
	Prefer not to answer	4
Race	White	0
	Black	1
	Hispanic	2
	Asian/Pacific Islander	3
	Native American	4
	Other	5
	Prefer not to answer	6
Age	Two or more races	7
	10 years	1
	11 years	2
	12 years	3
	13 years	4
	14 years	5
	15 years	6
	16 years	7
	17 years	8
Annual Household Income	18 years	9
	Less than \$30,000	1
	\$30,000–\$49,999	2
	\$50,000–\$74,999	3
	\$75,000–\$99,999	4
	\$100,000–\$149,999	5
	\$150,000 or more	6
Community Type	Prefer not to answer	7
	Rural	1
	Small city or town	2
	Suburb near a large city	3
Region	Large city	4
	South	1
	West	2
	Midwest	3
	Northeast	4

Table A2. Mediation model 1 exploring connection to nature's mediating effect between adolescent nature experience activity participation and mental well-being before COVID-19.

Variables	Connection to Nature before COVID-19 Path A			Mental Well-Being before COVID-19 Path C			Mental Well-Being before COVID-19 Path B and C'		
	Beta	Std. Beta	<i>p</i>	Beta	Std. Beta	<i>p</i>	Beta	Std. Beta	<i>p</i>
Nature experience activities before COVID-19	0.46	0.46	<0.001 ***	0.23	0.20	<0.001 ***	0.07	0.06	0.153
Connection to nature score before COVID-19							0.34	0.31	<0.001 ***
Race: White (Reference)									
Race: Black	−0.04	−0.02	0.583	0.29	0.15	<0.001 ***	0.30	0.16	<0.001 ***
Race: Hispanic	0.12	0.07	0.058 +	0.22	0.12	0.004 **	0.18	0.10	0.016 *
Race: Asian/Pacific Islander	0.12	0.05	0.16	0.02	0.01	0.877	−0.03	−0.01	0.792
Race: Native American	0.21	0.04	0.323	−0.12	−0.02	0.628	−0.19	−0.03	0.422
Race: Other	0.19	0.03	0.378	0.24	0.04	0.342	0.17	0.03	0.468
Race: Prefer not to answer	0.02	0.002	0.94	0.09	0.01	0.794	0.08	0.01	0.802
Race: Multi-race	0.12	0.06	0.139	0.18	0.08	0.055 +	0.14	0.06	0.121
Age	0.02	0.08	0.041 *	−0.03	−0.13	0.001 ***	−0.04	−0.15	<0.001 *
Gender	0.05	0.05	0.191	−0.11	−0.09	0.018 *	−0.13	−0.11	0.004 *
Income: <\$30,000 (Reference)									
Income: \$30,000–\$49,999	0.06	0.04	0.478	0.23	0.13	0.021 *	0.21	0.12	0.028 *
Income: \$50,000–\$74,999	0.01	0.01	0.875	0.08	0.05	0.403	0.08	0.05	0.409
Income: \$75,000–\$99,999	−0.06	−0.04	0.494	0.12	0.08	0.209	0.14	0.09	0.129
Income: \$100,000–\$149,999	−0.03	−0.02	0.724	0.11	0.07	0.258	0.12	0.08	0.198
Income: \$150,000 or more	0.06	0.04	0.485	0.17	0.10	0.105	0.15	0.09	0.139
Income: Prefer not to answer	0.01	0.003	0.929	0.05	0.013	0.765	0.04	0.01	0.776
Home density: Rural (Reference)									
Home density: Small city or town	−0.05	−0.03	0.472	0.05	0.03	0.543	0.06	0.04	0.394
Home density: Suburb	0.05	0.04	0.401	0.02	0.01	0.792	0.00	0.00	0.983
Home density: Large city	−0.01	−0.003	0.934	0.07	0.05	0.353	0.07	0.05	0.32
Region: South (Reference)									
Region: West	−0.02	−0.02	0.687	−0.05	−0.03	0.444	−0.04	−0.03	0.499
Region: Midwest	−0.02	−0.01	0.781	−0.06	−0.04	0.358	−0.06	−0.04	0.381
Region: Northeast	0.02	0.01	0.733	−0.06	−0.04	0.335	−0.07	−0.05	0.267
Intercept	−0.08		0.411	2.07		<0.001	2.10		<0.001
Adjusted R ²			0.2063			0.0815			0.1572
N			624			624			624

+ $p \leq 0.1$; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$.

Table A3. Mediation model 2 exploring connection to nature's mediating effect between adolescent nature experience activity participation and mental well-being during COVID-19.

