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Concurrent and Lagged Relations between Momentary Affect and Sedentary Behavior in Middle-Aged Women

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Abstract

Objective—The purpose of this study was to investigate the reciprocal relationship between sedentary behavior (SB) and momentary affect in the context of daily experiences.

Methods—Community-dwelling midlife women ($N = 121$; age range 40–60 years) were recruited for a 15-day daily diary study. The women rated their positive and negative affect when prompted on a personal digital assistant device four times per day and wore an accelerometer for objective assessment of SB. Multilevel models were estimated to test concurrent and lagged associations between momentary estimates of SB and affect.

Results—In models that controlled for day of week, number of hot flashes, and total minutes of accelerometer wear time, greater concurrent positive affect was associated with fewer minutes spent being sedentary ($\beta = -.31, p < .01$). Neither lagged positive nor negative affect predicted later SB, however, more sedentary minutes predicted lower positive affect at the next occasion ($\beta = -.04, p < .01$).

Conclusions—These results suggest that SB has negative affective consequences from moment to moment. The implications of reduced positive affect following prolonged bouts of SB for subsequent motivational, behavioral, or wellbeing outcomes remain to be determined.

Keywords

sedentary behavior; affect; midlife; ecological momentary assessment; menopause

The prevalence of sedentary behavior (SB) is increasing worldwide and is indicative of a “global pandemic” of physical inactivity¹. In addition to having negative health consequences and lowering life expectancy², being more sedentary has been associated with more depressive symptoms³ and lower quality of life⁴. Middle-aged women are among the least active population subgroups and also engage in high levels of SB⁵. Midlife also coincides with the menopausal transition, which puts women at increased risk for developing depression⁶. High levels of SB could further exacerbate this risk if being sedentary increases negative affect. Greater exposure to daily negative affect predicts concurrent poorer physical health^{7,8} and more recent research finds that elevated daily negative affect is related to

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greater likelihood of depressive symptoms and diagnosis 10 years later⁹. Identifying the behavioral antecedents of affect could lead to identification of new methods for improving wellbeing.

Affect both determines and is influenced by physical activity, but it is unclear what role affect plays in relation to SB in spite of how prevalent this behavior is. In one study, both positive and negative affect was accompanied by decreases in SB after controlling for pre-affect physical activity levels¹⁰. More studies are however needed to systematically evaluate the associations between momentary affect and SB in the context of daily experiences. As sedentary activity may be under-reported in ecological momentary assessment (EMA) protocols¹¹, studies with objective monitoring techniques of SB are especially needed. The present study used a daily diary approach with ecological momentary assessment methods to investigate the relationship between objectively measured SB and momentary changes in affect in middle-aged women. The objective of this study was to examine the concurrent and lagged associations between momentary SB and affect (while controlling for physical activity). Because additional characteristics such as menopausal status, fitness level, depression, or weight status could alter the association between SB and affect (e.g. as a function of altered hormonal regulation or other biological or psychosocial processes), as a secondary aim, it was also examined whether the association between momentary SB and affect varied as a function of these between-person influences.

Methods

Participants & procedures

The study sample and procedures were previously described¹². The sample comprised community-dwelling perimenopausal and postmenopausal women ($N = 121$; age range 40-60 years) who have not used hormone therapy within the last 6 months. All women completed detailed screening upon entry into the study which included cardiorespiratory fitness (maximal graded exercise test using TrueMax2400 Parvomedics Inc. metabolic system, Salt Lake City, Utah) and menopausal status assessment. The daily diary portion of the study included prospective monitoring across a 15-day period. SB was monitored objectively using accelerometry (Actigraph model GT1M, Pensacola, FL) and affect was assessed in real-time using an electronic personal digital assistant (PDA) device (Tungsten E2). The Purdue Momentary Assessment Tool (PMAT¹³) software was used to administer the PDA protocol. The PDA prompted women four times per day between 8am and 8pm randomly within four 3-hour blocks (8-10:59am; 11-1:59pm; 2-4:59pm, and 5-7:59pm). Assessments occurred at random but were at least one hour apart. Participants were also asked to self-report their hot flashes as they occurred using the PDA.

