Life Events and Longitudinal Effects on Physical Activity: Adolescence to Adulthood

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ABSTRACT

MILLER, J., T. NELSON, D. J. BARR-ANDERSON, M. J. CHRISTOPH, M. WINKLER, and D. NEUMARK-SZTAINER. Life Events and Longitudinal Effects on Physical Activity: Adolescence to Adulthood. *Med. Sci. Sports Exerc.*, Vol. 51, No. 4, pp. 663–670, 2019. **Introduction**: Common life events, such as getting married or gaining employment, may be opportunities to intervene on health behaviors like physical activity. The purpose of this study was to determine the changes in moderate-to-vigorous physical activity (MVPA) associated with several common life events from adolescence to young adulthood. **Methods**: Participants in Project EAT (ages 11 to 18 yr at baseline and 25 to 36 yr at wave 4) were surveyed at four timepoints from 1998 to 2016. Questions included marital status, employment status, postsecondary education completion and enrollment, and living situation between each wave. Linear regression was used to model the effect of each life event on change in self-reported MVPA. *Post hoc* mediation analysis was conducted to examine whether having a child mediated the effect of getting married on the change in MVPA. **Results**: Average MVPA declined from 6.5 $h \cdot wk^{-1}$ at baseline to 4.3 $h \cdot wk^{-1}$ at wave 4. Having a child was associated with a significant decrease in MVPA between waves 2 and 3 and between waves 3 and 4. Getting married and leaving parents' home were associated with significant decreases in MVPA between waves 3 and 4. Having a child both mediated and moderated the effect of getting married on MVPA. **Conclusions**: This study provides evidence that MVPA declines both after getting married and after having a child and that these effects are not independent. Interventions to maintain or increase MVPA could profitably target couples planning to get married or have a child. **Key Words:** MODERATE-TO-VIGOROUS PHYSICAL ACTIVITY, DETERMINANTS, NATURAL EXPERIMENT, MEDIATION ANALYSIS

Major population shifts toward inactivity commonly begin during adolescence (1,2). Declines in physical activity increase the risk of obesity, heart disease, and other health concerns (3). Yet, interventions to increase physical activity generally show modest effects across the life course (4–6), and there are continued calls for better describing social and environmental factors influencing physical activity across the life course (7,8). Life Course Theory proposes that people respond to events relevant to their time and place and that these events shape habits and routines during critical windows of time in which behaviors develop (9). "Critical windows" mean that if a behavior is not developed at a certain time of life, like adolescence, it is much more difficult to develop the behavior later. The sharp drop in physical activity from adolescence to young adulthood suggests that this transitional period may be a critical window for preventing declines in physical activity.

Professional advice for promoting physical activity commonly highlights forming routines to support habitual physical activity (10,11). Socially expected life events, like entering and leaving postsecondary education, leaving the parental home, gaining full-time employment, getting married, and having a child, are likely to alter one or more aspects of routines and may impact physical activity (12). Although previous studies reporting associations of life events with change in physical activity have been reviewed (12), there remains a lack of longitudinal studies that examine the impact of multiple life events on physical activity (7,13). Longitudinal studies offer the opportunity to examine the extent to which multiple life events have independent impacts on physical activity or whether these impacts are mediated by subsequent life

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events—as for example whether the impact of marriage on physical activity is mediated by having a child. Finally, there remains a need to better understand the relative importance of different life events or possible differences in the effect of life events on physical activity by demographics, like age or ethnicity/race, that may modify the impact of life events on levels of physical activity (7).

Socially expected life events can be disruptive to regular physical activity, but they also offer meaningful and predictable opportunities for intervention. For example, physicians are recommended to counsel their pregnant patients to get 30 min of moderate-intensity physical activity per day (14). Determining which life events could be optimally targeted as opportunities to support activity among different population groups requires identifying which life events produce large changes in physical activity and whether these changes differ by demographics, like age, sex, ethnicity/race, or socioeconomic status (SES). In this study we estimate effects of these socially expected life events on changes in physical activity.

