Mental Health and Physical Activity 14 (2018) 90–97

Contents lists available at ScienceDirect

Mental Health and Physical Activity

journal homepage: www.elsevier.com/locate/menpa

Stress and self-esteem in adolescence predict physical activity and sedentary behavior in adulthood

Jocelyn Smith Carter

Department of Psychology, DePaul University, 2219 North Kenmore Avenue, Chicago, IL 60614, USA

ARTICLE INFO

Article history:
Received 29 June 2017
Received in revised form
18 January 2018
Accepted 24 February 2018
Available online 1 March 2018

ABSTRACT

High levels of stress, high levels of sedentary behavior (SB), and low levels of physical activity (PA) contribute to risk for obesity. Cross-sectional studies suggest that youth exposed to more stressors are less likely to be physically active and more likely to be sedentary. However, it is not yet clear whether stressors in adolescence predict activity patterns into adulthood or protective factors mitigate the risk of stress exposure. The current study used data from the National Longitudinal Study of Adolescent to Adult Health to determine whether stressors, self-esteem, and the interaction between them predicted changes in PA and SB trajectories over three waves of data collection. Self-report data from 6504 adolescents (48.40% male; 57.4% European American; mean age = 15.53 years) were analyzed using multilevel modeling. Results showed that stressors significantly predicted PA and SB trajectories, but self-esteem was related only to PA. Self-esteem buffered the effects of stressors on PA over time. Results of the current study demonstrate the importance of stressors on both types of adolescent and adult activity and the unique effect of self-esteem as a protective factor on PA patterns.

Published by Elsevier Ltd.

High levels of physical activity and low levels of sedentary behavior are important in maintaining a healthy weight (Boone-Heinonen, Gordon-Larsen, & Adair, 2008; Hills, Andersen, & Byrne, 2011). Unfortunately, most adolescents fail to meet the weekly recommended levels of weekly physical activity (Eaton et al., 2011) and spend approximately half of their leisure time engaged in sedentary activities (Hardy, Bass, & Booth, 2007). Sedentary behavior increases and physical activity decreases in adulthood (Gordon-Larsen, Nelson, & Popkin, 2004) making it critical to understand factors that influence the continuity in health behaviors throughout this transition to prevent obesity and other poor health outcomes in adulthood (Gordon-Larsen et al., 2004; Nelson, Neumark-Sztainer, Hannan, Sirard, & Story, 2006).

Early life exposure to stressors such as poverty and maltreatment have been identified as contributing to poor health outcomes in adulthood. The adverse childhood experiences (ACES) studies have shown that with increased exposure to adverse experiences, the risk for obesity increases (Danese & McEwen, 2012; Felitti et al., 1998). The behavioral and biological model provides an integrated, developmentally-focused approach to clarifying the mechanisms of risk (Miller, Chen, & Parker, 2011). In this model, early psychological stress impacts health behaviors through the mechanism of impaired self-regulation, impulsivity, and future discounting (Miller et al., 2011). These mechanisms are associated with low levels of physical activity and high levels of sedentary behavior (Hall, Fong, Epp, & Elias, 2008; Teixeira et al., 2015).

Stressors (Ge, Lorenz, Conger, Elder, & et al., 1994; Hankin, Mermelstein, & Roesch, 2007) and stress reactivity increase during adolescence (Stroud et al., 2009) which makes understanding the role of stress in health behaviors particularly critical. Recent reviews demonstrate that high levels of stress are associated with greater risk of obesity (Heerman, Krishnaswami, Barkin, & McPheeters, 2016; Wilson & Sato, 2014) and low rates of physical activity (Stults-Kolehmainen & Sinha, 2014), but there is still need to use standardized conceptualizations of stressors across studies to better compare the findings (Grant et al., 2014). Several reviews and meta-analyses in adults reveal small effect sizes for the association between stress and obesity, particularly in longitudinal studies that predict weight gain over time (Wardle, Chida, Gibson, Whitaker, & Steptoe, 2011). Parallel findings with children and adolescents highlight the importance of: (1) identifying sensitive developmental windows for the stress response and (2) consistently measuring and conceptualizing the occurrence of stressors (Wilson & Sato, 2014).

The current study addresses previous gaps in the literature

E-mail address: jcarter9@depaul.edu.

https://doi.org/10.1016/j.mhpa.2018.02.005
1755-2966/Published by Elsevier Ltd.

through measuring the long-term effects of stress exposure during adolescence and focusing on major life events in contrast to perceived stress. While perceived stress has been found to predict obesity, physical activity, and sedentary behavior (Mouchacca, Abbott, & Ball, 2013), perceived stress measures confound the experience of objective stressors with cognitions, affect, and coping responses to stress (Grant et al., 2014). Individuals vary greatly in their response to stress (Hostinar, McQuillan, Mirous, Grant, & Adam, 2014; Stroud et al., 2009) and the failure to distinguish external stressors from their responses likely contributes to mixed findings in this literature. Specific types of stressors such as poverty, neighborhood safety, and interpersonal stressors are associated with higher levels of SB (Brodersen, Steptoe, Williamson, & Wardle, 2005; He, Harris, Piché, & Beynon, 2009) and lower levels of PA (Gordon-Larsen, McMurray, & Popkin, 2000; Molnar, Gortmaker, Bull, & Buka, 2004; Yin, Davis, Moore, & Treiber, 2005), but no studies to date have focused on a broad measure of life events that includes the types of stressors most likely to be experienced by adolescents (Allison et al., 1999).

The current study examines stressors in relation to both physical activity and sedentary behavior to clarify whether they uniquely predict these correlates of obesity and expand the focus of the stress-obesity link. Previous research on proximal predictors of obesity has focused primarily on energy intake rather than activity (Adam et al., 2007; Cartwright et al., 2003). PA and SB are defined in terms of Metabolic Equivalents (METS); SB is waking activity that expends less than 1.5 METs (Tremblay et al., 2017) while PA ranges from light to vigorous and expends between 1.5 and 6 METs (Gibbs, Hergenroeder, Katzmarzyk, Lee, & Jakicic, 2015). While the two constructs are related, they have unique correlates that are important to examine in prospective studies (Brodersen et al., 2005; Gordon-Larsen, McMurray, & Popkin, 1999). Research on adult women shows longitudinal, but not cross-sectional relationships between stressors and both reduced physical activity and increased sedentary behavior suggesting that the impact of stressors develops over time (Mouchacca et al., 2013). Further longitudinal studies are needed to understand the development of these processes in the transition to adulthood.

1. Self-esteem

While stressors confer risk for low activity levels, self-esteem may operate as a resilience factor that may buffer the negative effects of stressors on activity levels (Rutter, 1987). In the broad spectrum framework, self-esteem is a generic protective factor that decreases the risk for a variety of poor physical and mental health outcomes (Mann, Hosman, Schaalma, & De Vries, 2004). Self-esteem can be conceptualized as a predisposing factor that provides the rationale or motivation for engaging in particular behaviors (Mann et al., 2004) including PA and SB (Faulkner, Carson, & Stone, 2014; but see also; Inchley, Kirby, & Currie, 2011). Self-esteem appears to be more closely related to PA than SB (Haugen, Säfvenbom, & Ommundsen, 2011; Neumark-Sztainer et al., 2003), but has not yet been studied in longitudinal stress-buffering models.