Variables	Connection to Nature during COVID-19 Path A			Mental Well-Being during COVID-19 Path C			Mental Well-Being during COVID-19 Path B and C'		
	Beta	Std. Beta	p	Beta	Std. Beta	p	Beta	Std. Beta	p
Nature experience activities during COVID-19	0.42	0.35	<0.001 ***	0.39	0.26	<0.001 ***	0.22	0.14	<0.001 ***
Connection to nature score during COVID-19							0.41	0.34	<0.001 ***
Race: White (Reference)									
Race: Black	−0.15	−0.08	0.061	0.14	0.06	0.152	0.20	0.09	0.032 *
Race: Hispanic	−0.01	−0.01	0.853	0.15	0.07	0.109	0.16	0.07	0.08 +
Race: Asian/Pacific Islander	−0.12	−0.05	0.209	−0.09	−0.03	0.466	−0.04	−0.01	0.733
Race: Native American	0.22	0.03	0.354	−0.22	−0.03	0.46	−0.31	−0.04	0.274
Race: Other	0.36	0.06	0.137	−0.21	−0.03	0.495	−0.35	−0.05	0.221
Race: Prefer not to answer	−0.38	−0.04	0.258	−0.07	−0.01	0.867	0.08	0.01	0.835
Race: Multi-race	−0.09	−0.04	0.347	0.03	0.01	0.807	0.06	0.02	0.563
Age	0.01	0.04	0.253	−0.02	−0.08	0.035 *	−0.03	−0.10	0.009 **
Gender	0.06	0.05	0.181	−0.05	−0.03	0.387	−0.07	−0.05	0.172
Income: <\$30,000 (Reference)									
Income: \$30,000–\$49,999	0.01	0.00	0.957	0.21	0.10	0.091 +	0.21	0.10	0.078
Income: \$50,000–\$74,999	0.07	0.04	0.447	0.30	0.15	0.012 *	0.27	0.14	0.016 *
Income: \$75,000–\$99,999	−0.04	−0.03	0.658	0.33	0.17	0.005 **	0.35	0.18	0.002 **
Income: \$100,000–\$149,999	−0.03	−0.02	0.734	0.16	0.09	0.159	0.18	0.10	0.109
Income: \$150,000 or more	0.02	0.01	0.834	0.24	0.12	0.056 +	0.24	0.11	0.051 +
Income: Prefer not to answer	0.09	0.02	0.565	0.17	0.04	0.396	0.13	0.03	0.484
Home density: Rural (Reference)									
Home density: Small city or town	−0.18	−0.12	0.015 *	0.13	0.07	0.176	0.20	0.11	0.025 *
Home density: Suburb	0.06	0.05	0.356	0.08	0.05	0.354	0.05	0.03	0.506
Home density: Large city	−0.15	−0.10	0.049 *	−0.06	−0.03	0.552	0.00	0.00	0.965
Region: South (Reference)									
Region: West	0.01	0.01	0.857	−0.11	−0.06	0.181	−0.11	−0.06	0.141
Region: Midwest	0.01	0.00	0.911	−0.05	−0.03	0.543	−0.06	−0.03	0.497
Region: Northeast	0.02	0.02	0.706	−0.10	−0.05	0.211	−0.11	−0.06	0.148
Intercept	0.02		0.831	1.50		<0.001	1.49	.	<0.001
Adjusted R ²			0.1492			0.0798			0.1740
N			624			624			624

+ $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table A4. Mediation model 3 exploring connection to nature's mediating effect between adolescent outdoor play activity participation and mental well-being before COVID-19.

Variables	Connection to Nature before COVID-19 Path A			Mental Well-Being before COVID-19 Path C			Mental Well-Being before COVID-19 Path B and C'		
	Beta	Std. Beta	<i>p</i>	Beta	Std. Beta	<i>p</i>	Beta	Std. Beta	<i>p</i>
Outdoor play activities before COVID-19	0.48	0.47	<0.001 ***	0.38	0.34	<0.001 ***	0.26	0.23	<0.001 ***
Connection to nature score before COVID-19							0.26	0.23	<0.001 ***
Race: White (Reference)									
Race: Black	−0.07	−0.04	0.286	0.26	0.13	0.001 ***	0.28	0.14	<0.001 ***
Race: Hispanic	0.05	0.03	0.419	0.16	0.09	0.032 *	0.15	0.08	0.045 *
Race: Asian/Pacific Islander	0.12	0.05	0.154	0.01	0.00	0.951	−0.03	−0.01	0.791
Race: Native American	0.14	0.02	0.508	−0.19	−0.03	0.425	−0.22	−0.04	0.332
Race: Other	0.12	0.02	0.564	0.18	0.03	0.454	0.15	0.02	0.526
Race: Prefer not to answer	0.12	0.02	0.674	0.17	0.02	0.606	0.14	0.02	0.666
Race: Multi-race	0.11	0.05	0.164	0.18	0.08	0.048 *	0.15	0.06	0.089
Age	0.02	0.11	0.002 **	−0.03	−0.10	0.007 **	−0.03	−0.13	0.001 ***
Gender	0.04	0.04	0.245	−0.10	−0.08	0.028 *	−0.11	−0.09	0.012 *
Income: <\$30,000 (Reference)									
Income: \$30,000–\$49,999	0.09	0.06	0.28	0.24	0.14	0.012 *	0.22	0.12	0.02 *
Income: \$50,000–\$74,999	0.06	0.04	0.48	0.10	0.06	0.287	0.08	0.05	0.353
Income: \$75,000–\$99,999	−0.03	−0.02	0.713	0.12	0.07	0.217	0.12	0.08	0.177
Income: \$100,000–\$149,999	0.01	0.00	0.938	0.11	0.07	0.221	0.11	0.07	0.216
Income: \$150,000 or more	0.09	0.06	0.307	0.17	0.10	0.098 +	0.14	0.08	0.144
Income: Prefer not to answer	0.00	0.00	0.998	0.02	0.01	0.895	0.02	0.01	0.892
Home density: Rural (Reference)									
Home density: Small city or town	−0.09	−0.06	0.17	0.04	0.02	0.619	0.06	0.04	0.409
Home density: Suburb	−0.01	−0.01	0.867	−0.01	−0.01	0.879	−0.01	−0.01	0.907
Home density: Large city	−0.03	−0.02	0.654	0.06	0.04	0.438	0.06	0.04	0.369
Region: South (Reference)									
Region: West	−0.03	−0.03	0.53	−0.07	−0.04	0.293	−0.06	−0.04	0.351
Region: Midwest	−0.06	−0.04	0.288	−0.10	−0.06	0.147	−0.08	−0.05	0.214
Region: Northeast	0.00	0.00	0.943	−0.08	−0.05	0.203	−0.08	−0.05	0.187
Intercept	−0.34		0.001	1.77		<0.001	1.85	.	<0.001
Adjusted R ²			0.2146			0.1539			0.1953
N			624			624			624

