

12-1-2021

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**The Indirect Effect of Childhood Trauma on Body Mass Index Through Exercise
Frequency**

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Abstract

Objective: Research pertaining to Body Mass Index (BMI) and Childhood Trauma (CT) is very limited, with the main focus being on how these two variables correlate, disregarding other possible covariates. The purpose of the current study was to examine the effects of CT on BMI while including Exercise Frequency as a mediator of this relationship and sex as a moderator for both the direct and indirect relationships among these variables. Methods: Participants included 1,812 individuals (57.9% female and 42.1% male) who completed the Behavior Health Questionnaire, which included questions looking at exercise frequency, CT, and BMI. Results: CT was related negatively to exercise frequency, which acted as a mediator between CT and BMI. Sex only moderated the direct effect of CT on BMI. Conclusion: Sex and exercise frequency were both influential variables in the relationship between CT and BMI. Future research should focus on other variables such as obsessive-compulsive disorder and depression, among others, to expand on the complex relationship between CT and BMI.

Keywords: childhood trauma, BMI, exercise frequency, sex

The Indirect Effect of Childhood Trauma on Body Mass Index Through Exercise Frequency

Understanding health and its importance in a person's quality of life is beneficial for the health of society. Therefore, to understand what increases or decreases a person's ability to achieve maintenance of health, research needs to examine possible factors. Research has shown that exercise is a positive factor in maintaining/improving a person's mental and physical health (Mandolesi et al., 2018). Exercise is highly associated with health benefits, yet negative factors need to be studied as well to understand possible experiences that may decrease an individual's quality of life. Such research could allow for individuals to note possible negative factors that may affect their health, and allow for them to avoid engaging in them. However, there may be some factors that are unavoidable like prior trauma. Trauma is "the out of ordinary stressors that have low expectancy, probability, and controllability" (Kira, 2001). The Health Belief Model (HBM) is often used when studying these factors.

The HBM hypothesizes that people are likely to engage in health-related behaviors given that they perceive that they are susceptible to or likely to come in contact with the problem (perceived susceptibility), that the issue could hinder their daily functioning or have serious consequences (perceived severity), that an intervention or preventative actions will be effective in reducing symptoms (perceived benefits), and that there are few barriers (perceived barriers; Henshaw & Freedman, 2009). Childhood Trauma (CT) is a serious factor in the development of individuals and includes physical, emotional, and sexual abuse as well as neglect. It can be a perceived barrier that is severely detrimental and has multiple known adverse outcomes such as depression, eating disorders, and other maladaptive behavior, with repercussions lasting well into adulthood (Shin & Miller, 2012). The issues that arise from trauma need to be addressed to find

ways to promote the well-being of survivors. Research shows that intervention at an early age is beneficial for the individual in that it helps form resilience and healthy coping skills (Hund & Espelage, 2006). However, to provide the necessary help, the source of the problem needs to be addressed. Like most traumatic experiences, CT can make way for a plethora of mental as well as physical health issues. CT is most commonly associated with mental health problems in the form of depression, anxiety, and PTSD. Physical health is affected by CT in the form of eating disorders (ED), obesity, and other serious health conditions (Shin & Miller, 2012).

Eating Behaviors Influencing BMI

Although the current study examined body mass index (BMI) as the outcome of interest, EDs are related to BMI and highly prevalent in the United States, with 21 million Americans developing one during their lifetime (Streatfeild et al., 2021). EDs include Bulimia Nervosa (BN), Anorexia Nervosa (AN), and Binge-Eating Disorder (BED). BN consists of binge-eating habits with the need to purge. Those who suffer from BN can be underweight, average weight, or overweight. However, they typically are not as underweight as those who suffer from AN. AN is disordered eating in that food intake is greatly limited, there is an abnormal fear of being considered “fat,” and individuals have a distorted view of their bodies. BED is when an individual has episodes consisting of gorging on food excessively even when full and feeling shame/guilt when their episode ends at least once a week for 3 months. BED is different from BN in that no purging occurs after a binge-eating episode, and most individuals with this disorder tend to be overweight or even obese (American Psychiatric Association, 2013). With these EDs, weight fluctuation can be severely low or to the point of obesity. Obesity, which is also related to BMI, is an epidemic running rampant throughout the US, affecting 34 percent of adults and between 15-20 percent of children (Mitchell et al., 2011). Therefore, the research