Our first study aim was to identify which common life events during adolescence and young adulthood produce the greatest changes in physical activity. Next, we aimed to determine if the effects of life events on physical activity differed according to the age range at which the event occurred and whether any identified effects differed by sex, ethnicity/race, or SES. Based on the broader health disparities literature noting how factors, such as race, discrimination, and SES, are associated with additional life stress (15–18), which may influence the effect of life events on physical activity behavior, we expect that declines in physical activity after life events will be greater for females, minorities, and low SES participants than for males, white participants, and high SES participants.

METHODS

Study design. Data for this analysis were drawn from Project EAT (Eating and Activity in Teens and Young Adults), a 15-yr longitudinal study designed to examine diet, physical activity, weight control behaviors, weight status, and associated factors among young people. At baseline (1998–1999), middle, and high school students (adolescents, age 11 to 18 yr; n = 4746) at 31 public schools in the Minneapolis-St. Paul metropolitan area of Minnesota completed surveys and anthropometric measures (19,20). Contact information was available for 3672 baseline participants. These participants were contacted for follow-up assessments in 2003 to 2004 (wave 2: emerging young adults, age 15 to 23 yr, n = 2516), 2008 to 2009 (wave 3: young adults, age 19 to 31 yr; n = 2287) and 2015 to 2016 (wave 4: adults, age 25 to 36 yr, n = 1830) (21–23). The Project EAT sample was balanced between the sexes and ethnically/racially diverse at each wave of follow-up (Table 1). Because attrition from the original school-based sample did not occur at random, in all analyses, the data were weighted using the response propensity method described previously (24–27). The University of Minnesota Institutional Review Board Human Subjects Committee approved all protocols used in Project EAT at each time point. Participants provided written informed consent at each wave of follow-up.

We analyzed effects of life events using a natural experiment approach as it is not possible to randomly assign participants to different life events like having a child. To account for possible confounding of these effect estimates, we adjusted for multiple covariates in all analyses. To estimate possible residual confounding due to unmeasured variables, we conducted sensitivity analyses.

Measures. Moderate-to-vigorous physical activity (MVPA) was measured as hours per week at each wave with questions modified from Godin and Shepard (28). To identify life events, participants were asked how many children they have, whether they were married, whether they worked more than 20 $h \cdot wk^{-1}$ for pay, whether they lived with their parents, and whether they were part time or full-time postsecondary students. These questions were used to identify participants who had a first child, got married, began or left postsecondary school, left their parental house or began working more than 20 $h \cdot wk^{-1}$ between each wave of follow-up. Of these events, only employment was specifically assessed at baseline, so this was the only event we were able to analyze from baseline to wave 2. We completed a sensitivity analysis with working full-time operationalized as follows: all participants younger than 18 yr were coded to be not working more than 30 $h \cdot wk^{-1}$, all participants over 18 reported work hours in a way that let us know if they were working 30 $h \cdot wk^{-1}$ or more. Even though the responses were capped at 20 h or more for participants younger than 18 yr, we thought it reasonable that students in school were unlikely to be working more than 30 $h \cdot wk^{-1}$. Sex, ethnicity/race, and SES were self-reported at baseline. Age was self-reported at each wave of follow-up. Further details on question wording, reliabilities, and validities can be found in Supplemental Digital Content 1 (see Document, Supplemental Digital Content 1, Variable measurement details, http://links.lww.com/MSS/B440).

Statistical analyses. Demographics, mean hours per week of MVPA, and prevalence of common life events were calculated for participants at each wave of follow-up.

Which life events produced the greatest consistent change in MVPA? We used linear regression models to quantify the effect of each life event separately on change in MVPA between waves. Changes in MVPA from each wave to the subsequent wave were modeled separately as outcomes to determine whether life events had different effects at different developmental periods. Life events were analyzed as dichotomous variables: participants who experienced the life event were compared to participants who had not experienced the life event. Each model was restricted to participants who had not experienced the life event at the previous wave. For example, the change in MVPA between wave 2 (emerging young adults) and wave 3 (young adults) was compared between participants who reported having no children at wave 2 and subsequently reported having one child at wave 3 with participants who reported having no children at either

TABLE 1. Demographics and life events by study wave.

