THE ASSOCIATIONS AMONG NATURE EXPOSURE, PHYSICAL ACTIVITY, AND ADOLESCENT STRESS

by

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A THESIS

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INTRODUCTION: Stress has adverse health risks, especially during adolescent development, and can lead to depression or death by suicide. The present study examined the associations among nature exposure, physical activity, and adolescent stress. METHODS: A purposive sampling strategy was used for recruitment and 85 participants, 12 to 17 years old, from Lane County, OR during the Summer of 2022 were studied. Participants were involved in Visit One (consent/assent procedures, baseline survey, Actigraph accelerometer fitting, and downloading NatureQuant application), a 7-day participation period (wearing Actigraph accelerometer, regularly carrying a smartphone, and daily surveys completed), and Visit Two (Actigraph accelerometer returned, and gift cards earned for study completion). Mean daily nature exposure (NE) over the week, mean daily moderate to vigorous physical activity (MVPA) over the week, and mean daily stress score over the week were measured. RESULTS: Nature exposure was not significantly associated with stress and physical activity was not significantly associated with stress. However, nature exposure and physical activity were significantly positively associated ($R = 0.349$, $p = 0.001$). DISCUSSION: This study is a novel design with objectively measured independent variables. Further studies are needed to show the associations between NE, MVPA, and stress.

Keywords: nature exposure, physical activity, stress, adolescents

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Introduction

Adolescence is a critical stage of development wherein teens are transitioning into adulthood and navigating physical, cognitive, emotional, and social changes (McNeely and Blanchard, 2009). With these changes, stressful situations and sentiments can arise, and while the physical and mental consequences of stress have been studied among adults, there is less research on this escalating problem among adolescents. This population is crucial to consider as increasing rates of stress can have an immediate and or long-term bearing on adolescent development and overall well-being. Eiland and Romeo (2013) note that stressors can cause "changes in limbic and cortical structure and function, with important behavioral repercussions" among adolescents (p. 168). Increased exposure to stress during adolescence can impact neural maturation and increase psychological morbidities including anxiety or depression (Eiland and Romeo, 2013, p. 162). The World Health Organization (WHO) stated depression was the third leading burden of disease globally and is predicted to be first by 2030 (Hosseinkhani et al., 2022, p. 2). Depression can also lead to suicide and "Over 70,000 people die due to suicide every year. Suicide is the fourth leading cause of death in 15-29-year-olds," according to WHO (2021). Miller and Prinstein (2019) highlight the connection between stress and suicide further by finding that adolescents experience an increase in the frequency and intensity of interpersonal stressors triggering suicidal ideation and behavior (p. 28). Adolescents are especially vulnerable to suicidal ideation and behavior due to the biological and social changes occurring during this developmental time (Miller and Prinstein, 2019, p. 28). This research encapsulates the pervasiveness and dangers of stress among adolescents and the importance of conducting more studies in relation to this topic and population.

Now, more than ever, a better understanding of the behavioral and environmental factors associated with adolescents' stress is needed to inform prevention and intervention strategies. Existing literature underscores the benefits of nature exposure and physical activity on stress among adults (to an extent) but how these factors are associated with stress among adolescents, especially during this post-COVID or COVID-endemic period, is unknown. As such, the goal of this study is to assess the associations between nature exposure and physical activity with stress among adolescents in Lane County, Oregon in order to inform age-appropriate stress prevention and or intervention strategies. Research questions and hypotheses include:

.(1). How is nature exposure associated with stress among adolescents? It is hypothesized that nature exposure will be inversely associated with stress among adolescents; as nature exposure increases, the rates of reported stress among adolescents will decrease.

.(2). How is physical activity associated with stress among adolescents? It is hypothesized that physical activity will be inversely associated with stress among adolescents; as physical activity increases, the rates of reported stress among adolescents will decrease.