Measures

Background information—Basic demographic and health history information included menopausal status based on self-reported menstrual bleeding patterns¹⁴. Other measures in the baseline assessment battery included a measure of depressive symptoms¹⁵ and neuroticism¹⁶. BMI was assessed from weight and height obtained in the laboratory using standard procedures.

Affect—Affect was assessed using the 10-item Positive and Negative Affect Schedule (PANAS¹⁷) with wording adopted for momentary assessment. Respondents indicated their current feelings on a 0-100 scale ranging from “not at all” to “extremely”. Responses were averaged across the positive and negative affect items, respectively. Within-person reliability was calculated for each scale¹⁸ and were acceptable ($R_c = .81$ and $.82$ for the positive and negative affects scales, respectively).

Sedentary behavior—Participants wore an accelerometer (GT1M) on non-dominant hip with an adjustable elastic belt and were asked to take off the accelerometer when in contact with water (e.g., bathing or swimming) and at bedtime. The accelerometer collected data in 1 minute epochs, and the data were processed and analyzed using the ActiLife data analysis software from Actigraph (version 5.7.4). Wear-time was validated through the ActiLife software procedures, with valid hour considered to have at least 10% of non-zero activity counts and valid day reflecting at least 10 valid hours. Approximately 12% of the daily data did not meet the criterion for valid days. Only valid data (88% of all person-days) were analyzed. The primary measures in this study were total momentary minutes spent being sedentary (since the last EMA prompt) operationalized using the 0-99 counts per minute cutoff¹⁹. On average, the women spent 12.6 (SD = 1.7) hours being sedentary which is above the estimated national average for this age group⁵.

Data Analysis

Momentary affect and SB were nested within days and within persons, thus three-level multilevel models were used to examine between- and within-person associations between affect and SB. Models were estimated using SAS 9.3 PROC MIXED²⁰. Of the original 121 participants, 9 had less than 20% of valid survey or activity data leaving 112 participants for analysis. For these individuals, observations were removed from analyses if the survey was completed outside the required time frame (i.e., outside the respective 3-hour time block; 164, 3%) or valid activity data was not recorded (703, 12%). The final sample consisted of 112 participants providing 5,488 person-days (of a possible 6,720 or 81.7%) for analysis. On average participants completed 81% surveys ($M = 48.8$, $SD = 7.67$). Due to missing data, full information maximum likelihood was used to compute estimates²¹.

All within-person predictors were person-day centered and all between-person predictors were grand-mean centered prior to analysis. For analyses including lagged variables, we included both the outcome and predictor from occasion $t-1$ so the outcome in these models reflects change in affect across occasions rather than raw affect level at time t .

To test whether momentary SB significantly predicted affect, we fit three-level models such that:

$$\text{Level- 1: } \text{Affect}_{mdi} = \pi_{0di} + \pi_1(\text{Minutes sedentary})_{mdi} + \pi_1(\text{Minutes sedentary})_{m-1di} + \varepsilon_{mdi}$$

(1)

$$\text{Level- 2: } \pi_{0di} = \beta_{00i} + V_{0di} \quad (2)$$

$$\text{Level- 3: } \beta_{00i} = \gamma_{000} + U_{00i} \quad (3)$$

In these models, average momentary affect for a given individual (i) on day (d) at moment (m) is a function of the sample grand mean (γ_{000}) plus the person specific random intercept (U_{00i}), the day specific random intercept (V_{0di}) and error (ϵ_{mdi}). At level-1 we added concurrent and lagged momentary SB as a predictor of affect. Lagged momentary affect, number of hot flashes and total minutes wearing the actigraphy device were entered at level-1 as covariates. We chose not to include time of day as a level 1 covariate based on a recent simulation study suggesting that detrending for time is not always necessary and may lead to inaccurate results and interpretations²². Level-2 covariates were day of week (weekday versus weekend) and day-level SB and level-3 covariates were age, BMI, depressive symptoms, neuroticism, overall level of physical activity (defined as total physical activity counts across the monitoring period), fitness level, menopausal status, and person-level SB. Level 3 covariates were entered to account for individual differences in any of the variables. For example, including overall level of physical activity controlled for any variability due to an individual being higher or lower relative to others on their physical activity engagement throughout the study. All models were run without non-significant covariates; significant effects did not change and these variables were retained in presented analyses given their substantive value. For models using affect to predict SB, the roles of the primary variables of interest were switched.