conducted looking into EDs and obesity uses variables such as weight in pounds, waist circumference, or BMI. With research looking into variables that gauge possible EDs and obesity, other variables need to be studied to understand the root problem better. EDs and obesity, like many mental health issues, can arise from differing traumas and/or experiences, and treatment can be informed by addressing the source of the trauma, which often occurs in childhood.

Effects of CT

CT is defined as the experience of an event by a child that is emotionally painful or distressful, which often results in lasting mental and physical effects (Hund & Espelage, 2006). Much like EDs, CT is prevalent globally, with one in three children experiencing some form of CT by the time they are 16 years old (Weinreb et al., 2010). As stated within this definition, CT includes any maltreatment that a child experiences and emphasizes possible effects on not only the survivors' mental health but also their physical health. For example, a study examined how childhood maltreatment was associated with BMI from adolescents to young adulthood. The results showed that those who experienced childhood neglect, relative to those who did not, displayed more significant growth in BMI (Shin & Miller, 2012). Furthermore, what also needs to be taken into consideration is the fact that different age groups, when they have experienced some sort of CT, may have different reactions and coping mechanisms. Therefore, when researching CT, age and signs of traumatic stress need to be considered (Weinreb et al., 2010).

There is an abundance of research regarding CT and its adverse effects on mental health; however, the research lacks in the expansion of this domain in association with eating behaviors and possible unhealthy coping mechanisms that may lead to obesity or EDs. Current research displays the detriment CT has on individuals' well-being, with depression associated with CT,

mainly emotional abuse being the trauma that led to the development of depression in adulthood, which can lead to emotional eating (Michopoulos et al., 2015). Michopoulos et al. (2015) examined a primarily Black, low socioeconomic status, inner-city sample. They found that higher levels of emotional eating were associated with higher BMI, CT, and depressive symptoms as well as lower income. Their results also revealed that the relation between CT and emotional eating was mediated by depressive symptoms and emotion dysregulation, with emotion dysregulation demonstrating a stronger mediation effect. Another study examining women who were overweight or obese showed that women who have experienced severe CT suffered from binge eating and food addiction concurrently (Imperator et al., 2016). These studies emphasize the need to consider possible CT in individuals who experience disordered eating.

Another study examined the biological association of CT, depression, and BMI and found that women who had Major Depressive Disorder (MDD) but not CT had lower levels of cortisol when compared to the control group. The study implicated that stunted rather than increased cortisol levels might increase food intake, independent from CT and MDD (Wingenfeld et al., 2017). Midei et al. (2010) looked specifically at middle-aged women and the impact childhood abuse/neglect had on their waist circumference and BMI as well as their anger levels. The results showed that women who had experienced CT had a larger waist circumference. Those with higher BMI and waist circumference levels displayed higher scores on the Trait Anger Scale. This study suggests that women who experience CT have higher levels of anger and sex hormone-binding globulin, contributing to obesity/adiposity in mid-life, supporting a biological mechanism of CT on BMI.

The majority of research lacks in the inclusion of minorities. In research examining EDs, men are considered the minority because relatively less research has investigated the association between CT and BMI in men. However, in one study, Mitchell and Mazzeo (2005) focused on men and disordered eating that may arise from CT. The results showed that the type of men who only experienced physical abuse or neglect experienced disordered eating with depression mediating the relation. However, anxiety and alexithymia (i.e., lack of emotional awareness, specifically difficulty identifying feelings) were not mediators of this relation. This study shows the need for more research on men regarding CT and disordered eating because men and women experience different mental illnesses as well as certain types of CT, all of which can result in different effects depending on sex. Although not the focus of the current study, ethnicity also impacts these relationships. For example, Mazzeo et al. (2002) examined CT and EDs with several possible mediators in a sample consisting of Black and White female undergraduates. Mediators that were incorporated into the model were anxiety, alexithymia, and depression. Results showed that each of these mediators was significant in the relation between CT and EDs. It also concluded that cross-cultural influences need to be further researched through a test of invariance between the Black and White subsamples. The current research reveals that there is a connection between BMI and CT. However, it lacks in covering other variables that could possibly contribute to their relationship in a sample that includes both sexes and different ethnic backgrounds.