Various aspects of self-esteem have been used to understand health behaviors (McClure, Tanski, Kingsbury, Gerrard, & Sargent, 2010; Nihill, Lubans, & Plotnikoff, 2013) but there is a need to clarify which aspects of self-esteem are most closely related to activity levels in order to guide intervention efforts. Hierarchical models posit that self-esteem is composed of multiple levels; global self-esteem is the most superordinate and specific subdomains contribute to global self-esteem (Rosenberg, Schooler, Schoenbach, & Rosenberg, 1995). These specific domains are expected to be closely related to particular behaviors (Schwinger, Schöne, & Otterpohl, 2017), but they also contribute to global self-esteem (Hayes, Crocker, & Kowalski, 1999). Global self-esteem is important to study as an initial test of the stress-buffering hypothesis as it has unique effects on activity levels even when specific domains of physical concept are included in models (Haugen et al., 2011; Nihill et al., 2013).

2. The current study

The integrated biological/behavioral model (Miller et al., 2011) does not yet include resilience factors that mitigate the risk of poor health outcomes in individuals exposed to stress. Resilience theories (Fergus & Zimmerman, 2005; Masten & Powell, 2003) specify interactions between risk factors and individual protective factors such as high self-esteem (Casey, Eime, Payne, & Harvey, 2011; McLeroy, Bibeau, Steckler, & Glanz, 1988). To date, the role of self-esteem as a buffer against the adverse effects of stress has not been studied using longitudinal studies. These are important to consider as they may be responsible for the variation in findings on the influence of self-esteem on PA and SB into adulthood. The current study's purpose was to provide an empirical test of the biological behavioral model with respect to the development of activity behaviors throughout adolescence. Specifically, the current study will examine how stressors and self-esteem influence adolescents' trajectories of PA and SB. It is expected that high levels of stressors will be associated with decreases in PA and increases in SB during the course of adolescence. Additionally, it is expected that adolescents with higher levels of self-esteem will have increases in PA and decreases in SB over time. Finally, interactive effects are expected with positive self-esteem moderating the negative impact of stress on health behaviors (Maturo & Cunningham, 2013).

3. Methods

3.1. Procedure

This study was a secondary analysis of data from the National Longitudinal Study of Adolescent to Adult Health (Harris et al., 2009). This study was designed to be nationally representative of American middle and high school students and over-sampled subgroups that have previously been under-represented in research studies such as middle-income ethnic minority youth (Harris et al., 2016). The sample included 80 high schools and 52 middle schools stratified by region of the country (i.e., Northeast, West) and urbanicity (i.e., rural, urban, suburban; Harris & Udry, 2014, pp. 05–14). Four waves of data have been collected with various methods. At Wave I, parents gave informed consent and adolescents provided informed consent for in-school surveys with adolescents. Parents and adolescents also participated in at-home data collection including surveys and interviews. At Waves II and III, only in-home interviews were conducted. Waves I and II were separated by approximately one year and Waves II and III were separated by approximately five years; Wave IV was not included in the current study (Harris & Udry, 2014, pp. 05–14). The same participants were tracked over time, but the exact dates of the in-home data collections varied within these yearly ranges. The study was approved by the University of North Carolina School of Public Health Institutional Review Board. The data sets and documentation are in the public domain (Harris et al., 2009).

3.2. Participants

The current study included 6504 American adolescents with complete data on study measures at Wave I (48.40% male). The majority of the participants in the study were European American

(57.40%). Additionally, 24.40% participants identified as Black, 11.5% as Hispanic, 3.8% as Asian, 2.0% as Native American, and 0.80% as another race. At Wave I the mean age of participants was 15.53 years ($SD = 1.79$), at Wave II the mean age was 16.02 years ($n = 4832$; $SD = 1.62$), and the Wave III mean age was 21.82 ($n = 4855$; $SD = 1.81$).

3.3. Measures

Sedentary behavior. The SB variable was created using adolescents' self-reports of the hours they spent watching television, watching videos, playing computer games, and listening to the radio in the past week (Kim, Liu, Colabianchi, & Pate, 2010) as a measure of sedentary screen time (Tremblay et al., 2017). The mean number of hours on all activities combined was used in the current study with higher scores representing more SB. The internal consistency of this measure was low with scores ranging from .38 to .39 across waves.

Physical activity. The PA variable was created by using the three types of PA that were available in the first three waves of the study (Kim et al., 2010). These included roller-blading/cycling, playing an active sport, and exercising. Each activity was rated on a weekly basis ranging from 0 (not at all) to 3 (5 or more times per week). The ratings were averaged to create a summary score with higher scores representing more frequent PA. The internal consistency of this measure was low with scores ranging from .40 to .51 across waves.

Stressors. The stress variable consisted of the total occurrence of 25 major life events including stressors such as the death of a parent, running away from home, romantic break-ups, and witnessing violence in the year before Wave I. This variable has been used in other studies and found to be correlated with both obesity and depression (Boardman & Alexander, 2011; Carter, Dellucci, Turek, & Mir, 2015). The alpha coefficient for Wave I stressors was .66.

Self-esteem. Six items from the Rosenberg Self-Esteem Inventory (Rosenberg, 1965) were used to measure global self-esteem at Wave I (e.g., You have a lot of good qualities). These items have a 5-point response scale consisting of answers ranging from 1 (strongly agree) to 5 (strongly disagree). Items were reverse coded and averaged so that higher scores represent higher self-esteem. This measure has been validated for use with adolescents in previous studies (Hagborg, 1993; Supple, Su, Plunkett, Peterson, & Bush, 2013). In the current study, the alpha was good ranging from .85 to .86 across waves.

3.4. Data analysis

Chi-square analyses were used to determine whether there were ethnic and gender differences in study variables. Multi-level modeling with full information maximum likelihood (FIML) was used to test primary study hypotheses. This type of modeling allows each participant to have a unique data collection pattern and includes every available data point in model estimation which is particularly important given the unequal data collection spacing in the current study (Singer & Willett, 2003). In contrast to ordinary regression, multi-level modeling does not assume that individuals' observations across time are independent (Hox, 2010). Models included a level-1 model that specified how individuals changed over time (within-subjects) and a level-2 model that specified how changes varied across individuals (between-subjects; Singer & Willett, 2003). Trajectories for both types of outcomes (PA and SB) were modeled similarly with unconditional means models and unconditional growth models examining whether there are systematic changes in outcomes over time and whether substantive predictors are needed to explain that change (Singer & Willett, 2003). Model-building occurred through the systematic inclusion of between-subjects variables (stressors and self-esteem) as predictors of baseline intercept and trajectory of change (slope). Significant interactions were further interpreted for simple slope significance and visually plotted (Preacher, Curran, & Bauer, 2006).