Results

Sample Description

Participants in this study were on average 51.5 years old and predominantly Non-Hispanic (96%) White (95%). Most were married or in committed relationships (90%), well educated (72% were college graduates), had income above \$65,000 (68%), and had at least one child (90%). There was a representation across different menopause stages (26.4% early perimenopause, 30.6% late perimenopause, 43% early postmenopause). Across the entire 15-day monitoring period, 76% of women self-reported some hot flashes (average of 1.1 HFs per day). Average person-level positive affect was 54.51 (SD = 18.82) and negative affect was 2.68 (SD = 3.09). Using the cut-off of 2, neither variable was considered skewed (PAskew = .306; NAskew = 1.716).

Concurrent Associations between Affect and SB

There was substantial variation in both affect and SB at all three levels (see Table 1). Coefficients in Table 1 reflect the change in SB or affect with a one unit change of the associated predictor. For person-centered predictors this reflects a one unit change from that person's average. Momentary and daily SB were independently related to lower positive affect but not to negative affect. Examining models testing the opposing concurrent

relationship, greater momentary and daily positive affect predicted fewer sedentary minutes. Momentary negative affect did not have a significant relationship with SB though higher levels of daily negative affect were significantly related to more minutes of SB.

Time-lagged Associations between Affect and SB

To better test the time course of the relationships between affect and SB, we included lagged affect and SB at the momentary level. Lagged momentary SB significantly predicted positive affect; greater SB at the previous moment was related to less positive affect at the next moment. This relationship was specific to lagged SB and positive affect: lagged SB did not predict negative affect and neither lagged momentary affect type significantly predicted SB. Neither analysis indicated any significant moderation effects by menopausal, fitness, depression or BMI status.

Discussion

This study demonstrated that momentary SB leads to subsequent decreases in positive affect in middle-aged women. To our knowledge, this is the first study to link SB and affect at the within-person level with objective monitoring of SB over a period of two weeks. Lagged analyses found SB predicted affect and not the alternative suggesting that interventions should focus on targeting reductions or interruptions in momentary SB to help minimize its impact on positive affect. Reductions in positive affect are undesirable from both a wellbeing and motivational perspective. SB may reflect a lack of engagement with one's environment leading to an increase in low activation affect (e.g., boredom) and a subsequent decrease in positive affect. Although day of week (week day versus weekend) did not appear to impact the results (no significant main or moderator effects were found in analyses of lagged SB on positive affect), it cannot be ruled out that work status did not contribute to the observed associations with positive affect. The study sample was recruited primarily from working women. Supposing that most work environments nowadays are characterized by extended periods of sitting, positive affect could have been increased as a result of time off work when one is also likely to be less sedentary. Future studies are needed to further probe the SB-affect link to corroborate the direction of the relationship, the underlying mechanism, whether it operates differently at different timescales, and what potential consequences (if any) both have on daily wellbeing and motivation for physical activity.

Notable in this study was that only daily negative affect was related to SB. This is in contrast to previous work showing negative affective states are higher on days when individuals are physically active²³. However, other studies have failed to find such associations²⁴ suggesting that other daily experiences, such as daily stress, may have stronger influences on negative affect²⁵. SB itself does not seem to influence negative affect though intense bouts of physical activity may. Further research is needed to determine whether these divergent findings are an artifact of using different measures of affect or are population-dependent. It should also be noted that although using an objective measure of SB is a strength of this study, accelerometer-based estimates of SB are unable to distinguish between sitting and stationary standing, two behaviors that could potentially exhibit different relationships with affect. Future studies should strive to provide information on different types of SB and their

relation to affect. The findings in this study should be interpreted as applying specifically to mid-life women and may not generalize to younger/older women and men. Future studies are needed to corroborate these findings in diverse samples.