	Wave 1	Wave 2	Wave 3	Wave 4
Demographics				
n	4746	2516	2287	1830
Age: mean (SD), yr	14.9 (1.7)	19.4 (1.7)	25.3 (1.6)	31.1 (1.6)
Sex: *n* (%)				
Male	2377 (50.2%)	1130 (44.9%)	1030 (45%)	788 (43.1%)
Female	2357 (49.8%)	1386 (55.1%)	1257 (55%)	1042 (56.9%)
Ethnicity/race: *n* (%)				
White	2264 (47.7%)	1525 (60.6%)	1458 (63.8%)	1241 (67.8%)
Black or African American	887 (18.7%)	274 (10.9%)	212 (9.3%)	154 (8.4%)
Hispanic	352 (7.4%)	142 (5.6%)	124 (5.4%)	84 (4.6%)
Asian	896 (18.9%)	447 (17.8%)	373 (16.3%)	268 (14.6%)
Other	347 (7.3%)	128 (5.1%)	120 (5.2%)	83 (4.5%)
Baseline SES: *n* (%)				
Low	793 (17.4%)	330 (13.4%)	264 (11.8%)	199 (11.1%)
Low-middle	857 (18.8%)	413 (16.8%)	357 (16%)	266 (14.8%)
Middle	1209 (26.6%)	620 (25.3%)	575 (25.8%)	432 (24.1%)
High middle	1065 (23.4%)	683 (27.8%)	641 (28.7%)	556 (31%)
High	626 (13.8%)	408 (16.6%)	394 (17.7%)	340 (19%)
MVPA				
Mean (SD), $h \cdot wk^{-1}$	6.5 (4.8)	5.4 (4.4)	4.3 (3.9)	4.3 (3.7)
		Wave 1 to 2	Wave 2 to 3	Wave 3 to 4
Life events				
Marriage: *n* (%)				
Got married	NA[a]	NA	334 (25.6%)	479 (29.1%)
Got divorced	NA	NA	24 (1.8%)	41 (2.5%)
Stayed married	NA	NA	42 (3.2%)	343 (20.8%)
Never married	NA	NA	907 (69.4%)	783 (47.6%)
Children: *n* (%)				
Had first child	NA	NA	328 (17.5%)	456 (28.8%)
Never had children	NA	NA	1371 (73.2%)	779 (49.2%)
Already had children	NA	NA	141 (7.5%)	343 (21.6)
Lost child?	NA	NA	33 (1.8%)	7 (0.4%)
Work (more than 20 $h \cdot wk^{-1}$): *n* (%)				
Began working for pay	NA	944 (39.9%)	690 (38.6%	186 (13.4%)
Stopped working for pay	NA	0 (0.0%)	123 (6.9%)	91 (6.6%)
Continued working for pay	NA	165 (7.0%)	740 (41.3%)	1060 (76.6%)
Never worked for pay	NA	1255 (53.1%)	237 (13.2%)	47 (3.4%)
Student status: *n* (%)				
Out of school	NA	NA	551 (31.0%)	943 (57.1%)
Started school	NA	NA	327 (18.4%)	133 (8.1%)
Ended school	NA	NA	632 (35.5%)	469 (28.4%)
Stayed in school	NA	NA	270 (15.2%)	106 (6.4%)
Living with parents: *n* (%)				
Continued to live away from parents	NA	NA	564 (47.0%)	1029 (67.5%)
Moved away from parents' house	NA	NA	361 (30.1%)	311 (20.4%)
Moved back in with parents	NA	NA	94 (7.8%)	66 (4.3%)
Continued to live with parents	NA	NA	181 (15.1%)	119 (7.8%)

[a]Some life events cannot be assessed at early waves because the question was not asked on the surveys.

wave 2 or wave 3. All models were adjusted for sex, age, SES, and ethnicity/race. Models were estimated for the whole sample and stratified on sex.