4. Results

4.1. Attrition analyses

Attrition analyses were conducted to determine whether participants with complete data at all three waves significantly differed from those with incomplete data. Chi-square and ANOVA analyses were used to examine scores on demographic and substantive predictors. A total of 1590 participants were lost to follow-up at Wave III. There were no significant differences on race/ethnicity, gender, or poverty status due to attrition. Similarly, those with missing data did not differ from those with complete data on any Wave I variables including sedentary behavior or physical activity.

4.2. Preliminary analyses

Chi-square analyses showed that there were no ethnic differences in PA and SB. In contrast, one-way ANOVAs showed that males reported more stress, lower self-esteem, more SB, and more PA than females (see Table 1 for full details). Correlations between all study variables were also examined (see Table 2). Of note, the relationship between PA and SB was not significant at any wave. Stress was associated with SB at Wave I only. Self-esteem was negatively correlated with PA at Wave I and positively correlated with PA at Wave III (see Table 2).

Preliminary analyses were also run to confirm that self-esteem predicted PA and SB (rather than PA and SB predicting self-esteem) as modeled in the primary study analyses. Cross-lag panel models were set up in AMOS (IBM SPSS Amos, 2012) with reciprocal paths between self-esteem and each health behavior (See Fig. 1). The PA model did not fit the data well (χ^2 (20, $N = 7$) = 481.10; CFI = .47, RMSEA = .10). The SB model fit the data well (χ^2 (20, $N = 7$) = 14.42, $p < .05$; CFI = .96, RMSEA = .01). In this model, gender predicted Wave I SB ($B = -.59$, $p < .01$) and self-esteem ($B = .19$, $p < .001$), but no significant paths emerged between SB and self-esteem.

4.3. Physical activity models

The physical activity models included sex, but not ethnicity, as control variables based on tests for group differences conducted in the preliminary analyses. The unconditional growth model showed

Table 1
Means and standard deviations of study variables.

	Total		Male		Female	
	Mean	SD	Mean	SD	Mean	SD
1. Stressors[a]	1.84	2.05	2.00	2.25	1.68	1.81
2. Self-esteem[a]	1.91	.58	1.81	.55	2.00	.60
3. WI PA[a]	1.20	.71	1.35	.73	1.07	.66
4. WII PA	1.20	.69	1.18	.69	1.21	.69
5. WIII PA	1.48	1.46	1.44	.03	1.49	.03
6. WI SB[a]	10.16	8.05	10.46	8.39	9.88	7.71
7. WII SB	9.52	7.91	9.59	7.80	9.47	8.01
8. WIII SB	8.73	8.73	8.80	9.01	8.67	8.47

W = Wave; PA = physical activity, SB = sedentary behavior.
[a] Significant sex differences based on one-way ANOVA.

Table 2
Correlations among study variables.

	1	2	3	4	5	6	7	8
1. Stressors	–	.145**	.005	-.014	-.005	.151**	-.023	.015
2. Self-esteem		–	-.230**	-.002	.029*	.023	.011	-.025
3. WI PA			–	.009	-.018	-.004	.004	.039**
4. WII PA				–	.032*	-.012	.007	.014
5. WIII PA					–	.010	.004	-.003
6. WI SB						–	-.048**	.006
7. WII SB							–	.014
8. WIII SB								–
N	6504	6485	6498	4833	4882	6495	4832	4855

W = Wave; PA = physical activity, SB = sedentary behavior.
*$p < .05$, **$p < .01$, ***$p < .001$.

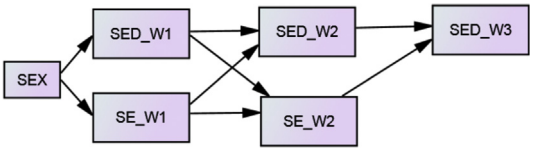

Fig. 1. Reciprocal effects of sedentary behavior and self-esteem over three waves.

that there was a significant effect of time on PA ($B = -.07$, $p < .05$). The complete model included the interaction between stress and self-esteem predicting both intercept and slope, the main effects of stress and self-esteem predicting both intercept and slope, and sex as a control variable (see Table 3 for full results). Sex was a significant predictor of physical activity intercept such that males reported more physical activity. Self-esteem predicted both intercept ($-.50$, $p < .001$) and slope ($.22$, $p < .001$) such that those with higher levels of self-esteem had lower levels of physical activity at baseline, but increased their levels of physical activity over time while those with lower levels of self-esteem decreased their physical activity over time. Stress did not predict PA intercept, but did predict the slope ($-.03$, $p < .001$) such that those with higher levels of stress decreased their physical activity levels over time.

The stress x self-esteem interaction showed a trend towards predicting the PA intercept (B = .01, $p = .05$) and significantly predicted the slope (B = .01, $p < .05$). Simple slope analyses showed that at Wave I, the relation between stress and PA was not significant ($t = 1.63$, p = .10), but by Wave III, it was significant ($t = 3.75$, $p < .001$; see Fig. 2). Those with low and high levels of stress had similar levels of PA at Wave I, but those with high levels of stress had sharper declines in PA than those with low levels of stress. The simple slope for self-esteem predicting the PA trajectory showed that the relation between self-esteem and PA was significant at both Time 1 ($t = 13.55$, $p < .001$) and Time 3 ($t = 5.11$, $p < .001$). At Wave I, those with low self-esteem had higher levels of PA than those with high self-esteem, but by Wave III, those with high self-esteem had higher levels of PA than those with low self-esteem. The interaction terms with sex were not statistically significant indicating that the pattern of relationships did not significantly differ by sex.

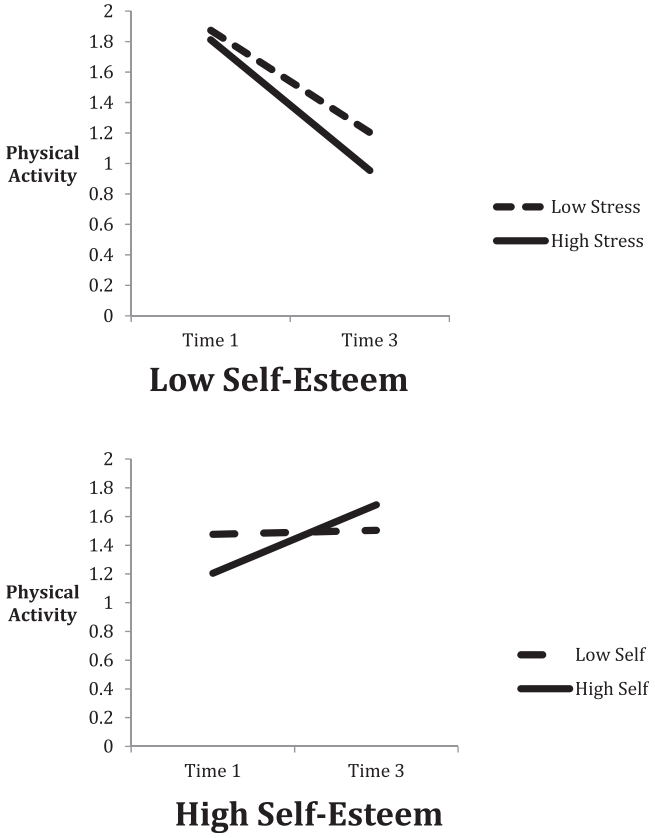

Fig. 2. Stress x Self-Esteem Predicting Physical Activity Trajectories.