The research that has looked at CT and physical effects has concluded that CT, specifically exposure to violence as well as abuse in childhood, does predict a higher BMI in adolescence (Gooding et al., 2015). Research shows that those who have experienced some form of CT are more likely to engage in unhealthy behaviors than those who did not. These unhealthy

behaviors include risky sexual behavior and substance use, among others (Rodgers et al., 2004). Another study specifically emphasized that CT, mainly neglect and emotional abuse, resulted in greater BMI due to unhealthy coping mechanisms in the form of BE (Amianto et al., 2018). These studies reveal that individuals who experience some form of trauma tend to be less inclined to take care of themselves. Through the research showing that their BMI is higher relative to others who do not experience CT, there is a possibility that exercise frequency (i.e., a self-care mechanism) for these individuals is affected. Although research does not appear to examine the impact of CT on exercise frequency, it is vital to examine the exercise frequency of these individuals to gain a sounder understanding of exercise frequency's role in the relationship between CT and BMI.

Current Study

Even though the literature reveals that both childhood abuse and neglect have a role in the obesity of adolescents (Shin & Miller, 2012), there is relatively less ongoing research that tries to find other variables that could account for the relation between CT and BMI. Thus, the purpose of the current study was to assess the relationship between CT and BMI, with that relationship being mediated by exercise frequency and with sex being a moderator for both the direct and indirect effects. Hypothesis 1 stated that a) CT would be related to BMI, b) CT would be related to exercise frequency, and c) exercise frequency would be related to BMI. Hypothesis 2 stated that CT would have an indirect effect on BMI through exercise frequency. Hypothesis 3 stated that sex would moderate both the direct and indirect effects; however, no a priori predictions are offered for this exploratory variable.

Methods

Participants

Participants from the Commonwealth of Pennsylvania ($N = 1820$) were recruited to a study based on their status as a twin and were asked to answer a Behavioral Health Questionnaire in 1996. The subjects were born between 1959 and 1978 in Pennsylvania. The subject pool consisted of 766 males and 1054 females and 1702 White, 61 Black, 3 Asian, 7 Hispanic, 18 Native, and 21 Other participants. Participants ranged in age from 20 to 55 years ($M = 33.17$, $SD = 6.01$). Also, 1638 of the subjects were employed, and the other 181 were unemployed at the time of data collection. Current family income of the participants ranged from below \$15,000 to over \$100,000 with 46 subjects' income being below \$15,000, 117 subjects between \$15,000 and \$24,999, 499 subjects between \$25,000 and \$49,999, 455 between \$50,000 to \$74,999, 338 between \$75,000 and \$99,999, 302 subjects exceeding \$100,000 in income, and 50 subjects who were unaware of their income. However, it is important to note that their income during data collection reflects a differing time period (e.g., inflation).

Measures

Exercise frequency, CT, sex, and BMI were measured. Exercise frequency was an interval variable measured on a Likert scale, including *one being nearly every day, two a few times a week, three once a week, four a few times a month, five once a month, and six not at all*. However, when conducting the data analysis exercise frequency was coded so that higher scores indicated higher exercise frequency. BMI was a ratio variable measured in kilograms divided by meters squared and was gathered through self-report.