+ *p* < 0.1; * *p* < 0.05; ** *p* < 0.01; *** *p* < 0.001.

Table A5. Mediation model 4 exploring connection to nature's mediating effect between adolescent outdoor play activity participation and mental well-being during COVID-19.

Variables	Connection to Nature during COVID-19 Path A			Mental Well-Being during COVID-19 Path C			Mental Well-Being during COVID-19 Path B and C'		
	Beta	Std. Beta	<i>p</i>	Beta	Std. Beta	<i>p</i>	Beta	Std. Beta	<i>p</i>
Outdoor play activities during COVID-19	0.44	0.41	<0.001 ***	0.53	0.40	<0.001 ***	0.39	0.29	<0.001 ***
Connection to nature score during COVID-19							0.33	0.27	<0.001 ***
Race: White (Reference)									
Race: Black	−0.11	−0.06	0.137	0.18	0.08	0.052 +	0.22	0.09	0.016 *
Race: Hispanic	−0.04	−0.02	0.594	0.12	0.06	0.162	0.14	0.06	0.111
Race: Asian/Pacific Islander	−0.04	−0.02	0.697	0.02	0.01	0.855	0.03	0.01	0.767
Race: Native American	0.11	0.02	0.646	−0.37	−0.05	0.196	−0.41	−0.05	0.143
Race: Other	0.35	0.06	0.129	−0.16	−0.02	0.574	−0.28	−0.04	0.32
Race: Prefer not to answer	−0.40	−0.05	0.216	−0.15	−0.01	0.707	−0.02	0.00	0.959
Race: Multi-race	−0.03	−0.01	0.731	0.11	0.04	0.306	0.12	0.04	0.249
Age	0.02	0.08	0.041 *	−0.02	−0.05	0.149	−0.02	−0.07	0.041 *
Gender	0.04	0.03	0.369	−0.07	−0.05	0.205	−0.08	−0.06	0.12
Income: <\$30,000 (Reference)									
Income: \$30,000–\$49,999	0.00	0.00	0.962	0.20	0.09	0.088 +	0.20	0.09	0.079 +
Income: \$50,000–\$74,999	0.07	0.05	0.417	0.29	0.15	0.009 *	0.27	0.14	0.014 *
Income: \$75,000–\$99,999	−0.10	−0.06	0.289	0.25	0.13	0.026 *	0.29	0.15	0.01 **
Income: \$100,000–\$149,999	−0.06	−0.04	0.466	0.11	0.06	0.341	0.13	0.07	0.236
Income: \$150,000 or more	0.00	0.00	0.976	0.21	0.10	0.083 +	0.21	0.10	0.074 +
Income: Prefer not to answer	−0.02	0.00	0.91	0.02	0.00	0.915	0.03	0.01	0.888
Home density: Rural (Reference)									
Home density: Small city or town	−0.20	−0.13	0.005 **	0.13	0.07	0.142	0.20	0.11	0.023 *
Home density: Suburb	0.02	0.01	0.806	0.06	0.04	0.481	0.05	0.03	0.508
Home density: Large city	−0.15	−0.10	0.036 *	−0.03	−0.02	0.739	0.02	0.01	0.82
Region: South (Reference)									
Region: West	0.02	0.01	0.799	−0.10	−0.06	0.17	−0.11	−0.06	0.136
Region: Midwest	−0.01	−0.01	0.837	−0.08	−0.04	0.338	−0.07	−0.04	0.349
Region: Northeast	0.04	0.03	0.47	−0.08	−0.04	0.324	−0.09	−0.05	0.223
Intercept	−0.10		0.33	1.28		<0.001	1.32		<0.001
Adjusted R ²			0.1927			0.1678			0.2242
N			624			624			624

+ $p \leq 0.1$; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$.

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