Table 3
Multilevel modeling results for stressors, self-esteem, and the interaction between them.

	Physical Activity		Sedentary Behavior	
	B	SE	B	SE
Intercept	2.21***	.06	8.91***	.61
Sex	-.14***	.02	-.39*	.17
Stress	.01	.01	.91***	.12
Self-esteem	-.50***	.03	.62*	.30
Stress x self-esteem	.01	.01	-.07	.05
Time (rate of change)	-.32***	.03	.29	.27
Stress	-.03***	.01	-.35***	.06
Self-esteem	.22***	.02	-.25	.14
Stress x self-esteem	.01*	.01	.04	.03
Variance component				
Repeated Measures: W1	.47***	.01	63.35***	1.11
Repeated Measures: W2	.48***	.01	62.85***	1.28
Repeated Measures: W3	2.18***	.04	76.37***	1.55

*$p < .05$, **$p < .01$, ***$p < .001$.

4.4. Sedentary behavior models

Parallel models were run with SB as the outcome variable. The unconditional growth model showed that there was a significant effect for time on SB ($B = -.71$, $p < .001$). Sex was a significant

predictor of sedentary behavior intercept such that males reported more sedentary behavior. Self-esteem significantly predicted the intercept (B = .62, $p < .05$) and showed a trend towards predicting the slope (B = −.25, $p = .07$). Stress significantly predicted the intercept (B = .91, $p < .001$) and slope (B = −.35, $p < .001$). The interaction between stress and self-esteem did not significantly predict the SB intercept or slope. The simple slope analyses for the main effect of stress showed that stress significantly predicted SB at Wave I ($t = 5.29$, $p < .001$), but not at Wave III ($t = .95$, p = .34; see Fig. 3). Those with high levels of stress had more SB at Time 1 than did those with low levels of stress, but the rates of SB decreased in this group over time. The interaction terms with sex included were not statistically significant indicating that the pattern of relationships did not significantly differ by sex.

5. Discussion

The primary purpose of the current study was to prospectively test the biological/behavioral model of stress by examining the effects of stressors on adolescent and adult trajectories of PA and SB. The secondary purpose was to determine whether high self-esteem protected youth from poor health profiles after exposure to stress. The results showed similarities and differences in the impact of stress and self-esteem on the two types of health behaviors. As expected, stressors were a consistent predictor of both PA and SB. In contrast, self-esteem predicted only PA and not SB. Finally, self-esteem moderated the impact of stressors on PA over time showing that youth with more self-esteem increased their PA over time while youth with lower self-esteem and more stressors decreased their PA over time. There was no moderating effect for self-esteem on SB. To our knowledge, this is the first study to test the moderating role of self-esteem on the relation between stressors and PA in the transition to adulthood and provides longitudinal support for a stress-buffering model of PA.

5.1. Stress

With its focus on major life events, the current study expands the knowledge of the impact of stressors on health behaviors and provides a developmentally-sensitive test of the impact of stressors on physical health behaviors (Miller et al., 2011). Previous studies have focused on the stressors of poverty and violence as ecological predictors of SB and PA (Gordon-Larsen et al., 2000; Gómez, Johnson, Selva, & Sallis, 2004; Singh, Yu, Siahpush, & Kogan, 2008) while the current study shows that major life events are also contributors to activity patterns. The impact of stressors on PA and SB suggest that these activity patterns are mechanisms through

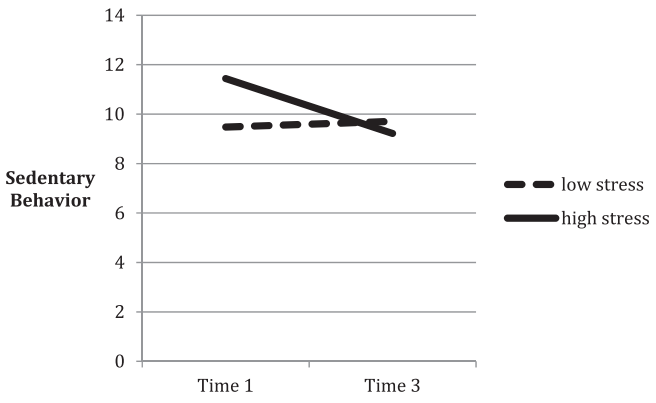

Fig. 3. Stress predicting sedentary behavior trajectories.

which early stressors impact later obesity in youth (Lumeng et al., 2013).

The biological/behavioral model posits that stressors impact specific health behaviors through the mechanisms of executive functioning, specifically decreased self-regulation, impulsivity, and future discounting (Miller et al., 2011). These mechanisms have not yet been explicitly studied in relation to physical activity and sedentary behavior, but related constructs such as action planning and coping strategies predict physical activity (Araújo-Soares, McIntyre, & Sniehotta, 2009; Balantekin & Roemmich, 2012). Sedentary behavior may be a reinforcing type of avoidant or distraction coping, but some coping measures include both sedentary behaviors and exercising as types of distraction coping (Connor-Smith, Compas, Wadsworth, Thomsen, & Saltzman, 2000; Hutchinson, Baldwin, & Oh, 2006) which makes it challenging to determine which type of activity contributes to high score on measures. These challenges to individuals' regulatory systems are magnified by the corresponding challenges on individuals' social environments as stressors impact health behaviors through the disruption of family routines and relationships (Lundahl, Nelson, Van Dyk, & West, 2013; O'Connor et al., 2017; S. G. Trost & Loprinzi, 2011) that facilitate engagement in physical activity and increase the likelihood of SB.

5.2. Self-esteem

Despite the clear negative impact on stressors on sedentary behavior and physical activity patterns into adulthood, the current study also identified self-esteem as a protective factor with relation to physical activity. Adolescents with high levels of stress and high levels of self-esteem had trajectories of increasing physical activity over time. This finding is important because it identifies a mechanism of resilience in stress-exposed adolescents. For example, youth with higher self-esteem are more likely to value their health (Schmitz et al., 2002), feel challenged and motivated by stressors rather than threatened (Seery, 2011), and seek help in responding to stressors (Trzesniewski et al., 2006). Previous studies have identified self-esteem as a protective factor in relation to psychological outcomes and health risk behaviors (Mann et al., 2004). The current study builds on this literature by extending it to health lifestyle behaviors that contribute to physical health outcomes. Furthermore, this is one of the first studies to test this model in a specific interactive effects model (Masten & Powell, 2003).