CT was measured with the Childhood Trauma Questionnaire (CTQ; Liebschutz et al., 2018). The measure includes five subscales assessing emotional, physical, and sexual abuse as well as physical and emotional neglect. Response choices included *none to low trauma exposure, low to moderate trauma exposure, moderate to severe trauma exposure, and severe to extreme*

trauma exposure for each scale. Scores for each subscale range from 5 to 25, and the total score, which was used in the current study, ranges from 25 to 125. Initial validation of this measure was tested in psychiatric and community samples by measuring the CTQ against several forms of trauma assessment methods, including therapist's ratings of the client's history of trauma, the Child Maltreatment Ascertainment Interview through their primary therapist, as well as previous reports from child welfare investigations, referring clinical agencies, and other treatment teams (Liebschutz et al., 2018).

Data Analysis and Cleaning

Correlations and mean comparisons were conducted by sex on all variables using SPSS 27.0. The moderated mediation analysis, as shown in Figure 1, was conducted using AMOS 27.0. Standardized indirect effects were bootstrapped using 5,000 iterations as suggested by MacKinnon (2008) and Hayes (2009). The maximum likelihood method of covariance structure analysis was used. Sex comparisons were tested with multiple group analysis using pairwise parameter comparisons, a statistical test comparing the difference between path coefficients (Byrne, 2013). This comparison produces a *Z* score indicating the statistical difference between two path coefficients, similar to comparing correlation coefficients.

Missing data occurred at a rate of < 1% and were handled with listwise deletion given recommendations by Schafer (1999) that such little missingness will not bias results. Variables were checked for multicollinearity and found to be within normal limits as indicated by all variance inflation factors < 2. Variables were checked for normality and found to be within normal limits according to Kline (2016).

Results

Table 1 displays correlations and mean comparisons by sex. Men and women did not differ on CT or exercise frequency, but men did have higher BMI than women. CT shared a negative relationship with exercise frequency across sex and shared a positive relationship with BMI in women but not men. Exercise frequency shared a negative relationship with BMI across sex.

As shown in Figure 1, CT shared a positive path with BMI for women but not men, partially supporting hypothesis 1a. CT shared a negative path with exercise frequency (supporting hypothesis 1b), which in turn shared a negative path with BMI (supporting hypothesis 1c) across sex. Supporting hypothesis 2, the indirect effect was significant for women and men. In support of hypothesis 3, the direct effect between CT and BMI was moderated by sex ($Z = 3.93, p < .001$). Failing to support hypothesis 3, the paths involved with the indirect effect were not moderated by sex; thus, moderated mediation was not demonstrated.

Discussion

Results in this study supported parts of the hypothesis that CT did predict an increase in BMI with exercise frequency mediating their relationship. However, the results provided evidence that sex only affected the direct effect (i.e., CT on BMI) rather than the indirect effect pathways (i.e., CT on exercise frequency and exercise frequency on BMI).

The results pertaining to the positive relationship between CT and BMI were consistent with previous literature (Danese & Tan, 2014). Furthermore, the inclusion of exercise frequency revealed that participants who reported higher CT tended to report less exercise, which in turn was associated with a higher BMI. The HBM is a possible explanation for these results. Exercise frequency is the health-related behavior that is being observed, and the problem is BMI. The

results show that related to a higher CT, people were less likely to engage in exercise. Therefore, it is plausible that CT acts as a perceived barrier that associates negatively with the beneficial behavior, in turn associating with BMI. These findings show that exercise may not be as effective of a coping mechanism within this study as hoped. For example, suppose those with additional barriers in their life are most in need of coping but are less likely to do those behaviors in relation to their barriers. In that case, it could be challenging to intervene meaningfully. Furthermore, exercise also can be done obsessively and as a purging technique. High interval training also is a specific coping technique for intense emotions, as seen in those who engage in non-suicidal self-injury (NSSI) in search for an endorphin release (Störkel et al., 2021). Exercise could also be used as a tool to avoid the trauma they have faced, rather than as a direct coping mechanism. Therefore, how and why people exercise is important to understand. Similarly, it has been shown that emotional eating is a coping mechanism for some who have experienced an adverse childhood (Michopoulos et al., 2015). These results could explain a possible coping mechanism, albeit a negative one, within this study that was not measured but could be included in later research.