The primary limitation of natural experiments is the possibility that failing to adjust for unmeasured confounders will bias the effect estimate. Therefore, a sensitivity analysis was undertaken using a method derived from VanderWeele (29) for each of the effects of life events identified as statistically significant at $P < 0.05$. We created five scenarios for the strength of the association of an unmeasured confounder with the probability of experiencing the life event. These scenarios ranged from a weak association—a 1% difference in the prevalence of the confounder between participants experiencing and not experiencing the life event—to a strong association—a 50% difference in the prevalence of the confounder. For each scenario, we estimated the association the unmeasured confounder would need to have with change in MVPA to eliminate the statistical significance of the observed effect (moving the lower 95% confidence level to 0). This sensitivity analysis was conducted with the simplifying assumptions: that the unmeasured confounder was binary; that the association of the unmeasured confounder with MVPA did not differ between participants who did and who did not experience the life events; and that the prevalence difference in the unmeasured confounder between levels of the exposure was constant over the levels of the measured confounders.

Do the effects of life events with MVPA differ by demographics? Because of consistent differences in MVPA between the sexes, models were stratified *a priori* by sex (30). To test statistically for differences in the effects of life events by age, sex, ethnicity/race, SES, completing education and participant's highest level of education, interaction terms for these demographics with the life events were modeled between each wave of follow-up. This resulted in 76 separate, but not independent, tests for interaction. We

TABLE 2. Changes in MVPA associated with life events—all participants.

	Change in MVPA ($h \cdot wk^{-1}$) from Wave 1 to Wave 2[a]	Change in MVPA ($h \cdot wk^{-1}$) from Wave 2 to Wave 3[a]	Change in MVPA ($h \cdot wk^{-1}$) from Wave 3 to Wave 4[a]
Had first child	N/A	−0.84 [−1.39, −0.30][b]	−1.03 [−1.52,-0.54][b]
Began working more than 20 $h \cdot wk^{-1}$ for pay	−0.24 [−78, 0.30]	0.07 [−0.57, 0.71]	−0.27 [−1.75, 1.22]
Got married	N/A	−0.25 [−0.83, 0.33]	−1.09 [−1.62, −0.56][b]
Began postsecondary education	N/A	0.02 [−0.70, 0.74]	0.27 [−0.52, 1.05]
Left postsecondary education	N/A	−0.19 [−0.79, 0.41]	−0.80 [−1.69, 0.08]
Left parental home	N/A	0.46 [−0.33, 1.25]	−0.98 [−1.87, −0.09][b]

[a]Model adjusted for age, race, sex and SES.
[b]Estimate is statistically significant at $P < 0.05$.

accounted for multiple statistical tests using the false discovery rate (FDR) method (31). The FDR applies progressively less stringent Bonferroni correction to the ordered list of raw *P* values from the multiple tests. Therefore, the denominator for the Bonferroni correction for the smallest *P* value of 76 raw *P* values would be 76, the denominator for the next smallest *P* value would be 75, and so on. The FDR represents the probability that rejecting a null hypothesis based on the *P* value would represent a false discovery given the number of tests conducted and the place that the given *P* value falls in the ordered list of raw *P* values. There is no convention for what constitutes a good FDR, but a cutpoint of 0.2 has previously been used in genetics studies (32). We chose to consider an FDR of less than 0.2 as evidence of a meaningful interaction. Stratified results are reported for models with an FDR less than 0.2.

Does having a child mediate the effect of getting married on MVPA? Previous reviews have noted that assessing the independent effects of life events that often occur close in time, particularly marriage and having children, is difficult (12). Therefore, a *post hoc* mediation analysis was conducted to better understand the combined contribution of marriage and having children on physical activity from waves 3 to 4. VanderWeele's four-way decomposition method was used (33) to quantify the amount of interaction between marriage and having a child on physical activity as compared with the amount that the effect of getting married on physical activity is mediated by having a child. To better clarify results of the four-way decomposition, a total effect for the combination of marriage and having a child on MVPA between wave 3 and wave 4 was estimated using linear regression.