The failure to find a buffering effect of self-esteem on sedentary behavior is consistent with previous studies that have also failed to find associations between self-esteem and sedentary behavior (Faulkner et al., 2014; Webb, Benjamin, Gammon, McKee, & Biddle, 2013). Those studies differed from the current study in that they were both cross-sectional in nature and included measures of subdomains of self-esteem that were related to sedentary behavior. More research is needed on the relative utility of global versus specific conceptualizations of self-esteem. In a study of Australian adolescent girls, global self-esteem, but not physical self-concept, was negatively associated with specific types of sedentary behavior, but not others (Nihill et al., 2013). Future research in this area should explore the possibility that specific dimensions of self-esteem and specific types of sedentary behavior may be more closely related to each other than the broader measures used in the current study.

5.3. Physical activity and sedentary behavior trends and patterns

The overall study trends for physical activity and sedentary behavior differed from what was hypothesized given previous research with this sample (Gordon-Larsen et al., 2004). Contrary to

study hypotheses, mean levels of PA increased over time and mean levels of SB decreased over time. The current study measured PA and SB as continuous variables rather than measuring them as the likelihood of obtaining recommended levels of each activity (Gordon-Larsen et al., 2004) which may explain the differences in findings. At Wave III, participants in the current study reported 1.5 h per week of physical activity which is lower than the current recommendations for 150 min of moderate to vigorous PA per week (U.S. Department of Health and Human Services, 2008). The Australian government has released guidelines on the benefits of taking breaks from sitting (Australian Government Department of Health, 2014). Although there are not yet formal recommendation for how many breaks are needed, more frequent breaks from sitting are associated with better health outcomes (Owen, Healy, Matthews, & Dunstan, 2010). Future research in sedentary behavior should also measure periods of prolonged sitting to increase precision in the measurement of the types of sedentary behavior that are most dangerous to health (Hamilton, Healy, Dunstan, Zderic, & Owen, 2008).

Additionally, the current study revealed only sex and not ethnic/racial differences in mean levels of SB or PA at any wave. At Wave I, boys reporting higher levels of both PA and SB. Although sex significantly predicted both PA and SB in the MLM analyses, sex did not have a significant moderating effect on either outcome suggesting that the patterns of the relationships between variables was consistent across both sexes. Other studies have found that separating PA into intensity categories and measuring PA and SB using accelerometers reveals sex and ethnic/racial differences (Brodersen, Steptoe, Boniface, & Wardle, 2007; Gordon-Larsen, Adair, & Popkin, 2002; Troiano, Berrigan, & Dodd, 2008).

5.4. Strengths and limitations

The current study has several strengths as well as limitations that provide directions for further research. This study's strengths include its nationally-representative, ethnically diverse, American sample; longitudinal modeling of behaviors during a critical developmental period; and theoretically-driven hypotheses. The study's primary limitations include the self-report of PA and SB, single time-point assessment of stressors and self-esteem, uneven spacing of measurement occasions, and focus on global self-esteem. While adolescents and adults are adequate reporters of their activity levels (Prince et al., 2008; Sallis, Buono, Roby, Micale, & Nelson, 1993), objective physical measurement such as accelerometers are the preferred method for capturing activity while minimizing reporting errors (Trost et al., 2002). The current study asked youth to report on only the past seven days increasing the likelihood of accurate reporting. The current study's first two waves of data were separated by one year and the second and third were separated by five years and demonstrated the impact that adolescents stressors can have on activity over the long term. The MLM analyses accounted for these differences in the timing of waves, but shorter-term longitudinal studies will be critical in identifying the mechanisms and processes that are involved in this effect. Global self-esteem was chosen as a broad spectrum protective factor (Mann et al., 2004), but additional types of cognitions such as physical self-concept and self-efficacy are important to consider as well (Babic et al., 2014; Hagger, Chatzisarantis, & Biddle, 2001).

6. Summary

In summary, the current study found support for the biological/behavior model with prospective relations between stress and PA and SB (Miller et al., 2011). The stress-buffering role of self-esteem showed specificity across the two outcomes with an effect for PA only. The current study shows how stressors that occur during adolescence continue to put adults at risk for low activity levels and poor health outcomes in adulthood.

References

Adam, T. C., Epel, E. S., McLean, N. J., Davis, E. A., Byrne, S. M., Daniels, S., & Johnson, C. (2007). Stress, eating and the reward system. *Physiology & Behavior, 91*(4), 449–458. https://doi.org/10.1016/j.physbeh.2007.04.011.

Allison, K. W., Burton, L., Marshall, S., Perez-Febles, a, Yarrington, J., Kirsh, L. B., et al. (1999). Life experiences among urban adolescents: Examining the role of context. *Child Development, 70*(4), 1017–1029.

Araújo-Soares, V., McIntyre, T., & Sniehotta, F. F. (2009). Predicting changes in physical activity among adolescents: The role of self-efficacy, intention, action planning and coping planning. *Health Education Research, 24*(1), 128–139. https://doi.org/10.1093/her/cyn005.

Australian Government Department of Health. (2014). Australia's physical activity and sedentary behaviour guidelines for adults (18-64 years). *Australian Government*, 1–8.

Babic, M. J., Morgan, P. J., Plotnikoff, R. C., Lonsdale, C., White, R. L., & Lubans, D. R. (2014). Physical activity and physical self-concept in uouth: Systematic review and meta-analysis. *Sports Medicine, 44*(11), 1589–1601. https://doi.org/10.1007/s40279-014-0229-z.

Balantekin, K. N., & Roemmich, J. N. (2012). Children's coping after psychological stress. *Choices among food, physical activity, and television, 59*, 298–304. https://doi.org/10.1016/j.appet.2012.05.016.

Boardman, J. D., & Alexander, K. B. (2011). Stress trajectories, health behaviors, and the mental health of black and white young adults. *Social Science & Medicine, 72*(10), 1659–1666.

Boone-Heinonen, J., Gordon-Larsen, P., & Adair, L. S. (2008). Obesogenic clusters: Multidimensional adolescent obesity-related behaviors in the U.S. *Annals of Behavioral Medicine, 36*(3), 217–230. https://doi.org/10.1007/s12160-008-9074-3.

Brodersen, N. H., Steptoe, A., Boniface, D. R., & Wardle, J. (2007). Trends in physical activity and sedentary behaviour in adolescence: Ethnic and socioeconomic differences 350. *British Journal of Sports Medicine*, (41), 140–144.

Brodersen, N. H., Steptoe, A., Williamson, S., & Wardle, J. (2005). Sociodemographic, developmental, environmental, and psychological correlates of physical activity and sedentary behavior at age 11 to 12. *Annals of Behavioral Medicine, 29*(1), 2–11. https://doi.org/10.1207/s15324796abm2901_2.