Existing literature supports the hypotheses wherein nature exposure decreases stress among adults. Beyer et al. (2014) study concluded that higher levels of neighborhood green space (while controlling for individual and neighborhood characteristics) were associated with "lower levels of symptomology for depression, anxiety, and stress" (3453). Beyer et al. (2014) reported adding 25% more neighborhood green space decreased stress significantly (-0.735, $p < 0.05$). An et al. (2016) study also reported an association between exposing adults to more natural elements and lessened role stressors at work. Increasing exposure to natural elements decreased role stressors, increased job satisfaction, and lowered depressed moods (An et al.,

2016, p. 12). Additionally, Sahlin et al. (2014) employed a nature and garden stress management course that reported less stress-related symptoms and increased tools/strategies to manage stress and achieve relief among adults after enrolling in the program. The natural environment and garden activities proved to have beneficial effects as a stress management intervention (Sahlin et al., 2014, p. 6587).

Research reveals associations between increased physical activity and lower levels of stress among adults. Rueggeberg, Wrosch, and Miller (2012) found that those who engaged in physical activity frequently decreased perceived stress levels over two years. The findings also revealed that physical activity could potentially decrease chronic high perceptions of stress and, in turn, improve physical health long-term (Rueggeberg, Wrosch, and Miller, 2014, p. 168). Skurvydas et al. (2021) more recently found similar results that higher levels of moderate to vigorous physical activity (MVPA) were associated with higher emotional intelligence (EI) leading to less stress and depression among adults 18-24 to 65-74 years old. The existing research highlights that higher levels of physical activity and nature exposure not only lower stress but improve other mood and cognitive health entities among adults. To see if these health benefits are also possible among adolescents, more research needs to be done regarding the associations between nature exposure, physical activity, and stress for this population.

Literature Review

Existing literature identifies many benefits of nature exposure and physical activity on stress prevention and reduction; however, most of these studies are among adult populations leaving a need for further research on this topic among adolescents. Teens are developmentally different from adults and may respond differently to stress and other behavioral and environmental factors. Eiland and Romeo (2013) speak to these differences explaining how the

adolescent brain may be more sensitive to stressors consequentially hurting the health and well-being of adolescents short and long term. Regarding adolescent development and neurobiological processes, Eiland and Romeo write, “The continued maturation of stress-responsive brain regions, the shifts in hormonal reactivity, and the changes in the quantity and quality of stressors that occur at this time may contribute to this heightened sensitivity” (2013, p. 168). Alternatively, the plasticity occurring during maturation means the adolescent brain is receptive to intervention strategies to avoid stress-based trauma (Eiland and Romeo, 2013, p. 168). Studying the associations between nature exposure, physical activity, and stress may reveal a possible intervention strategy during this critical and changing stage of development.

Careful analysis of previous studies can provide a better sense of what has already been addressed regarding nature exposure and physical activity on stress among adolescents and what is left to be determined. Extant studies with nature exposure display notable limitations in measuring and accounting for the individual-level effects or benefits of nature exposure as a variable. Instead, most studies utilize an environmental level proxy in the research process such as a neighborhood green space—park, community garden, school playground, etc. Mennis, Mason, and Ambrus (2018) found an association between synchronous greenspace exposure and a reduction in psychological stress for adolescents. Relying on an environmental level proxy approach in their study presented some drawbacks; for example, Mennis et al. were unable to determine the true extent to which nature exposure is associated with stress due to the exogenous setting. Li, Zhou, Slavenas, and Sullivan's (2018) study found an association between increased concentrations of diverse nature and better moods by measuring varying concentrations of nature exposure on adolescents. Li et al. are among the few researchers who have studied the adolescent

population and topic jointly. There is still a great deal to be determined and more variables to discern regarding nature exposure in unstructured spaces.

To contribute to the aforementioned gaps, I will utilize Dr. Budd and Dr. Kelly's data from their Summer 2022 study in Lane County, Oregon, *Parsing the Effects of Nature Exposure and Physical Activity on Mood and Cognitive Functioning Among Adolescents.* I will be running an independent statistical analysis to determine the associations between nature exposure, physical activity, and stress among adolescents. The objective of the study is to contribute to filling the gaps for the adolescent population regarding nature exposure, physical activity, and stress, as well as improve the depth of knowledge on this topic by using a novel objective measure of nature exposure. The nature exposure measurement tracks individual level exposure and is less prone to error and bias compared to the studies that use proxy measures.