RESULTS

Which life events produced the greatest consistent change in MVPA? Between wave 2 (ages 15 to 23 yr) and wave 3 (ages 19 to 31 yr) having a first child was associated with less MVPA (Table 2). Between wave 3 and wave 4 (ages 25 to 36 yr), getting married, having a first child, and leaving the parental home were all associated with less MVPA. Events related to work (beginning to work more than 20 $h \cdot wk^{-1}$) or school (beginning or leaving postsecondary education) did not significantly affect levels of MVPA at any period. For example, beginning to work more than 20 $h \cdot wk^{-1}$ was associated with a 0.07-$h \cdot wk^{-1}$ or 4.2-$min \cdot wk^{-1}$ increase in MVPA from wave 2 to wave 3 (95% confidence interval [CI], −0.57 to 0.71) (Table 2). The sensitivity analysis using 30 $h \cdot wk^{-1}$ as the cutpoint for full-time work did not produce results different from using 20 $h \cdot wk^{-1}$. There was no significant association between starting to work more than 30 $h \cdot wk^{-1}$ and MVPA at any wave (wave 1 to wave 2: $\beta = -0.05$; 95% CI, −0.57 to 0.47; wave 2 to wave 3: $\beta = 0.23$; 95% CI, −0.30 to 0.76; wave 3 to wave 4: $\beta = -0.57$; 95% CI, −1.65 to 0.51).

Natural experiments cannot control for bias due to unmeasured confounding. We quantified the strength of association with MVPA that an unmeasured confounder variable would need to have to change our interpretation of the effect estimates from these natural experiment analyses. This analysis showed that there would have to be a strong association between an unmeasured confounder and MVPA to change our effect interpretations for having a child and getting married, whereas a relatively weak association would change our effect interpretation for leaving the parental home (Table 3). For example, an unmeasured confounder that has even a strong association with having a child (50% prevalence difference between people who did and did not have a child) would still have to be associated with a 1.08-$h \cdot wk^{-1}$ change in MVPA to lead to the effect estimate of having a first child on MVPA to no longer be considered statistically significant. Conversely, an unmeasured confounder that has even a strong association with having a leaving the parental

TABLE 3. Strength of an unmeasured confounder needed to change the interpretation of significance for those life events identified as significant.[a]

	Difference in Prevalence of Unmeasured Confounder Between Participants Experiencing Life Event and Those Not Experiencing Life Event.				
	0.01	0.1	0.2	0.3	0.5
Wave 2 to Wave 3					
Had first child	$\beta = -30\ h \cdot wk^{-1}$	$\beta = -3\ h \cdot wk^{-1}$	$\beta = -1.5\ h \cdot wk^{-1}$	$\beta = -1\ h \cdot wk^{-1}$	$\beta = -0.6\ h \cdot wk^{-1}$
Wave 3 to wave 4					
Had first child	$\beta = -54\ h \cdot wk^{-1}$	$\beta = -5.4\ h \cdot wk^{-1}$	$\beta = -2.7\ h \cdot wk^{-1}$	$\beta = -1.8\ h \cdot wk^{-1}$	$\beta = -1.08\ h \cdot wk^{-1}$
Got married	$\beta = -56\ h \cdot wk^{-1}$	$\beta = -5.6\ h \cdot wk^{-1}$	$\beta = -2.8\ h \cdot wk^{-1}$	$\beta = -1.87\ h \cdot wk^{-1}$	$\beta = -1.12\ h \cdot wk^{-1}$
Left parental home	$\beta = -9\ h \cdot wk^{-1}$	$\beta = -0.9\ h \cdot wk^{-1}$	$\beta = -0.45\ h \cdot wk^{-1}$	$\beta = -0.3\ h \cdot wk^{-1}$	$\beta = -0.18\ h \cdot wk^{-1}$

[a]The numbers in cells represent the regression coefficient an unmeasured confounder would need to have with MVPA (hours per week) to change the significance of the effect estimates for each life event.