Carter, J. S., Dellucci, T., Turek, C., & Mir, S. (2015). Predicting depressive symptoms and weight from adolescence to adulthood: Stressors and the role of protective factors. *Journal of Youth and Adolescence, 44*(11), 2122–2140. https://doi.org/10.1007/s10964-015-0301-5.

Cartwright, M., Wardle, J., Steggles, N., Simon, A. E., Croker, H., & Jarvis, M. J. (2003). Stress and dietary practices in adolescents. *Health Psychology, 22*(4), 362–369. https://doi.org/10.1037/0278-6133.22.4.362.

Casey, M. M., Eime, R. M., Payne, W. R., & Harvey, J. T.. (n.d.). Using a socioecological approach to examine participation in sport and physical activity among rural adolescent girls. https://doi.org/10.1177/1049732309338198.

Connor-Smith, J. K., Compas, B. E., Wadsworth, M. E., Thomsen, A. H., & Saltzman, H. (2000). Responses to stress in adolescence: Measurement of coping and involuntary stress responses. *Journal of Consulting and Clinical Psychology, 68*(6), 976–992. https://doi.org/10.1037//0022-006X.68.6.976.

Danese, A., & McEwen, B. S. (2012). Adverse childhood experiences, allostasis, allostatic load, and age-related disease. *Physiology & Behavior, 106*, 29–39. https://doi.org/10.1016/j.physbeh.2011.08.019.

Eaton, D. K., Kann, L., Kinchen, S., Shanklin, S., Flint, K. H., Hawkins, J., & Wechsler, H. (2011). Youth risk behavior surveillance — United States, 2011. *Morbidity and Mortality Weekly Report - Surveillance Summaries, 61*, 1–162. https://doi.org/10.2307/24806047.

Faulkner, G., Carson, V., & Stone, M. (2014). Objectively measured sedentary behaviour and self-esteem among children. *Mental Health and Physical Activity, 7*(1), 25–29. https://doi.org/10.1016/j.mhpa.2013.11.001.

Felitti, V. J., Anda, R. F., Nordenberg, D., Williamson, D. F., Spitz, A. M., Edwards, V., & Marks, J. S. (1998). Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults: The adverse childhood experiences (ACE) study. *American Journal of Preventive Medicine, 14*(4), 245–258. https://doi.org/10.1016/S0749-3797(98)00017-8.

Fergus, S., & Zimmerman, M. A. (2005). Adolescent resilience: A framework for understanding healthy development in the face of risk. *Annual Review of Public Health, 26*, 399–419.

Ge, X., Lorenz, F. O., Conger, R. D., Elder, G. H., et al. (1994). Trajectories of stressful life events and depressive symptoms during adolescence. *Developmental Psychology, 30*(4), 467–483. https://doi.org/10.1037/0012-1649.30.4.467.

Gibbs, B. B., Hergenroeder, A. L., Katzmarzyk, P. T., Lee, I.-M., & Jakicic, J. M. (2015). Definition, measurement, and health risks associated with sedentary behavior. *Medicine & Science in Sports & Exercise, 47*(6), 1295–1300. https://doi.org/10.1249/MSS.0000000000000517.

Gómez, J. E., Johnson, B. A., Selva, M., & Sallis, J. F. (2004). Violent crime and outdoor physical activity among inner-city youth. *Preventive Medicine, 39*(5), 876–881. https://doi.org/10.1016/j.ypmed.2004.03.019.

Gordon-Larsen, P., Adair, L. S., & Popkin, B. M. (2002). Ethnic differences in physical