Method

Sample

This research aims to examine the associations among nature exposure, physical activity, and adolescent stress by investigating data derived from Dr. Budd and Dr. Kelly's Summer 2022 study in Lane County, Oregon, *Parsing the Effects of Nature Exposure and Physical Activity on Mood and Cognitive Functioning Among Adolescents.* Drawing from Dr. Budd and Dr. Kelly's larger sample, this research included data from 85 participants, 12-17 years old. Participants had to be in the target age, be able to both read and understand English at a 5th-grade level (determined through a self-reported "yes" or "no" response), have personal access to a smartphone, and be able to meet at Kidsports Civic Park twice over the study period to participate.

Recruitment Methods

The recruitment process employed a purposive sampling strategy by: (1) sending mass mailings of recruitment postcards to households in and around the Eugene and Springfield areas to families with adolescents 12-17 years old in age, (2) emailing community-based organizations in Lane County, Oregon that serve adolescents 12-17 years old in age and attaching recruitment flyers encouraging their circulation on site or via email to the organization's mailing list, (3) passive distribution of recruitment flyers in-person at Kidsports Civic Park, and (4) sharing about the study via word of mouth by participants who were currently in or had already completed the study. While the recruitment strategies were centered in and around the Eugene and Springfield areas, there were no residency requirements to participate in the study. Interested teens could text, call, or email the research team to learn more about the study or had the option to scan a QR

code on recruitment flyers. The QR code directed parents of potential participants to a screening survey on University of Oregon (UO) Qualtrics (an online application where surveys can be created, shared, and reports/results downloaded by faculty, staff, and students from the University of Oregon) where it (a) asked about their teens interest in participating in the study, (b) requested contact information, and (c) outlined the requirements for the study. Research team members would then reach out via the preferred contact method—if eligibility requirements were met—to schedule what the study called "visit one" for the parent and teen. During visit one, parent or guardians and teens had to complete an informed consent and assent form to participate and begin the study. All study procedures were approved by the University of Oregon's Institutional Review Board.

Study Design

July through September, Summer of 2022, participants were involved in week-long studies that consisted of three parts: visit one, the 7-day participation period, and visit two.

Visit One

A research team member would contact the eligible teen to schedule a date and time to meet with them and their parent or guardian at Kidsports Civic Park. This meeting was referred to as "visit one" and participants would complete an informed assent procedure and the parent or guardian would complete an informed consent procedure. Visit one also required participants to fill out the baseline survey, be fitted for an Actigraph accelerometer, and download the NatureQuant application on their smartphone. The parent or guardian and the teen would read and sign the designated informed consent and assent form agreeing to participation in the study. The informed consent and assent procedures described the study, involvement guidelines, and outlined the participation reward incentive, confidentiality agreement, benefits of participating

(e.g., help the research team and greater academic community understand how nature, movement, and stress are associated), risks to participating (e.g., surveys include sensitive subjects that may bring up uncomfortable feelings), and voluntary withdrawal (teens have the option to stop participating in the study at any time). Consent and assent forms underwent privacy measures to ensure the safety of all participants and their personal information (e.g., locking up forms in secure areas or reporting data in aggregate form—without identifying information). A baseline survey was then completed by clicking on a UO Qualtrics link using an iPad provided by the research team which evaluated participants demographics (e.g., racial/ethnic background, gender, age, and education), mental health (e.g., anxiety, depression, attention deficit hyperactivity disorder (ADHD), etc.), physical activity self-efficacy (e.g., believing in their ability to be active under different circumstances), mindful actions (e.g., purposeful or thoughtful behaviors), resilience (e.g., ability to handle or recover from stress or stressful situations), social support system (e.g., friends and family to reply upon), body-image (e.g., gauging body positivity or appreciation), social media sentiments (e.g., time spent, engagement, and reactions to various applications), and nature connectedness (e.g., sense of belonging). The participants had the option of completing the entire survey or select questions based on their comfort level. All participants were assigned a participant ID number to provide data confidentiality during and concluding the study. After the baseline survey, an Actigraph GT3X+ accelerometer would be set up by entering the participants ID number, age, height, and weight into the software to initiate the device. The Actigraph accelerometer objectively measures any moderate to vigorous physical activity (MVPA) over the 7-day participation period. The last step was downloading an application called NatureQuant onto the participants smartphone which objectively and automatically measures the amount of time spent near nature or urban

greenspaces such as parks, trails, or other natural areas. Participants are then reminded during visit one to always wear the Actigraph accelerometer and regularly keep their phone on them over the 7-day study period.