TABLE 4. Changes in MVPA associated with life events by sex.

	Change in MVPA ($h \cdot wk^{-1}$) from Wave 1 to Wave 2[a]	Change in MVPA ($h \cdot wk^{-1}$) from Wave 2 to Wave 3[a]	Change in MVPA ($h \cdot wk^{-1}$) from Wave 3 to Wave 4[a]
Males			
Had first child	N/A	−1.21 [−2.19, −0.23][b]	−0.59 [−1.42 to 0.24]
Began working more than 20 $h \cdot wk^{-1}$ for pay	−0.09 [−0.97, 0.80]	−0.24 [−1.41, 0.93]	0.28 [−2.68 to 3.24]
Got married	N/A	0.19 [−0.83, 1.21]	−0.64 [−1.55 to 0.27]
Began postsecondary education	N/A	−0.2 [−1.48, 1.09]	−0.34 [−1.76 to 1.08]
Left postsecondary education	N/A	−0.96 [−2.06, 0.14]	−0.17 [−1.74 to 1.39]
Left parental home	N/A	0.93 [−0.43, 2.29]	−1.19 [−2.6 to 0.23]
Females			
Had first child	N/A	−0.6 [−1.22, 0.03]	−1.46 [−2.03 to −0.88] *
Began working more than 20 $h \cdot wk^{-1}$ for pay	−0.36 [−1.02, 0.33]	0.35 [−0.40, 1.10]	0.09 [−1.51 to 1.69]
Got married	N/A	−0.55 [−1.23, 0.13]	−1.60 [−2.23 to −0.98] *
Began postsecondary education	N/A	0.18 [−0.66, 1.01]	0.66 [−0.2 to 1.53]
Left postsecondary education	N/A	0.28 [−0.43, 0.99]	−1.38 [−2.38 to −0.38] *
Left parental home	N/A	−0.07 [−0.98, 0.85]	−0.98 [−2.14 to 0.19]

[a]Model adjusted for age, race and SES.
*Estimate is statistically significant at $P < 0.05$.

home (20% prevalence difference between people who did and did not leave their parental home) would need only to be associated with a 0.45-$h \cdot wk^{-1}$ (27 $min \cdot wk^{-1}$) change in MVPA to lead to the effect estimate of leaving the parental home on MVPA to no longer be considered statistically significant.

Do the effects of life events with MVPA differ by demographics? Although the statistical evidence for interactions of life event effects by sex is weak (see Table, Supplemental Digital Content 2, interaction *P* values and FDR, http://links.lww.com/MSS/B441), there was a substantive difference between men and women in the effect of getting married on MVPA. Getting married is associated with greater decreases in MVPA among women than among men. For example, from wave 3 to wave 4, women who married showed a 1.60-$h \cdot wk^{-1}$ decrease in MVPA (95% CI, −2.23 to −0.98), whereas men showed a nonsignificant 0.64-$h \cdot wk^{-1}$ decrease in MVPA (95% CI, −1.55 to 0.27) (Table 4).

Although there was little statistical evidence for a difference in the effect of most life events on MVPA by ethnicity/race or SES (see Tables, Supplemental Digital Contents 3 and 4, models stratified by ethnicity/race and SES, http://links.lww.com/MSS/B442 and http://links.lww.com/MSS/B443), the predicted effect of leaving postsecondary education did differ significantly (FDR = 0.03) and substantially by ethnicity/race. White participants showed little change in MVPA after leaving postsecondary education between wave 3 and wave 4 (0.09 $h \cdot wk^{-1}$; 95% CI, −1.11 to 1.30]), whereas participants of color showed a 1.21-$h \cdot wk^{-1}$ decline in MVPA after leaving postsecondary education between wave 3 and wave 4 [95% CI, −2.57 to 0.16].