activity and inactivity patterns and overweight status. *Obesity Research, 10*(3), 141–149. https://doi.org/10.1038/oby.2002.23.
Gordon-Larsen, P., McMurray, R. G., & Popkin, B. M. (1999). Adolescent physical activity and inactivity vary by ethnicity: The national longitudinal study of adolescent health. *The Journal of Pediatrics, 135*(3), 301–306.
Gordon-Larsen, P., McMurray, R. G., & Popkin, B. M. (2000). Determinants of adolescent physical activity and inactivity patterns. *Pediatrics, 105*(6). Retrieved from http://pediatrics.aappublications.org/content/105/6/e83.short.
Gordon-Larsen, P., Nelson, M. C., & Popkin, B. M. (2004). Longitudinal physical activity and sedentary behavior trends: Adolescence to adulthood. *American Journal of Preventive Medicine, 27*(4), 277–283. https://doi.org/10.1016/j.amepre.2004.07.006.
Grant, K. E., McMahon, S. D., Carter, J. S., Carleton, R. A., Adam, E. K., & Chen, E. (2014). The influence of stressors on the development of psychopathology. In *Handbook of developmental psychopathology* (pp. 205–223). New York: Springer.
Hagborg, W. J. (1993). The Rosenberg self-esteem scale and Harter's self-perception profile for adolescents: A concurrent validity study. *Psychology in the Schools, 30*(2), 132–136, 10.1002/1520-6807(199304)30:2<132::AID-PITS2310300205>3.0.CO;2-Z.
Hagger, M. S., Chatzisarantis, N., & Biddle, S. J. H. (2001). The influence of self-efficacy and past behaviour on the physical activity intentions of young people. *J Sports Sci, 19*(9), 711–725.
Hall, P. A., Fong, G. T., Epp, L. J., & Elias, L. J. (2008). Executive function moderates the intention-behavior link for physical activity and dietary behavior. *Psychology and Health, 23*(3), 309–326. https://doi.org/10.1080/14768320701212099.
Hamilton, M. T., Healy, G. N., Dunstan, D. W., Zderic, T. W., & Owen, N. (2008). Too little exercise and too much sitting: Inactivity physiology and the need for new recommendations on sedentary behavior. *Current Cardiovascular Risk Reports, 2*(4), 292–298. https://doi.org/10.1007/s12170-008-0054-8.
Hankin, B. L., Mermelstein, R., & Roesch, L. (2007). Sex differences in adolescent depression: Stress exposure and reactivity models. *Child Development, 78*(1), 279–295. https://doi.org/10.1111/j.1467-8624.2007.00997.x.
Hardy, L. L., Bass, S. L., & Booth, M. L. (2007). Changes in sedentary behavior among adolescent girls: A 2.5-year prospective cohort study. *Journal of Adolescent Health, 40*, 158–165. https://doi.org/10.1016/j.jadohealth.2006.09.009.
Harris, K. M., Halpern, C. T., Whitsel, E., Hussey, J., Tabor, J., Entzel, P., et al. (2016). *The national longitudinal study of adolescent to adult Health: Research design. 2009*. http://www. cpc. unc. edu/projects/addhealth/design. Accessed, 5.
Harris, K. M., Halpern, C. T., Whitsel, E., Hussey, J., Tabor, J., Entzel, P., et al. (2009). *The national longitudinal study of adolescent to adult health: research design [WWW document]*. URL: http://www.cpc.unc.edu/projects/addhealth/design.
Harris, K. M., & Udry, J. R. (2014). *National longitudinal study of adolescent to adult health (add health), 1994–2008 [public use]. ICPSR21600-v15*. Chapel Hill, NC: Carolina Population Center, University of North Carolina-Chapel Hill. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributors].
Haugen, T., Säfvenbom, R., & Ommundsen, Y. (2011). Physical activity and global self-worth: The role of physical self-esteem indices and gender. *Mental Health and Physical Activity, 4*(2), 49–56.
Hayes, S. D., Crocker, P. R. E., & Kowalski, K. C. (1999). Gender differences in physical self-perceptions, global self-esteem and physical activity: Evaluation of the physical self-perception profile model. *Journal of Sport Behavior, 22*(1), 1–14. Retrieved from http://search.proquest.com/docview/215874425?accountid=10134.
Heerman, W. J., Krishnaswami, S., Barkin, S. L., & McPheeters, M. (2016). Adverse family experiences during childhood and adolescent obesity. *Obesity, 24*(3), 696–702. https://doi.org/10.1002/oby.21413.
He, M., Harris, S., Piché, L., & Beynon, C. (2009). Understanding screen-related sedentary behavior and its contributing factors among school-aged children: A social-ecologic exploration. *American Journal of Health Promotion, 23*(5), 299–308. https://doi.org/10.4278/ajhp.07070965.
Hills, A. P., Andersen, L. B., & Byrne, N. M. (2011). Physical activity and obesity in children. *British Journal of Sports Medicine, 45*(11), 866–870. https://doi.org/10.1136/bjsports-2011-090199.
Hostinar, C. E., McQuillan, M. T., Mirous, H. J., Grant, K. E., & Adam, E. K. (2014). Cortisol responses to a group public speaking task for adolescents: Variations by age, gender, and race. *Psychoneuroendocrinology, 50*, 155–166. https://doi.org/10.1016/j.psyneuen.2014.08.015.
Hox, J. (2010). Multilevel analysis - techniques and applications. *Multilevel analysis techniques and applications*.
Hutchinson, S. L., Baldwin, C. K., & Oh, S. S. (2006). Adolescent coping: Exploring adolescents' leisure-based responses to stress. *Leisure Sciences, 28*(2), 115–131. https://doi.org/10.1080/01490400500483984.
IBM SPSS Amos. (2012). *Ibm SPSS Amos. IBM software business analytics, YTD03114-U*.
Inchley, J., Kirby, J., & Currie, C. (2011). Longitudinal changes in physical self-perceptions and associations with physical activity during adolescence. *Pediatric Exercise Science, 23*(2), 237–249. https://doi.org/10.1123/pes.23.2.237.
Kim, J., Liu, J., Colabianchi, N., & Pate, R. R. (2010). The effect of perceived and structural neighborhood conditions on adolescents' physical activity and sedentary behaviors. *Archives of Pediatrics and Adolescent Medicine, 164*(10), 935–942. https://doi.org/10.1001/archpediatrics.2010.167.
Lumeng, J. C., Wendorf, K., Pesch, M. H., Appugliese, D. P., Kaciroti, N., Corwyn, R. F., et al. (2013). Overweight adolescents and life events in childhood. *Pediatrics, 132*(6), e1506–e1512.
Lundahl, A., Nelson, T. D. V., Dyk, T. R., & West, T. (2013). Psychosocial stressors and health behaviors: Examining sleep, sedentary behaviors, and physical activity in a low-income pediatric sample. *Clinical Pediatrics, 52*(8), 721–729. https://doi.org/10.1177/0009922813482179.
Mann, M., Hosman, C. M. H., Schaalma, H. P., & De Vries, N. K. (2004). Self-esteem in a broad-spectrum approach for mental health promotion. *Health Education Research, 19*(4), 357–372. https://doi.org/10.1093/her/cyg041.
Masten, A. S., & Powell, J. L. (2003). A resilience framework for research, policy, and practice. *In Resilience and Vulnerability: Adaptation in the Context of Childhood Adversities*, 1–26. https://doi.org/10.1017/CBO9780511615788.003.
Maturo, C. C., & Cunningham, S. A. (2013). Influence of friends on children's physical activity: A review. *American Journal of Public Health, 103*(7), e23–e38.
McClure, A. C., Tanski, S. E., Kingsbury, J., Gerrard, M., & Sargent, J. D. (2010). Characteristics associated with low self-esteem among US adolescents. *Academic Pediatrics, 10*(4), 238–244. e2 https://doi.org/10.1016/j.acap.2010.03.007.
McLeroy, K. R., Bibeau, D., Steckler, A., & Glanz, K. (1988). An ecological perspective on health promotion programs. *Health Education Quarterly, 15*, 351–377. https://doi.org/10.1177/109019818801500401.
Miller, G. E., Chen, E., & Parker, K. J. (2011). Psychological stress in childhood and susceptibility to the chronic diseases of aging: Moving toward a model of behavioral and biological mechanisms. *Psychological Bulletin, 137*(6), 959–997. https://doi.org/10.1037/a0024768.
Molnar, B. E., Gortmaker, S. L., Bull, F. C., & Buka, S. L. (2004). Unsafe to play? Neighborhood disorder and lack of safety predict reduced physical activity among urban children and adolescents. *American Journal of Health Promotion, 18*(5), 378–386.
Mouchacca, J., Abbott, G. R., & Ball, K. (2013). Associations between psychological stress, eating, physical activity, sedentary behaviours and body weight among women: A longitudinal study. *BMC Public Health, 13*(1), 828. https://doi.org/10.1186/1471-2458-13-828.
Nelson, M., Neumark-Stzainer, D., Hannan, P. J., Sirard, J. R., & Story, M. (2006). Longitudinal and secular trends in physical activity and sedentary behavior during adolescence. *Pediatrics, 118*(6), e1627–e1634. Retrieved from http://pediatrics.aappublications.org/content/118/6/e1627.short.
Neumark-Sztainer, D., Story, M., Hannan, P. J., Tharp, T., Rex, J., & Services, U. D. (2003). Factors associated with changes in physical activity. *Archives of Pediatrics and Adolescent Medicine, 157*(8), 803. https://doi.org/10.1001/archpedi.157.8.803.
Nihill, G. F. J., Lubans, D. R., & Plotnikoff, R. C. (2013). Associations between sedentary behavior and self-esteem in adolescent girls from schools in low-income communities. *Mental Health and Physical Activity, 6*(1), 30–35. https://doi.org/10.1016/j.mhpa.2012.02.003.
Owen, N., Healy, G. N., Matthews, C. E., & Dunstan, D. W. (2010). Too much sitting: The population health science of sedentary behavior. *Exercise and Sport Sciences Reviews, 38*(3), 105–113. https://doi.org/10.1097/JES.0b013e3181e373a2.
O'Connor, S. G., Maher, J. P., Belcher, B. R., Leventhal, A. M., Margolin, G., Shonkoff, E. T., et al. (2017). Associations of maternal stress with children's weight-related behaviours: A systematic literature review. *Obesity Reviews, 18*(5), 514–525. https://doi.org/10.1111/obr.12522.
Preacher, K. J., Curran, P. J., & Bauer, D. J. (2006). Computational tools for probing interactions in multiple linear regression, multilevel modeling, and latent curve analysis. *Journal of Educational and Behavioral Statistics, 31*(4), 437–448. https://doi.org/10.3102/10769986031004437.
Prince, S., Adamo, K., Hamel, M., Hardt, J., Gorber, S., & Tremblay, M. (2008). A comparison of direct versus self-report measures for assessing physical activity in adults: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 5*(56). https://doi.org/10.1186/1479-5868-5-56.
Rosenberg, M. (1965). *Rosenberg Self-Esteem Scale*. New York https://doi.org//S0034-98872009000600009.
Rosenberg, M., Schooler, C., Schoenbach, C., & Rosenberg, F. (1995). Global self-esteem and specific self-esteem: Different concepts, different Outcomes. *American sociological review, 60*(1), 141. https://doi.org/10.2307/2096350.
Rutter, M. (1987). Psycholocial resilience and protective mechanisms. *American Journal of Orthopsychiatry, 57*(3), 316–331. https://doi.org/10.1111/j.1939-0025.1987.tb03541.x.
Sallis, J. F., Buono, M. J., Roby, J. J., Micale, F. G., & Nelson, J. A. (1993). Seven-day recall and other physical activity self-reports in children and adolescents. *Medicine & Science in Sports & Exercise, 25*, 99–108. https://doi.org/10.1249/00005768-199301000-00014.
Schmitz, K. H., Lytle, L. A., Phillips, G. A., Murray, D. M., Birnbaum, A. S., & Kubik, M. Y. (2002). Psychosocial correlates of physical activity and sedentary leisure habits in young adolescents: The Teens Eating for Energy and Nutrition at School Study. *Preventive Medicine, 34*(2), 266–278. https://doi.org/10.1006/pmed.2001.0982.
Schwinger, M., Schöne, C., & Otterpohl, N. (2017). Structure of contingent self-esteem: Global, domain-specific, or hierarchical construct? *European Journal of Psychological Assessment, 33*(5), 388–397. https://doi.org/10.1027/1015-5759/a000296.
Seery, M. D. (2011). Challenge or threat? Cardiovascular indexes of resilience and vulnerability to potential stress in humans. *Neuroscience & Biobehavioral Reviews, 35*(7), 1603–1610. https://doi.org/10.1016/j.neubiorev.2011.03.003.
Singer, J. D., & Willett, J. B. (2003). *Applied longitudinal data Analysis: Modeling change and event occurrence*. Oxford: Oxford University Press.
Singh, G. K., Yu, S. M., Siahpush, M., & Kogan, M. D. (2008). High levels of physical inactivity and sedentary behaviors among US immigrant children and adolescents. *Archives of Pediatrics and Adolescent Medicine, 162*(8), 756–763.
Stroud, L. R., Foster, E., Papandonatos, G. D., Handwerger, K., Granger, D. A.,