Seven-Day Participation Period & Author's Role

Participants wear the Actigraph accelerometer and have their smartphone readily available to track their nature exposure over the period of one week. During the study, participants also completed short daily surveys on UO Qualtrics. Participants were asked about time spent on social media applications and pointed "yes" or "no" questions about whether potentially stressful situations happened in their day. Participants were sent an alert every evening after 6:30 pm indicating it was time to complete the daily survey along with a link to the UO Qualtrics survey page. As a research team member with a thesis concentrating on adolescent stress, it was my responsibility to manage the daily surveys as the automated text technical personnel and retention specialist. My role involved monitoring the research team Google Calendar for participants first and second visits, sending personalized daily survey links, contacting parents, and managing questions, concerns, or technical difficulties relating to the UO Qualtrics survey platform. A participant's first of the seven total daily surveys would be sent one day after enrollment/visit one. Next, using UO Qualtrics, I created personalized daily survey links connected to participants ID numbers to ensure data confidentiality. I would then send each of the participants the assigned link and these expired at 11:59 pm each night to guarantee the responses were reflective of the day it was sent. A new personal survey link connected to participants ID number was created daily on UO Qualtrics. This process would be repeated seven times until the day before participants second visit. On day two of surveys, participants received a text reminding them to wear the Actigraph accelerometer and asked if they had questions

regarding the device. On day five of surveys, participants parent or guardian received a text reminding them of their second scheduled visit at Kidsports Civic Park. An Excel spreadsheet was used to track the multiple participants in a week who were at different stages of the study. Along with these tasks, I would monitor the completion of the daily surveys on UO Qualtrics and encourage participants to complete upcoming surveys if past surveys were not done. During visit two, if participants completed at least five out of the seven total daily surveys, they were entitled to a $20 gift card. Any questions, technical difficulties, or assistance in relation to the daily surveys would fall to me. This position required a meticulous eye, diligent attitude, and patience, but it allowed a first-hand perspective of data collection regarding the stress measurement.

Visit Two & Participation Incentive

Participants and a research team member would schedule another meeting after the 7-day data collection period called "visit two" which involved the teen returning the Actigraph accelerometer and receiving gift cards for participating in the study. A participant could earn up to $100 in VISA gift cards for completing four different steps during the research process: (1) $30 could be earned for attending visit one; completing the baseline survey, being fitted for an Actigraph accelerometer, and downloading NatureQuant onto a smartphone, (2) $30 could be earned for wearing the Actigraph accelerometer 70% of the time over the 7-day data collection period, (3) $20 could be earned for completing five or more daily surveys, and (4) $20 could be earned for returning the Actigraph accelerometer after the study during visit two. The gift cards were used to incentivize interest and participation. Participants were not penalized for not meeting the criteria to receive gift cards, but they were not financially awarded without successfully completing these steps.

Measures

These analyses include averages of key study variables across the 1-week span of time, and so only associations can be determined rather than causal pathways. The independent variables in this study are (1) mean daily nature exposure (NE) over the week and (2) mean daily moderate to vigorous physical activity (MVPA) over the week while the dependent variable in the study is the mean daily stress score over the week. The independent variables were both objectively measured which is a rarity with data collection.

Nature Exposure (NE)

The independent variable, nature exposure, was collected through the NatureQuant application on participants' smartphones. The NatureQuant application has a service called NatureDose which tracks in minutes the time spent inside, outside, and exposed to nature. The tracker runs in the background of other phone operations and determines an individual's variations in nature exposure. NatureDose relies on phone location services as well as a proprietary algorithm that calculates relative exposure to natural elements. Participants NE was downloaded, and a composite variable of a max nature score was created for each day the NatureDose application was running. These scores were added together and divided by the number of days NE was collected to create a participant's individual daily max nature score for the week. Each participant's mean NE per day was then added together and divided to create a mean daily NE score over the week for the adolescent, 12-17 years old, sample population.