Conclusion

The results of this intensive longitudinal study suggest that sedentary behavior negatively influences momentary affect in middle-aged women. Overall, positive affect was more likely to be related to sedentary behavior rather than negative affect. This was true both concurrently as well as over the course of 3-6 hours. Specifically, we observed reductions in positive affect while engaging in sedentary behavior as well as following a period of being sedentary. Future intervention efforts should focus on reducing or interrupting sedentary behavior to lessen the detrimental effects sedentary behavior appears to have on positive affect.

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Table 1
Multilevel models predicting concurrent and lagged behavior

	PosAffect -> SB Estimate (SE)	NegAffect -> SB Estimate (SE)	SB -> PosAffect Estimate (SE)	SB -> NegAffect Estimate (SE)
Intercept	105.60 (1.28) **	105.96 (1.29) **	53.37 (1.73) **	2.54 (0.30) **
Concurrent	-0.31 (0.04) **	-0.06 (0.13)	-0.08 (0.01) **	-0.001 (0.004)
Daily	-0.33 (0.06) **	0.35 (0.17) *	-0.11 (0.02) **	0.01 (0.01)
Person	-0.01 (0.07)	-0.15 (0.45)	-0.08 (0.15)	0.01 (0.02)
Lagged	-0.03 (0.05)	-0.14 (0.13)	-0.04 (0.01) **	-0.003 (0.01)
<i>Level-1 Covariates</i>				
# of hot flashes	2.72 (1.35) *	2.99 (1.37) *	-0.51 (0.73)	-0.33 (0.26)
Wear time (mins)	0.56 (0.03) **	0.55 (0.04) **	0.09 (0.02) **	0.02 (0.01) **
Lagged outcome	-0.27 (0.03) **	-0.27 (0.03) **	-0.27 (0.02) **	-0.29 (0.02) **
<i>Level-2 Covariates</i>				
Day of week	-3.78 (0.67) **	-3.72 (0.68) **	-0.36 (0.38)	-0.16 (0.15)
<i>Level-3 Covariates</i>				
Age	0.59 (0.38)	0.63 (0.38)	0.70 (0.53)	0.18 (0.09) *
BMI	0.12 (0.31)	0.15 (0.31)	0.64 (0.42)	-0.04 (0.07)
Depression	0.84 (7.05)	0.91 (7.03)	-18.42 (9.62)	2.07 (1.61)
Neuroticism	-3.71 (2.51)	-3.40 (2.59)	-8.90 (3.44) **	1.85 (0.57) **
Overall activity	-0.02 (0.002) **	-0.02 (0.002) **	0.0006 (0.004)	0.0004 (0.001)
Fitness	-1.60 (1.38)	-1.58 (1.37)	2.92 (1.93)	0.20 (0.32)
Menopause status	-0.77 (1.89)	-1.02 (1.93)	-0.55 (2.64)	-0.72 (0.44)
Intra-class correlations				
	Sedentary Behavior	PosAffect	NegAffect	
Level-3 Variance (%)	195.6 (18.7%)	340.95 (59.2%)	8.49 (21.1%)	
Level-2 Variance (%)	180.66 (17.4%)	40.35 (7.01%)	7.06 (17.5%)	
Level-1 Variance (%)	664.66 (63.9%)	194.22 (33.7%)	24.72 (61.4%)	

Note.

PosAffect = positive affect, NegAffect = negative affect; SB = sedentary behavior, BMI = body mass index, mins = minutes, SE = standard error. Coefficients reflect the change in SB or affect with a one unit change of the associated predictor. For person-centered predictors this reflects a one unit change from that person's average.

*
 $p < .05$

**
 $p < .01$