Does having a child mediate the effect of getting married on MVPA? We found that getting married and having a first child were the most significant and robust life events predicting decreases in MVPA, particularly between waves 3 and 4. We conducted a *post hoc* mediation analysis to determine whether the effect of getting married on MVPA was mediated by having a first child and to determine the magnitude of the effect. The four-way effect decomposition shows that the proportion of the total effect of getting married on change in MVPA could be decomposed into 53% (95% CI, 24% to 82%) attributable to mediation by having a first child, and 45% (95% CI, −15% to 105%) attributable to interaction with having a first child (Table 5). This finding indicates that although part of the effect of getting married on change in MVPA is mediated by having a child, an equally large part of the effect of getting married on change in MVPA is due to an interactive effect with having a child. Having a child both mediates and interacts with the effect of marriage on change in MVPA.

The combined impact of mediation and moderation becomes clearer when considering the total effects. The total effect of getting married between wave 3 and 4 on MVPA is −1.09 $h \cdot wk^{-1}$. The total effect of having a child between wave 3 and 4 on MVPA is −1.03 $h \cdot wk^{-1}$ (Table 2). If the effect of getting married on MVPA was completely mediated by having a child, we would expect that participants who got married *and* had a child between waves 3 and 4 would also have a roughly 1 $h \cdot wk^{-1}$ decrease in MVPA, however the total effect of getting married and having a child is −1.90 $h \cdot wk^{-1}$ (95% CI, −2.61 to −1.18). The effect of getting married and having a child in the 5-yr

TABLE 5. Four-way decomposition estimates for the mediation of the effect of marriage on change in MVPA from EAT-III to EAT-IV by having a child.

	Proportion of Estimate [95% CI]
Controlled direct effect: marriage—> MVPA	0.45 [−0.23 to 1.13]
Reference interaction: (marriage * child)—> MVPA	0.23 [−0.12 to 0.58]
Mediated Interaction: (marriage * child) and (marriage—> child)— > MVPA	0.42 [−0.19 to 1.02]
Pure indirect effect: marriage—> Child—> MVPA	0.35 [−0.12 to 0.81]
Proportion of marriage—MVPA effect mediated by having a child[a]	0.53 [0.24 to 0.82]
Overall proportion of MVPA effect attributable to interaction between marriage and having a child[a]	0.45 [−0.15 to 1.05]
Overall proportion of marriage—MVPA effect eliminated if participant does not also have a child	0.69 [0.26 to 1.12]

[a]Proportion mediated and proportion attributed to interaction can add to more than 100% because there is a proportion that is due to *both* mediation and interaction.

period on MVPA levels is greater than the effect of either event alone.

DISCUSSION

Our results indicate that family-related life events—having a first child, getting married, and leaving the parental home—during the transition from adolescence to young adulthood are associated with large decreases in physical activity in the total population. By contrast, employment and education related life events—beginning or leaving postsecondary education or beginning to work more than 20 $h{\cdot}wk^{-1}$ for pay—appeared to not be associated with large changes in physical activity in the total population. There were differences between population subgroups in the effect of life events on physical activity. The decrease in physical activity after getting married appears stronger among women than men. By contrast, the decrease in physical activity after the birth of a first child is consistent between the sexes. Participants of color showed greater decreases in physical activity upon leaving postsecondary education than did white participants. We are unaware of any studies that have tested for differences in effects of life events on physical activity by ethnicity/race, and our finding suggests that supporting people of color in maintaining physical activity as they finish their education may be an effective point for intervention.

Our mediation analysis shows that the effect of getting married on physical activity is partly, but not completely mediated and moderated by having a child. The combined effect of getting married and having a child on decreases in physical activity is greater than the effect of either event on its own, suggesting that couples experiencing marriage and childbirth in a short time may need additional support for maintaining healthy levels of physical activity. Previous studies of single life events have shown that marriage and childbirth are related to decreases in physical activity among men and women (12,34,35), and the decrease in physical activity after marriage is greater for women than for men (12,36). However, we are unaware of any previous studies that have used mediation analysis to examine whether the effect of marriage on physical activity is mediated and/or moderated by having a child. Understanding mediation and moderation of life events is important for identifying points of intervention and populations at risk. For example, if the effect of marriage on physical activity were completely mediated by having a child, then the natural population to target for interventions would be couples having a child rather than couples experiencing both marriage and childbirth in a short time frame as we found in this study.