An interesting finding was that sex as a moderator revealed that only women demonstrated a significant direct relationship between CT and BMI. These results could suggest possible different coping mechanisms that may occur between men and women, which should be examined by future research to add depth to extant literature. Some possible reasoning behind gender differences in coping mechanisms could be rooted back to the expression/development of depressive symptoms. For example, a cross-sectional study by Balkis and Erdinç (2020) revealed that men and women exhibit demandingness, i.e., the insistence of attention from others, as their primary irrational belief system (coping mechanism), which in turn predicted the occurrence of

depressive symptoms through the secondary belief system of awfulizing, i.e., an irrational thought pattern where one tends to overestimate the severity of a situation. However, the study goes on to explain that there are indeed some gender differences. Specifically, men's frustration intolerance, i.e., the inability to withstand obstacles and stressful situations, led them to develop depressive symptoms. In contrast, global evaluation of self, i.e., a cognitive mechanism by which a positive self-concept can be preserved even when a person's interactions with the environment in specific areas do not indicate the existence of outstanding characteristics and abilities (Alicke, 1985), led to the development of depressive symptoms in women. The pathway to developing depressive symptoms provides evidence that men and women differ; thus, men and women may need different interventions. For example, coping mechanisms for frustration tolerance may differ from those for global evaluation of self.

Even though psychopathology was not included in the model, the association between CT and exercise frequency could be explained by other psychological disorders such as depression. Current literature suggests that depression, among other problems, can result from CT and that this depression leads to emotional eating and other maladaptive eating patterns that lead to higher BMI (Amianto et al., 2018). Furthermore, depression can lead to lower quality of health which may be due to lack of exercise (Gerhards et al., 2011).

The current study had certain limitations. The data was gathered in a cross-sectional nature; therefore, no experimental manipulation occurred. With this, the direction of the effects of causality cannot be determined; future research should examine the variables longitudinally. Participants were overwhelmingly White, causing cultural and ethnic limitations in the generalizability of the results. In the future, other studies should examine a more representative population and include other variables such as anxiety and depression to create a more well-

rounded study that may allow for the discovery of possible coping mechanisms and the creation of programs to help the survivors of CT. Also, to expand the scope of this study, different components of exercise could be measured, such as type of exercise, level of intensity, duration, etc. Doing this would allow for a deeper understanding of how specific exercise components moderate the relationship between CT and BMI. Furthermore, research has shown that BMI is not the best measure of obesity due to its limited diagnostic performance (Romero-Corral et al., 2008). Therefore, additional measures for obesity should be utilized; for example, current research reveals that waist circumference is a helpful parameter and positive indicator of overweight and obese subjects (Chinedu et al., 2013). Furthermore, the time period in which the subjects were born and when the data was collected was decades ago; therefore, they may have been exposed to different media pressures and trauma disclosures might be experienced differently in the past than the present, affecting the validity of the results in relation to today's time.

However, the study also possessed strengths. The inclusion of men was very significant in this research study. Throughout the research process and seeking articles that encompass both sexes, there was very little research on EDs in men as well as its relation to CT. This is important to note because according to Jones and Morgan (2010), men account for 10-20% of anorexia nervosa and bulimia nervosa cases and 40% of binge eating diagnoses. This is serious because a lot of the current eating disorder treatments are female centered and there appears to be none that are male-specific (Robinson et al., 2013). Even though men are diagnosed with Eds, it is mainly associated with women, and the men are overlooked (Robinson et al., 2013). Furthermore, Eds, like a lot of mental health disorders, occur in relation to some form of childhood trauma. According to Strother et al. (2012), 30% of people who experienced some form of sexual abuse

developed an ED later in life. However, while looking through the literature, men were highly underrepresented, and it could be due to the stigma and shame behind sexual abuse (Strother et al., 2012). The same could be said with men who experience EDs. Within the study conducted by Robinson et al. (2013), participants stated that they felt as though EDs were thought as a female disorder among society, and the massive amounts of research on females and EDs supported their thoughts. An individual noted that something had to be wrong with him because people who are diagnosed with EDs are just women. Future research needs to focus on EDs among men so that they can be offered treatments that are suited to them. This study is a small step in the inclusion of men in ED/CT research. Furthermore, sex was included as a predictor and moderator rather than a control variable allowing for the results to allow for generalizability of possible sex differences. Also, this study is one of the few that examined CT's impact on exercise frequency, which is important to study because it may provide findings that support a healthy coping mechanism among individuals who struggle in relation to CT.