Kivlighan, K. T., et al. (2009). Stress response and the adolescent transition: Performance versus peer rejection stressors. *Development and Psychopathology, 21*(1), 47. https://doi.org/10.1017/S0954579409000042.

Stults-Kolehmainen, M. A., & Sinha, R. (2014). The effects of stress on physical activity and exercise. *Sports Medicine, 44*(1), 81–121. https://doi.org/10.1007/s40279-013-0090-5.

Supple, A. J., Su, J., Plunkett, S. W., Peterson, G. W., & Bush, K. R. (2013). Factor structure of the Rosenberg self-esteem scale. *Journal of Cross-cultural Psychology, 44*(5), 748–764. https://doi.org/10.1177/0022022112468942.

Teixeira, P. J., Carraça, E. V., Marques, M. M., Rutter, H., Oppert, J. M., De Bourdeaudhuij, I., et al. (2015). Successful behavior change in obesity interventions in adults: A systematic review of self-regulation mediators. *BMC Medicine, 13*, 84–100. https://doi.org/10.1186/s12916-015-0323-6.

Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., Latimer-Cheung, A. E., et al. (2017). Sedentary behavior research network (SBRN) – terminology consensus project process and outcome. *International Journal of Behavioral Nutrition and Physical Activity, 14*(1), 75. https://doi.org/10.1186/s12966-017-0525-8.

Troiano, R., Berrigan, D., & Dodd, K. (2008). Physical activity in the United States measured by accelerometer. *Medicine in Science in Sport and Exercise, 40*(1), 181–188.

Trost, S. G., & Loprinzi, P. D. (2011). Parental influences on physical activity behavior in children and adolescents: A brief review. *American Journal of Lifestyle Medicine, 5*(2), 171–181. https://doi.org/10.1177/1559827610387236.

Trost, S. G., Pate, R. R., Sallis, J. F., Freedson, P. S., Taylor, W. C., Dowda, M., et al. (2002). Age and gender differences in objectively measured physical activity in youth. *Medicine in Science in Sport and Exercise, 34*(2), 350–355. https://doi.org/10.1097/00005768-200202000-00025.

Trzesniewski, K. H., Donnellan, M. B., Moffitt, T. E., Robins, R. W., Poulton, R., & Caspi, A. (2006). Low self-esteem during adolescence predicts poor health, criminal behavior, and limited economic prospects during adulthood. *Developmental Psychology, 42*(2), 381–390. https://doi.org/10.1037/0012-1649.42.2.381.

U.S. Department of Health and Human Services. (2008). 2008 Physical activity guidelines for Americans. *President's Council on Physical Fitness & Sports Research Digest, 9*(4), 1–8. https://doi.org/10.4085/1062-6050-44.1.5.

Wardle, J., Chida, Y., Gibson, E. L., Whitaker, K. L., & Steptoe, A. (2011). Stress and adiposity: A meta-analysis of longitudinal studies. *Obesity, 19*(4), 771–778. https://doi.org/10.1038/oby.2010.241.

Webb, O. J., Benjamin, C. C., Gammon, C., McKee, H. C., & Biddle, S. J. H. (2013). Physical activity, sedentary behaviour and physical self-perceptions in adolescent girls: A mediation analysis. *Mental Health and Physical Activity, 6*(1), 24–29.

Wilson, S. M., & Sato, A. F. (2014). Stress and paediatric obesity: What we know and where to go. *Stress and Health, 30*(2), 91–102. https://doi.org/10.1002/smi.2501.

Yin, Z., Davis, C. L., Moore, J. B., & Treiber, F. A. (2005). Physical activity buffers the effects of chronic stress on adiposity in youth. *Annals of Behavioral Medicine, 29*(1), 29–36. https://doi.org/10.1207/s15324796abm2901_5.