Marriage, the birth of a child, and leaving postsecondary education are socially common life events during the transition from adolescence to adulthood that offer real intervention potential to improve population levels of physical activity. Although our study has shown that these life events are followed by decreases in physical activity, they are also opportunities to support activity. Marriage and childbirth offer opportunities to develop healthy family activities that support the physical activity habits of several people at once. Pointing couples entering marriage or childbirth to safe places to be active with children, cheap rentals of equipment, ideas to be active, and resources like exercise groups could be integrated into premarital counseling or prenatal visits. Additionally, postsecondary education could be a time to provide training on lifelong physical activity behaviors, particularly among people of color.

Finally, our findings imply that having two significant life events, like marriage and childbirth, occur within quick succession may combine to decrease physical activity. Future studies and interventions should consider interactions, mediation, and sequencing among multiple common life events in their effects on physical activity. These analyses may be particularly useful when examining demographic characteristics that can vary over the life course like SES. Although our analyses only examine possible effect differences by SES measured at baseline, SES can vary over a person's life course and examining the interactions of this life course variation in SES with significant life events of levels of physical activity or other health behaviors would be useful in future studies. Mediation analysis for life events could also usefully be extended to other health behaviors to identify other possible areas for supporting young adults in maintaining healthy habits during this period marked by substantial transitions.

Although increasing population levels of PA at all ages remains a major public health objective, people designing programs and interventions to achieve this objective should reflect on the relatively modest effects achieved by interventions at any age to date (4–6). Barriers like self-efficacy and time remain obstacles to maintenance of physical activity (7,37). Although improvements to intervention effects will likely be incremental, the health risks related to physical inactivity (3) are a compelling reason for continuing to examine determinants of activity, as with this study, and incorporating findings into ongoing development of population health interventions.

STRENGTHS AND LIMITATIONS

The natural experiment design used in this study offers a solid basis for causal evidence. Although a randomized controlled trial generally presents the strongest causal evidence for effects of exposures like life events on outcomes like physical activity, we cannot randomize participants to receive life events. The primary challenge in natural experiments is controlling for potential unmeasured confounding. The number of variables captured in the Project EAT surveys allows us to adjust for measured confounding from many known sources, and we have quantified the strength needed for an unmeasured confounder to change our inferences to further our causal evidence. An additional limitation of this design was the modeling of events as dichotomous variables. Impacts on physical activity may be different, for example, when someone transitions from 35 $h{\cdot}wk^{-1}$ of work to 45 $h{\cdot}wk^{-1}$

than when a person transitions from 25 to 35 $h \cdot wk^{-1}$. Future studies should consider these possible nonlinear dose responses.

Self-reports of physical activity are subject to different biases than device measures like accelerometer: particularly to social desirability biases. However, the validation sample from wave 3 showed that self-reports did not systematically over or underestimate MVPA compared to accelerometer measurement (38). Additionally, because Project EAT used the same self-report measure at each of the four waves of follow-up, we expect that the change scores modeled in this analysis will be less affected by biases than if the outcome were measured at just one timepoint.

Although our design has some limitations, there are several points of strength in the Project EAT study. In particular, the 15-yr follow-up with four waves of data collection allow us to analyze the life events as natural experiments. The large sample size also provided sufficient sample to examine effects across different demographic subgroups.

CONCLUSIONS

Our study shows that physical activity drops substantially after getting married and after having a child, and that people of color may experience greater decreases in physical activity after leaving postsecondary education than white people. Further, the effects of getting married and having a child on physical activity are not independent and need to be considered together. Community health organizations, faith organizations, education institutions, and clinicians could point people experiencing these life events to resources that can support healthy levels of physical activity.

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Conflict of Interest: The authors declare no conflicts of interest.

EPIDEMIOLOGY

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