Moderate to Vigorous Physical Activity (MVPA)

The independent variable, physical activity, was collected using an Actigraph GT3X+ accelerometer. Participants wore the Actigraph accelerometer like a wristband on their non-dominant wrist for 7 days. The device tracks movement such as moderate to vigorous intensity

changes in physical activity. After the week, a research team member collected the Actigraph accelerometer and downloaded the reports. A composite variable of daily minutes of MVPA was created with the data and divided by the number of days physical activity was collected to create a participant's individual daily minutes of MVPA for the week. Participant's mean MVPA were then added together and divided to create a mean daily minute's score of MVPA over the week of the sample population.

Stress

The dependent variable, stress, was collected with the UO Qualtrics daily survey which participants received everyday over the 7-day study period. The UO Qualtrics survey's intention was to inquire about what kinds of stress participants were experiencing throughout a day. The survey also examined the amount of time spent on participants smartphones and various applications, but for the purpose of this study, stress responses were the only ones measured. Seven different "yes" or "no" questions were asked, for example, "Did you have an argument or disagreement with anyone today?" or "Did anything happen today at work or school that most people would consider stressful?" Other questions discussed different kinds of stress such as discrimination based on race, gender, sexual orientation, body size, age, or other factors. The Daily Inventory of Stressful Events (DISE) was used as a model for type of stress questions and scaling in Dr. Budd and Dr. Kelly's study for the daily survey. Based on the responses, participants received a score of one for every "yes" and a score of zero for every "no" which was then added together to create a total daily stress score. The daily stress scores for each participant were added together and divided by seven to create a participant's individual mean weekly stress score. Lastly, the participants mean weekly stress score were added together and divided by the

number of participants to find the mean daily stress score over the week for the sample population.

Statistical Analyses

To test hypothesis 1, first, the distribution of nature exposure was examined by creating a mean daily NE over the week for the sample. Then a Pearson Correlation test was conducted using IBM SPSS Statistics version 28.0.0.0 (190). Nature exposure was the independent variable and stress was the dependent variable. Since both the independent and dependent variable were an interval or ratio scale and not skewed or kurtotic, a Pearson Correlation test was used.

To test hypothesis 2, first, the distribution of physical activity was examined by creating a mean daily MVPA over the week for the sample. Then a Pearson Correlation test was conducted on IBM SPSS Statistics version 28.0.0.0 (190). Physical activity was the independent variable and stress was the dependent variable. Since both the independent and dependent variable were an interval or ratio scale and not skewed or kurtotic, a Pearson Correlation test was used.

Results

Sample Descriptives

Table 1 shows the sample size (N = 85) of the study examining adolescents between 12 to 17 years old in age and interval variable results measuring the central tendency of the data collection: mean daily NE over the week (56.01), mean daily MVPA over the week (119.41), mean daily stress score over the week (1.83), and mean age (14.99). Table 1 also shows the measures of variability including the standard deviation, minimum, maximum, skew, and kurtosis of the interval variables. Physical activity had a greater standard deviation (56.36) than nature exposure (22.94) and both had greater standard deviations compared to stress (1.25) (see Table 1). Table 2 shows the sample (N = 85) majority were girls (49.41%), identified as White (61.90%), and were between the ages of 12 to 17 years old (see Table 2).

Table 1. Descriptive Statistics of Interval Variables (N = 85)

Variable	Mean	SD	Min, Max	Skew	Kurtosis
Nature Exposure (Minutes)	56.01	22.94	16.43, 98.77	0.20	-1.17
Physical Activity (Minutes)	119.41	56.36	14, 299	0.74	0.59
Stress	1.83	1.25	0, 5.29	0.54	-0.19
Age (Years)	14.99	1.67	12, 17	-0.33	-1.18

Note: SD: standard deviation; sample includes participants in Lane County, OR

Table 2. Demographic Characteristics of Adolescent Sample (N = 85)

Variable	N (%)
Gender	
Girl	42 (49.41)
Boy	38 (44.71)
Transgender	3 (3.53)
Non-Binary	2 (2.36)
Race	
White	52 (61.90)
Person of Color	32 (38.10)
Missing	1

Note: sample includes 12–17-year-old participants in Lane County, OR

Research Question #1 Results

Nature exposure was not significantly associated with stress (R = -0.001, p = 0.996).

Research Question #2 Results

Physical activity was not significantly associated with stress (R = 0.166, p = 0.130).

Exploratory Results

Nature exposure was significantly positively associated with physical activity (R = 0.349, p = 0.001).