It is important to understand the complexity of CT on several aspects of life and the impact research can have on those impacted by CT and other trauma. CT and its impact on health is not only a psychological field issue but also one that encapsulates public policy, public/global health, education, etc. By providing evidence that a specific action is a beneficial and healthy coping mechanism, it allows for other sectors to shift the way that certain areas are ran. For example, in regard to policy makers, by providing support that exercise is a beneficial means to cope, they may seek to implement policies within schools, community partnerships, and more that emphasis exercise and its physical and mental health benefits. This then will provide children with a discipline that may allow for them to cope with any trauma they have and may face in the future. Furthermore, with these actions, the health of communities may increase,

lessening the burden on the health care system and other sectors that are impacted by health-related issues. By funding research that seeks to understand CT and coping mechanism such as exercise, that are beneficial to the afflicted, it may allow for prevention plans to be implemented within the community.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Compliance with Ethical Statement

Competing Interests: On behalf of all authors, the corresponding author states that there is no conflict of interest.

Informed Consent: Participants indicated their informed consent on an IRB approved consent form and were treated in accordance with APA Code of Ethics.

Funding: The current study was not funded.

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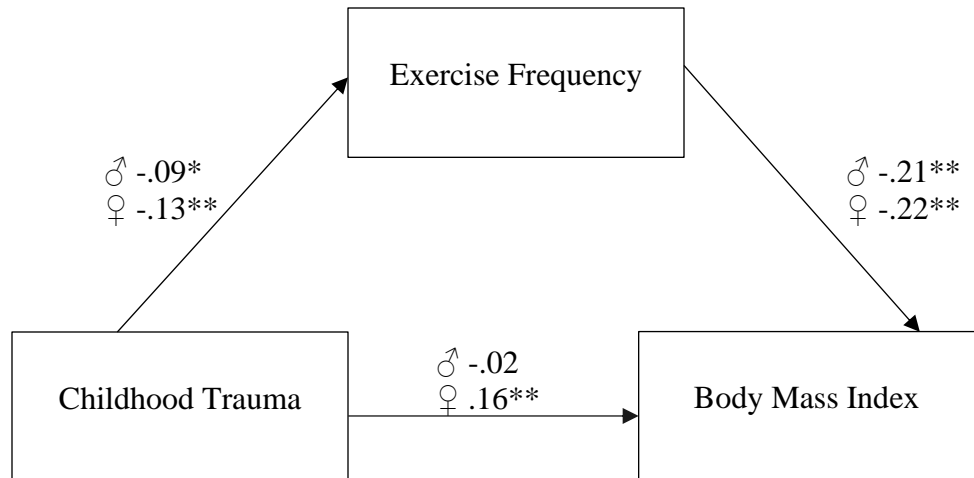
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Table 1

Descriptives Across Gender

	1.	2.	3.	Female <i>M(SD)</i>	Male <i>M(SD)</i>	<i>t</i>
1. Childhood Trauma	1	-.09*	.00	46.96(11.19)	46.60(9.03)	-0.73
2. Exercise Frequency	-.13**	1	-.21**	2.93(1.62)	3.02(1.69)	1.22
3. Body Mass Index	.19**	-.24**	1	24.82(6.00)	26.83(4.46)	7.84**

Note. Correlations for females and males appear below and above the diagonal. * indicates $p < .05$, ** indicates $p < .01$.



Indirect effect of childhood trauma on body mass index: $b = .02^*$ for men, $b = .03^{**}$ for women

Figure 1. Moderated mediation model. Sex was examined as a moderator of all paths with multiple group analysis and pairwise parameter comparisons. ♀ and ♂ indicate female and male coefficients, respectively. Only the direct effect was moderated by sex. ** indicates $p < .001$, * indicates $p = .01$.