Discussion

Main Findings

It was hypothesized that nature exposure (NE) was inversely associated with stress in adolescents between 12 to 17 years old; if nature exposure increased, stress scores would decrease. The Pearson Correlation test showed that NE increased, and stress decreased, but NE was not significantly associated with stress so, the null hypothesis failed to be rejected. Mennis, Mason, and Ambrus (2017) found that exposure to greenspace was associated with lower psychological stress and was consistent with observational studies that were previously conducted (p. 7). Li et al. (2018) also found that more daily exposure to greenspace improved moods among adolescents such as lowering stress levels (p. 39). The existing literature aligns with the present study's hypothesis that NE would be inversely associated with stress, however, NE and stress were not significantly associated in this study compared to previous research. Objectively measuring nature exposure through individual-level tracking contributed to filling in the gaps in the existing literature.

It was hypothesized that physical activity was inversely associated with stress in adolescents between 12 to 17 years old; if physical activity increased, stress scores would decrease. The Pearson Correlation test showed physical activity increased while stress increased and physical activity was not significantly associated with stress so, the null hypothesis failed to be rejected. Moljord et al. (2011) reported that no significant difference was found between stress and being physically active every day versus two or three times a week among adolescents 13 to 18 years old (p. 631). Alternatively, in a 2021 study, Lee found that participating consistently in physical activity, along with self-concept clarity, relieved stress relating to the COVID-19 pandemic among adolescents (p. 1). There is diverging evidence that physical

activity and stress are inversely associated indicating the need for further research. Physical activity was also objectively measured which contributed to filling in the gaps in the existing literature.

It was not hypothesized that nature exposure and physical activity were associated, but the Pearson Correlation test showed there was a significant positive association (a low correlation, but positive); as nature exposure increased, physical activity increased. There are gaps in extant literature regarding the joint benefits of nature exposure and physical activity. Wicks et al. (2022) found that physical activity was more beneficial in natural environments compared to urban environments for various psychological reasons (p. 1031). Partly why this study was novel was that nature exposure and physical activity were studied simultaneously compared to other extant studies.

Strengths and Limitations

There are several limitations of this study that could be modified or improved. While the present study had the largest sample size for this topic, the sample was limited to 85 participants in and around the Eugene and Springfield areas. It is unknown how the findings can be generalized to other adolescent populations from urban and suburban areas with greenspace differing from Lane County, OR. Additionally, it is unknown how the findings could be generalized to a more diverse sample of adolescents with different race/ethnicity backgrounds from those represented in the study. Another limitation was the stress variable. The Daily Inventory of Stressful Events (DISE) measurement was used which simply measured—using self-reported responses —potentially stressful events in 24 hours. A more sophisticated stress measurement was desired to better represent participants' stress scores, however, there is not a quality tool to measure stress day to day established in previous research. DISE was employed in

this study since it was the leading option in existing literature, but the study could have utilized more sub-scales from the DISE measurement. Data was also collected during the Summer of 2022 and stress levels could differ based on the time of year when day-to-day conditions are more normal for adolescents. Summer could be a less stressful season compared to Fall or Winter. The associations between nature exposure, physical activity, stress, and adolescent academic achievement could be the next step for research. Collective effort and action are needed to contribute to filling in the gaps for the adolescent population.

Even with these limitations, the study exhibits many strengths and adds to existing literature regarding nature exposure, physical activity, and stress among adolescents. The developmental changes during adolescence and the consequential impact of stress on these changes were conveyed in this study. Moreover, rising health concerns in adolescence can have long-term impacts into adulthood further exemplifying the need for additional research on the adolescent population (Eiland and Romeo, 2013, p. 162). The present study also used novel objective measurements compared to previous studies. The adult population has been repeatedly investigated, but it is necessary to examine the associations among adolescents to find prevention and intervention strategies for their health and well-being as well. For example, discovering the significant positive association between nature exposure and physical activity could be used to increase movement, increase time outdoors, and establish healthy behaviors. Future research should be done regarding associations between stress, NE, and MVPA to better address health concerns linked to stress such as depression or death by suicide. It is important to study behavioral and environmental factors associated with adolescents due to these endangering concerns. This research is a starting point with a novel study design, objective measures, and significant findings that can be applied moving forward.

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